Six Essays in Industrial Organization

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Preface

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List of Abbreviations

ASP	Association of Surfing Professionals
CCGT	Closed-cycle gas turbine
CPI	Consumer Price Index
GW	Gigawatt
GWh	Gigawatt hour
MW	Megawatt
MWh	Megawatt hour
OMIE	OMI-POLO ESPAÑOL, S.A.
OMEL	Operador del Mercado Ibérico de Energía, Polo Español, S. A.
REE	Red Eléctrica de España, S.A.
RES	Renewable Energy Resources
VAR	Vector Autoregression

Chapter 1

Introduction

This dissertation contains six essays on topics from the field of industrial organization. The aim is to approach the broad field of industrial organization with a wide range of methods. To capture the characteristics of different markets and problems, different techniques are needed. The industrial organization toolbox offers, among others, theoretical models, empirical analysis and experiments to answer different research questions. In the following chapters, those techniques are applied to different markets and current issues.

After the introduction, the dissertation is structured in three parts and six chapters. In part I, two-sided markets and media markets are analyzed. Chapter 2 uses a theoretical model to analyze the effects of habituated newspaper readers on the strategy of the newspaper. In chapter 3 the effects of market entry in emerging two-sided markets are considered, again theoretically. Then, chapter 4 uses data from the surf World Cup to analyze if two-sided platforms have an incentive to distort their service towards the interests of advertisers.

Part II focuses on energy economics. Chapter 5 analyses the influence of wind and solar power on the conventional power plant fleet in Spain, using data from 2008 to 2012. Chapter 6 looks at the influence of the primary energy resource oil on the monetary part of the economy. With data from Germany from 1970 to 2010, the influence of the oil price on price level and money supply over time is analyzed.

In part III, the focus is not on a special industry but on cartels. Precisely, in chapter 7 the effect of buyer groups on collusive behavior is experimentally analyzed.

Part I: The Economics of Two-Sided Markets and Media Markets

Media markets have changed drastically over the last two decades. The Internet has transformed the media branch into a highly dynamic and highly competitive industry. Before, classical media companies such as newspapers, radio or TV stations operated in a rather stable environment.

The fundamentals of the business, however, are still the same, for classical newspapers as well as for new Internet services. A media platform connects two different markets - the reader (the consumers in general) and the advertisement market. It sells two products to this two different customer groups: advertisement space to companies and content to readers. Advertisers use the media platform to reach potential customers. The more users a platform can attract, the more valuable it becomes for advertisers. Users on the other hand, may benefit from the commercial or perceive it as disturbing. Hence, the utility of one group depends on the other, the two customer groups are connected via indirect network effects. The platform serves both groups and internalizes the indirect network effects between them.

The theory of two-sided markets offers a convenient tool to analyze media markets and to capture the effects of interrelated markets. Chapter 2 to 4 use this theory and apply it to current issues in media markets.

Chapter 2: Newspaper Habit

Newspaper markets are characterized by habitual behavior of readers. In Germany, over 90% of the daily regional and local newspapers are delivered on subscription base. For daily national newspapers, the subscription rate is almost equally high with 82%. Also, three out of four Germans read a printed newspaper on a regular base (BDZV, 2013).

The habitual behavior and the large subscription base affect newspapers on the reader and on the advertisement market. On the one hand, readers get used to the newspaper and buy the newspaper again. On the other hand, the recurring reader base attracts advertisers. Thus, the newspaper has to incorporate the habituated behavior of the readers on the reader and the advertisement market.

The interrelationship between the two markets has been a topic in many theoretical and empirical studies (e.g. Rochet and Tirole, 2003; Anderson and Gabszewicz, 2006; or Kaiser and Wright, 2006). But the dynamic effect of habitual behavior on one market is, so far, a problem that is paid little attention to.

Chapter 2 contributes to the existing two-sided market literature by allowing for myopic habit formation. The past consumption positively influences the current consumption. Habitual behavior and addiction to certain goods can be modeled in different ways (Becker and Murphy, 1988; Gruber and Köszegi, 2001 or Carrol, 2000). The approach in chapter 2, however, uses an intuitive way to incorporate dependence of the current consumption on past consumption in a two-sided market model.

More precisely, the impact of habit formation in media markets on the behavior of a two-sided newspaper is analyzed. The dynamic approach shows that the habit formation in combination with indirect network effects lead to higher quantities and profits for a monopolistic newspaper. Price setting of the newspaper, however, strongly depends on the strength and relationship between network and habit effect.

Chapter 3: Market Entry into Emerging Two-Sided Markets

In the European Union exist about 2,500 newspapers with a circulation of 85 Million. Germany has 333 daily newspapers and is therefore the country with the greatest diversity measured by the number of newspapers. The market for news in the Internet is likewise versatile. At the moment there are 990 German news sites available (BDVZ, 2012). In media markets and especially in newspaper or TV markets, diversity is, apart from competition issues, considered as a goal by itself. One of the major objectives of most public broadcasters is to promote diversity and to provide content not only for the majority but to also integrate minorities which would possibly not be considered by the market.

But, what is true for newspapers and for the online news is not necessarily true for all media platforms. Some services are highly concentrated and have only one or few big players. Search engines are a typical example, with Google as the major player in most European countries. Social networks and online auction also tend to be highly concentrated. In contrast, online travel agencies, online book stores or newpages for sport are examples for markets with very low concentration tendencies.

Online markets have become an important issue in media economics. They not only bring up new technologies, applications and services but also new competition issues. Some years ago, hardware and software producers like IBM or Microsoft were on the radar of competition authorities. Lately, the attention of competition authorities, policy makers and also the public shifted more and more to Internet content provider, like Google or Facebook.

The conventional wisdom, that more firms in the market are better for welfare and consumer surplus is not directly transferable to two-sided markets. Especially, emerging two-sided markets need to capitalize on indirect network effects. Here, two effects are at work: a competition effect which increases quantities brought to the market with the number of firms entering the market. And a reverse effect caused by the indirect network effect, which decreases quantities with more firms entering the market.

In chapter 3 an intuitive approach is used to model market entry in two-sided markets under imperfect competition. In conventional markets, fixed and marginal costs have a direct impact on the market structure. In emerging two-sided markets also the strength of indirect network effects can be responsible for higher or lower concentration.

Emerging two-sided markets can have a tendency towards monopolies. This may not be detrimental for welfare. High concentration in, for example, search engines or online auctions markets do not necessarily lead to deadweight losses but can, depending on the indirect network effects, also create higher welfare.

Chapter 4: The Influence of Advertising in Two-Sided Markets

Revenues of two-sided platforms often depend on the advertisement market. As advertisement customers typically benefit more from readers than readers benefit from advertisement, two-sided platforms often subsidize the reader market and charge a higher price on the advertisement market. This is very typical for newspapers and magazines: consumers pay less or exactly the marginal costs and advertisers pay substantially more (e.g. Kaiser and Wright, 2006). The lower copy price attracts more reader, which makes the newspaper again more valuable for advertisers, which are then charged higher for their ads. Thus, the major part of the revenues comes from advertisement.

The connection of the consumer market and the advertisement market has an inherent risk of a media bias. If the advertiser is interested in reaching consumers and in the content of the newspaper, newspapers may have an incentive to distort the content to please advertisers. The incentive is stronger, the stronger the platform depends on the revenues from the advertisement market (Ellman and Germano, 2009).

The literature on media bias is originally concerned with political influence on newspapers, how certain media companies influence the opinion of their customers or how newspapers adapt to the preferences of their readers (e.g. Mullainathan and Shleifer, 2005; Gentzkow and Shapiro, 2006; DellaVigna and Kaplan, 2007 or Gentzkow and Shapiro, 2010).

A profit oriented media bias, in contrast, arises out of the two-sided nature of media markets. The concern is not that media platforms are abused for political interests, but that content is distorted to increase advertisement revenues. The problem of the profit oriented bias is emphasized through the Internet. So far, only few newspapers successfully introduced payment mechanisms for their online content. Therefore, the only revenues for Internet services often come from advertisement.

Empirically, media bias is difficult to measure. There is no objective benchmark which topics a newspaper should cover or how they should write about certain issues. For an empirical analysis it would be necessary to find measures to evaluate the content of a newspaper and compare it to the real or the most desirable content. Existing studies use, for example, product ratings from newspapers to test for a potential influence of the advertisement market over these rankings (e.g. Dewenter and Heimeshoff, 2012).

Profit oriented media bias is, however, not an exclusive feature of newspapers and media platforms. It can occur in every two-sided market which connects the advertisement with the consumer market. In contrast to the newspaper market, where the problem is most relevant, the effect is easier measurable in other two-sided markets. The results may then not be directly transferable to every other media platform, but still some insights how the connection of the platform with the advertisement market affects the other market can be gained.

Sport events are often organized as two-sided markets. They attract viewers through the competition and sell the attention of the viewers to sponsors. The more successful they are and the more interesting the event is, the more viewers they can attract and the more valuable they are for their sponsors. The sponsor of the event or the sponsor of a certain team, however, should not have an influence on the outcome of the event.

Sports events where the performance is measured by judges offer a good opportunity to test a potential influence of advertisers over the subjective results. An influence can be expected, when the sponsor is connected with the sport event and with some of the participants. That is, the sponsor is interested in reaching the viewers of the event but also in certain athletes to perform well. The surf World Tour is a good example for this: surfers compete against each other and their performance gets rated by independent judges. Over the season, several events take place in different locations. Each event is sponsored exclusively by one sponsor. But the sponsor also has commercial relationships with some of the surfers participating in the event. In theory, this leads to a bias of the results (the content) towards the need of the advertiser (Ellman and Germano, 2009). Also, empirical results show, that an influence of the advertisement market over the results should be expected.

In chapter 4, data from 2009 to 2011 from the World Tour in surfing is used to analyze the possible influence of the sponsor over the results of the event. The results show that the influence of advertisers over the service of a two-sided platform might be rather low, even though the connection between the platform and the advertiser is strong. Reasons for this result are the high frequency and the replicability of the judging decisions.

Part II: Energy Economics

Energy is fundamental to industry and society. Both primary energy resources such as oil and secondary energy sources such as electric power raise important economic questions. Energy markets, however, are also subject to political interest and political influence.

Higher energy prices often directly impact the cost of living of the population and the competitiveness of the industry. Central banks concerned with inflation may have to react to increasing prices of primary energy resources. The market for electrical power, on the other hand, should guarantee security of supply, low power prices for industry and population, consider ecological goals and be in line with the industrial policy of a country.

It is therefore crucial that those markets work well and that policy makers react reasonable to volatile prices in those markets. In chapter 5 the influence of electric power production by wind and solar over power production from conventional power plants is analyzed. Chapter 6 considers the impact of oil on the monetary part of the economy.

Chapter 5: The effects of Wind and Solar Power on the Merit Order

Electric power is one of the most basic goods in society. It is, however, different from many other goods. Electricity is neither storable[1] nor substitutable, its provision has physical limitations and generation has to equal consumption at all time. Demand also varies substantially during the day and over the year.

Through these characteristics, power is provided by several power plant types: Baseload plants run most hours of the year and cover the steady demand which varies only little over the course of a year. Mid-merit plants cover the fluctuating demand within the normal magnitude and still run a substantial part of the year. Finally, peak plants cover the very high demand peaks and run only little during the year.

The power plants in those three categories differ in their costs. Baseload plants have very high investment costs but can then produce with very low marginal costs, e.g. nuclear power plants. Mid-merit plants have lower investment costs but higher variable

[1] Electric power is not economically storable to balance substantial fluctuation of demand.

costs and peak plants have rather low investment costs but very high variable costs. Ordering the power plants according to their variable costs is called merit order. Given sufficient competition, all power plants bid their power according to their marginal costs into the market. The bid of the last power plant still needed to satisfy demand, sets the price. All other power plants left of it in the merit order, earn money on top of their marginal costs.

The aim of chapter 5 is to analyze the influence of renewable energy sources over this merit order and thus over the market mechanism. Renewables, like wind and solar, can be regarded as exogenous to the market: they get fixed remuneration for the power they produce and often other public support schemes promote investment in those technologies. Their production decision does also not depend on other plants or the current wholesale price but solely on the availability of wind and sun.

Renewable energy sources are supposed to make power production greener and more sustainable. With the increasing share of power production by wind and solar, however, comes one problem: they cannot produce whenever they are needed. Wind and solar power reduce the need for conventional power plants when they produce, but the conventional power plants are needed when wind and solar do not produce. Depending on the weather conditions, different power plants within the merit order have to produce more or less. This affects the current and future generation mix. If peak plants with high variable costs are not needed anymore and leave the market, power prices should decrease. If, on the other hand, the fluctuating production of wind and solar power reduces the runtime of mid-merit plants substantially they may not be able to cover their fix costs anymore and could be forced to leave the market. Then, more flexible but also more expensive plants would be used more frequently to cover demand. This would then again increase power prices.

Chapter 5 uses data from Spain for 2008 to 2012 to show that mid-merit plants suffer in fact most from production of wind and solar power. The effect, however, is mainly driven by wind power. Solar power has, in contrast to the expectations, a positive influence on the wholesale price, as peak plants increase their production, when solar produces more. Overall, mid-merit plants are affected most by increasing production of wind and solar.

Chapter 6: Oil Prices and Inflation: A Stable Relationship?

Energy provision and therefore energy prices not only affect power markets but society and economy as a whole. Energy expenditures constitute a large part of the spending of a household. In Germany, energy and housing accounts for one third of the total spending of a household (Statistisches Bundesamt, 2010).

An extensive literature has evolved to analyze the effect of the oil price on the economy (e.g. Hamilton, 1983; Bernanke et al. or Blanchard et al. 2010). Especially for central banks, it is important to know the influence of the oil price to be able to choose the right policies to counteract inflation.

To react correctly to changes in the oil price, central banks also have to know the time structure of the influence of oil prices on the economy. An important question therefore is, if there is a stable relationship between the oil price and price levels over time. Only a persistent impact of the oil price would satisfy measures by the central bank. If the influence is only temporary, the measures taken may not achieve their initial goal.

Chapter 6 contributes to the literature on oil prices by answering a very specific question: how does the oil price influence the price level and the money supply in Germany over time? Our interest lies in the time structure of the influence and the identification of periods when the oil price affected the economy significantly. Therefore, not only the oil price itself but also positive and negative oil price shocks are considered.

Without a stable relationship, central bank actions following oil price shocks would not be justified in every situation. The results provide evidence that only for some periods between 1970 and 2010 oil prices had a significant influence on the German price level. During most time periods, however, there is no stable relationship.

Part III: Cartels

Cartels are not specific to certain industries but a general issue in competitive markets. In some industries cartels may be more likely but the fundamental mechanics remain the same across markets. In competitive situations companies often try to increase their profits through cooperation with direct competitors. This is detrimental to welfare and treated as anti-competitive behavior around the world.

Empirically, cartels are hard to analyze. Data is typically only available for detected cartels. As it is fundamental for cartels not to be observable, current cartels can never be analyzed but only those which got detected. Antitrust authorities additionally only gather certain data which are needed to prove the cartelization of the market but not the necessary data to empirical investigate the mechanics of cartels. Data on the beginning and end date or the structure of a cartel, the number of participating firms and penalties are available, but only for those cartels which got detected. Form an empirical point of view, only little is known about the procedures within cartels. Therefore, chapter 7 uses an experimental approach to identify which factors facilitate collusions in markets with buyer groups.

Chapter 7: Do Buyer Groups Facilitate Collusion?

Empirical literature on cartels shows that common market institutions are often involved in cartels. Levenstein and Suslow (2006) find that trade associations and common market institutions played a major role in many US cartels. Why and how they facilitate collusion, however, cannot be answered.

Theoretically, common market institutions can increase the stability of a cartel if they offer an extra punishment mechanism through the institutions. Also, the behavior of the cartel members can be better monitored, when for example prices are more transparent. Thus, common market institutions may be used as a coordination device. The possibility to communicate through the common market institution, however, does not increase the stability from a theoretical point of view.

The effects of communication within a cartel are not observable. It can be efficient to allow firms to communicate with each other but it can also increase anti-competitive behavior. Allowing firms, for example, to jointly buy their input factors can reduce input costs. If those companies then compete on the downstream market the lower production costs would be, at least partly, passed through to customers. But if the buyer group is used as a vehicle to explicitly or tacitly collude, it may be detrimental for consumers and welfare.

Chapter 7 experimentally investigates if and how buyer groups facilitate collusive behavior. Competition authorities have been quite successfully in uncovering and prosecuting explicit cartels, more tacit forms of collusion, however, are still hard to detect and to deal with. This chapter models a certain market situation, joint purchase through a buyer group, which is likely to be used for collusion, to identify practices in this setup that facilitate such behavior. The goal is to understand how cartels operate and what competition authorities should look for.

Experiments have become an established method in economics and a useful tool in the toolbox of industrial organization. The application of experiments and the implications drawn from laboratory studies are, however, subject to controversial discussions. In the focus of this discussions are the questions: how and for what problems experiments should be used (e.g. Rubenstein 2001 and 2006) and the question of the external validity (e.g. Guala and Mittone, 2005). In detail, can the behavior of firms be simulated with students and if so, what can be learned for real market situations from those studies.

For this dissertation, the framework of experimental economics is taken as given. It would be out of the scope of the work to discuss all issues regarding appropriability and external validity. Within this framework, chapter 7 intends to analyze factors facilitating collusion as it is both from an empirical and theoretical point of view hard to look inside cartels and help competition authorities to shed light on more tacit forms of collusion. Nevertheless, the results have to be interpreted with caution. It has to be considered carefully if and how the results can be transferred to other situations.

The experimental design abstracts from other factors that might influence collusive behavior and concentrates on the effects of communication and the punishment mechanism which arise from buyer groups. Members of the buyer group can exclude certain firms from the buyer group and prevent them from getting better purchasing conditions. This punishment mechanism is very costly for the punished firm but not for the punisher. It enables the cartel members to punish certain firms, without being exposed to the same punishment themselves. Theoretically, this substantially increases the likelihood of cartels.

While theoretically, communication does not facilitate collusion, we find that it is the driving force behind collusive behavior. When both is possible, communication and punishment, punishment is hardly used and only non binding communication is used to cartelize the market. We do not simulate cartel authority or punishment for being in a cartel, but focus solely on the two factors punishment and communication.

Part I

The Economics of Two-Sided Markets and Media Markets

Chapter 2

Newspaper Habit*

*This chapter is published as Dewenter R. and J. Rösch (2011) in Economics Bulletin, 34(4), 2884-2889.

2.1 Introduction

Media markets and especially the newspaper and magazine industry show several characteristics which distinguish them from other industries and markets. Newspapers (and of course also magazines) act as so called two-sided platforms (see Rochet & Tirole, 2003) that connect advertisers with readers. It is broadly understood that readers exert a positive externality on the advertising market as the advertising customers' utility increases with the number of recipients. It is, however, less clear cut whether readers perceive ads as useful or disturbing and if the number of advertisers creates a positive or negative externality for readers. However, it is clear that the two markets are interconnected and that newspapers and magazines are at least partly able to internalize two-sided indirect network effects. Empirical evidence suggests, that newspapers tend to set copy prices just above, at or even below marginal costs. Advertising rates on the other hand tend to be much higher. The externalities are internalized through the price setting of the two-sided platform.

In addition to indirect network effects, however, media markets frequently show also some kind of habituated behavior. Readers of newspapers and magazines, for instance, get used to a specific print medium (newspaper habit). TV viewers, radio listeners and Internet users sometimes get 'addicted' to a specific broadcast, show or Internet service, such as online games and social networks. Recipients then tend to consume the same product with a higher probability in future periods or even consume the product to a greater extend over time. In any case, habit effects increase the consumers' willingness to pay.

Obviously, habituated behavior gives newspapers the opportunity to better plan circulation numbers and adjust the content to the preferences of the (habituated) readers. But besides this, habit effects also influence the firms' price setting behavior and has influence on the interconnection between the two markets.

This note aims at analyzing how indirect network effects and habituated behavior interact and influence prices, quantities and profits in the steady state. We therefore build a simple dynamic model of a monopolistic newspaper serving a reader and an advertising market alike. We find that the reduction of the price on the market with the higher relative externality can be partly lowered through the habit effect. Which in turn allows newspapers with habituated readers to raise prices above marginal costs and exploit the behavior of the readers. As advertisers benefit from the loyalty of the readers, advertising rates also increase. Newspapers facing habituated readership therefore act differently form other two-sided markets and can extract further profits, as indirect network effects are enforced and lowered at the same time. Nevertheless, quantities are always higher with habit effects.

2.2 Model

2.2.1 Basic Setup

Suppose that a monopolistic, say, regional newspaper sells content to readers and advertising space to advertisers. Suppose furthermore that both markets are interrelated by two-sided indirect network effects. Newspapers are therefore typically referred to as two-sided platforms (see Rochet and Tirole, 2003). The inverse demand function of the advertising market can then be described as

$$r_t = 1 - s_t + gq_t, \tag{2.1}$$

where r_t is the advertising rate in time t, s_t is the amount of advertising space and q_t is circulation in t. The parameter $g > 0$ indicates the indirect network effect from the reader to the advertising market. Put differently, increasing circulation also increases the willingness to pay for advertising as the advertising rate per reader or contact (r/q) declines with higher circulation.

In the same way inverse demand for newspapers can be described as

$$p_t = 1 - q_t + \eta q_{t-1} + ds_t, \tag{2.2}$$

where p_t is the copy price in time t. Since q_{t-1} is circulation in $t-1$ newspaper consumption depends on previous consumption indicating myopic habit formation in newspaper reading.[1] Moreover, $\eta < 1$ represents the strength of the habit effect.

[1]Modeling myopic habit formation by assuming that current consumption depends positively on past consumption is the easiest way to assume habituated behavior (see Brown, 1952). Even if there are many more elaborate ways to deal with habit effects this approach is advantageous because of its simplicity,

Combining inverse demand equation, assuming an infinite lifetime and assuming profit maximization, the monopolistic newspaper maximizes the current value of all (current and future) profits

$$\max_{q_t,s_t} \pi_t = \sum_{t=1}^{\infty} \beta^{t-1}[(1 - q_t + \eta q_{t-1} + ds_t)q_t + (1 - s_t + gq_t)s_t], \tag{2.3}$$

where $\beta \in [0, 1]$ is a constant discount factor. The respective Euler equations to solve the optimization problem are

$$\beta^t \eta q_{t+1} + \beta^{t-1}(1 - 2q_t + \eta q_{t-1} + (d + g)s_t) = 0 \tag{2.4}$$

for the reader market and

$$\beta^{t-1}(1 - 2s_t + (d + g)q_t) = 0 \tag{2.5}$$

for the advertising market.

2.2.2 Steady State Equilibrium

Quantities

Combining the Euler equations and assuming that all quantities are equal in the steady state yields

$$q = \frac{2 + d + g}{4 - (d + g)^2 - 2\eta(1 + \beta)} \tag{2.6}$$

and

$$s = \frac{2 + d + g - \eta(1 + \beta)}{4 - (d + g)^2 - 2\eta(1 + \beta)}. \tag{2.7}$$

As can easily be shown, habit formation as well as indirect network effects lead to increasing quantities.[2] In case of one-sided markets both network effects equal zero and therefore quantities reduce to $\bar{q} = \frac{1}{2-\eta(1+\beta)}$ and $\bar{s} = \frac{1}{2}$. In case of two-sided markets

especially in connection with the two-sidedness of the market. For examples of more elaborate models see e.g., Becker and Murphy (1988) for a model of rational addiction or Gruber and Köszegi (2001) for a model of rational habit formation. See also Carrol (2000) for some more literature on this issue.

[2]Note that in comparison to one-sided markets both quantities (q, s) are higher as long as the sum of the indirect network effects $(d + g)$ is positive. As $g > 0$ by definition this always holds as long as $|d| < g$ if $d < 0$.

without habit formation ($\eta = 0$) q and s reduce to $\hat{q} = \hat{s} = \frac{1}{2-d-g}$. While the effect of the two-sidedness on advertising space is always larger than the effect of habit formation ($\hat{s} - \bar{s} > 0$) the impact on the reader market strongly depends on the parameter values ($\hat{q} - \bar{q} \gtreqless 0 \Leftrightarrow \eta(1+\beta) \lesseqgtr 2 - d - g$). Comparing circulation and advertising space yields that the direct influence of habit formation in reader markets always leads to higher circulation numbers.

Prices

Inserting quantities into inverse demand curves leads to optimal prices

$$p = \frac{(1-g)(2+d+g) - \eta(\beta(2+d)) - g}{4 - (d+g)^2 - 2\eta(1+\beta)} \tag{2.8}$$

and

$$r = \frac{(1-d)(2+d+g) - \eta(1+\beta)}{4 - (d+g)^2 - 2\eta(1+\beta)}. \tag{2.9}$$

Starting with the advertising rate (r) yields the (with respect to two-sided markets) well known result that prices are lower when indirect network effects can be exploited. First, without any habit effect the advertising rate is $\hat{r} = \frac{1-d}{2-d-g}$. A higher positive network effect d that is induced by the amount of advertising lowers the advertising rate in order to exploit this effect.

Second, analyzing the advertising rate when network effects are absent ($d = g = 0 \Rightarrow \bar{r} = \frac{1}{2}$) and comparing this price with r it follows that $\bar{r} \gtreqless r$ if $g \gtreqless d$. That is, network effects lead to a lower advertising rate if the effect from the advertising to the reader market is bigger than the opposite network effect (i.e. from the reader to the advertising market). The advertising rate decreases in case that the network effect d is strong (i.e. stronger than g).

Furthermore, habit formation has a positive (negative) impact on the advertising rate as long as $d < g$ ($d > g$). To put differently, the advertising rate is higher with habit formation ($\hat{r} = \frac{1-d}{2-d-g} < r$) when the indirect network effect from the advertising market to the reader market (d) is smaller than the indirect network effect from the reader to the advertising market (g).[3] The intuition behind this result is as follows: as habit formation increases circulation and therefore also the demand for advertising space,

[3]Indeed $\frac{\partial r}{\partial \eta} \gtreqless 0$ if $g \gtreqless d$.

this positive impact can be exploited best when prices are set according to the network effects. Advertising rates are therefore higher (lower) in markets with habit effects when circulation is more important for advertisers than advertising space for readers (et vice versa).

When analyzing the copy price similar results can be derived. Setting $\eta = 0$ yields $\hat{p} = \frac{1-g}{2-d-g}$. Without habit effects, the copy price is higher with low network effects from the reader to the advertising market. Setting $(d = g = 0)$, i.e. abstaining from network effects, leads to $\bar{p} = \frac{1-\eta\beta}{2-\eta(\beta+1)}$. In this case habit formation has, not surprisingly, a positive impact on the copy price ($\frac{\partial\bar{p}}{\partial\eta} > 0$).

However, when accounting for habit effects and network effects simultaneously results are less straightforward. Analyzing the impact of network effects on p yields that $\bar{p} - p \lesseqqgtr 0$ if $g \gtreqless d\frac{1-\eta\beta}{1-\eta}$.[4] Similar as in a world without habit formation a strong network effect from the reader to the advertising market leads to a lower copy price. However, as habit formation increases circulation (and as future profits are at most as valuable as current profits) g has to be even larger than d for decreasing prices. Put differently, a strong habit effect (and also a low discount factor) and therefore higher demand for newspapers enables the newspaper to set higher prices for copies. The effect initiated by the network effect from reader to advertising markets is then damped by habit formation.[5]

Overall, one can conclude that publishers which are able to bind their readership to their newspapers and magazine are able to attract more readers, set higher copy prices and also might set higher advertising rates (in case that $g > d$). Though network effects are still fully internalized, prices would be higher.

[4]More exactly, analyzing the impact of network effects on p yields that $\hat{p}-p \gtreqless 0$ if $g(1-\eta)+d(\eta\beta-1) \gtreqless 0$. As $\eta\beta < 1$ it follows that $\hat{p}-p \gtreqless 0$ if $g(1-\eta) \gtreqless d(1-\eta\beta)$ or $g \gtreqless d\frac{1-\eta\beta}{1-\eta}$. As $\beta \in [0,1]$ $1-\eta\beta \leqq 1-\eta$ g has to be bigger than d plus a mark-up determined by η and β for higher copy prices under habit formation.

[5]Interestingly, a relatively high η (or a low enough β) can theoretically also overcompensate the aggregate network effect such that copy prices are higher than usual monopoly prices in spite of a large g.

Profits
Turning to profits yields $\pi = pq + rs$ or

$$\pi = \frac{(2+d+g)\left[(1-g)(2+d+g) - \eta\left(\beta(2+d)\right) - g\right)]}{\left(4-(d+g)^2 - 2\eta(1+\beta)\right)^2} + \frac{(2+d+g-\eta(1+\beta))\left((1-d)(2+d+g) - \eta(1+\beta)\right)}{\left(4-(d+g)^2 - 2\eta(1+\beta)\right)^2}. \tag{2.10}$$

As can easily been shown profits are always higher when readers are habituated to newspapers. The same holds when markets are interrelated by indirect network effects. The newspaper monopolist benefits from habit formation as well as from the two-sidedness of the markets.[6]

2.3 Conclusion

Two-sided platforms which are facing habituated behavior benefit from both effects positively. Indirect network effects reduce the price on the market which exerts the relatively higher network effect on the other market. This can lead to prices at or below the marginal costs (see, e.g., Kaiser and Wright, 2006). Therefore, it is possible that a loss on one market and correspondingly higher earnings on the other market can be a profit maximizing strategy. The effect of habituated behavior, however, counteracts this price reduction. Publishers are possibly able to increase copy prices as well as ad rates in case that habit effects are strong and readers are 'more important' to readers that vice versa. However, readers as well as advertisers might suffer from habit effects because of higher prices.

From a competition policy perspective, it is worthwhile to identify habit effects in order to evaluate two-sided media markets. As the habituated behavior of the readership may contradict the possible positive effects that indirect network effects might have on prices, also a negative impact on consumer surplus might be effected.

[6] As with $\eta = 0$ profits reduce to $\hat{\pi} = \frac{1}{2-d-g}$, the impact of the indirect network effect is always positive. Furthermore as with $d = g = 0$ profits reduce to $\bar{\pi} = \frac{8-4\eta-8\eta\beta+\eta^2+2\eta^2\beta+\eta^2\beta^2}{(4-2\eta-2\eta\beta)^2}$, the derivative $\frac{\partial\bar{\pi}}{\partial\eta} = \frac{(\beta+\beta^2)\eta-2}{(1+\beta)\eta-2)^3}$ is always positive as long as $\beta \leqq 1$ and $\eta < 1$. Since both network effects and habit formation lead to higher profits also a combination of both must lead to an increase in earnings.

Chapter 3

Market Entry into Emerging Two-Sided Markets[*]

[*]This chapter is published as Dewenter R. and J. Rösch (2012) in Economics Bulletin, 32(3), 2343-2352.

3.1 Introduction

Many two-sided platforms such as Internet service providers are placed in a constantly changing environment, bringing up new technologies, applications and services and therefore higher demands. As a consequence, many of these markets grow steadily and become more and more important. One reason for this success may be the existence of substantial indirect network effects. A large network of users from one market typically positively affects the utility of users from a second market and vice versa. Strong network effects therefore stimulate users to prefer a specific network over others (see Rochet and Tirole, 2003). As a consequence, markets may be enlarged by attracting new customers due to indirect network effects which in turn lead to higher concentration. Hence, a tendency towards *natural monopolies* may also be expected for two-sided markets.

Market structures of two-sided markets are quite versatile. While some of the markets are highly concentrated, there is also a number of dynamic markets which are characterized by fierce competition and market entry. Nevertheless, recently the focus of competition authorities shifted from hard- and software producers like IBM or Microsoft to two-sided platforms such as Google, Apple's iTunes or the social network Facebook. Some of those platforms are highly concentrated. Many others such as news sites, travel agencies, online bookstores, etc. face a high number of competitors and are far from being dominant. In network industries, however, intense competition is not always desirable as network effects can sometimes be better utilized by a single firm.

Concentration tendencies are a well known problem of media markets and network industries. The so called circulation spiral is supposed to lead to a high concentration (e.g., Corden, 1952; Furhoff, 1973; Gustafsson, 1978). In online media markets the discussion was fueled with the emergence of new and powerful platforms like eBay or Google. While direct network effects may not always favor intense competition, Evans and Schmalensee (2008) analyze how indirect network effects can lead to endogenous monopolization of markets but find that this is not commonly observable.

However, in network industries intense competition is not always desirable as network effects can sometimes be better utilized by a single firm. From a theoretical perspective, Caillaud and Jullien (2003) argue that agents can better coordinate or match through a single platform. In case of multihoming, however, the existence of two platforms can be efficient (Caillaud and Jullien, 2003; Jullien, 2005). Damiano and Li (2008) find that in matching models a monopoly platform can be favorable. Further works in this area are Burguet and Sákovics (1999) and Ellison, Fudenberg and Mobious (2004). Matching quality seems to be higher under monopoly structure and also larger network effects seem to favor a monopolistic platform. On the other hand, with multihoming and congestion competition is more favorable in their model.

Our work builds on the existing literature by analyzing two-sided markets, say online platforms, offering two products, say content to recipients and advertising space to advertising customers, with interrelated demands. The aim of this note is to abstract from other issues and concentrate fully on the effect of indirect network effects on market entry in a non-saturated market environment. Therefore, we first present an intuitive two-sided market model in section 3.2 to calculate optimal quantities, prices and profits. Then, in section 3.2.5, we look at the welfare effects of market entry and the optimal number of firms. Finally, section 3.3 concludes.

3.2 An Oligopoly Model of Two-Sided Markets

Suppose that there are $i = 1, ..., n$ homogeneous platforms (2SP) serving two different but interrelated markets. Both markets are assumed to be interconnected via indirect network effects. The strategic variables in both markets are quantities.[2] The inverse demand equations of platform i for the first and second market are given by $p_i = 1 - q_i - Q_{-i} + ds_i$ and $r_i = 1 - s_i - S_{-i} + gq_i$, where p_i is the price for the first good of the two-sided platform i ($2SP_i$) and r_i the price for a second good. Quantities in both markets are given by q_i and s_i. The cost function of platform i is $K_i = cq_i + cs_i + F$ where $c \in [0, 1]$ are the marginal costs and F the fixed costs.[3] The parameters d and g (with $d + g = \theta < 2$) represent the indirect two-sided network effects from one market to the other. An increase of d (g) shifts the respective consumers demand curve outwards. That is, a stronger indirect network effect from one market leads to an increase of the willingness to pay of the respective other market. The assumption of market enlargement especially

[2]Several papers assume quantity competition in a two-sided market environment. Prominent examples are Reisinger et al. (2009), Anderson and Coate (2005), Anderson (2007), Gabszewicz et al. (2004) and Crampes et al. (2007).

[3]Arguable, marginal costs play a minor role in many two-sided markets, especially in online markets. Assuming $c = 0$ would therefore also be possible.

holds in a non-saturated market environment. As long as markets are still growing, network effects are likely to lead to increasing markets size[4].

3.2.1 Quantities

The $i = 1, ..., n$ 2SPs maximize profits with respect to q_i and s_i:

$$\max_{q_i, s_i} \pi_i = [p(q_i, Q_{-i}, s_i) - c]\, q_i + [r(s_i, S_{-i}, q_i) - c]\, s_i - F. \tag{3.1}$$

Using the first order conditions, assuming symmetry of firms and markets leads to:

$$q_i = s_i = \frac{1-c}{n+1-\theta}. \tag{3.2}$$

Quantities in both markets are equal and increase with stronger network effects. The pivotal factor for optimal quantities, is the sum of the network effects θ rather than each single network externality. That is, even if a single network effect is negative, a positive effect on quantities can be observed as long as this negative effect is dominated by the second (positive) network effect ($|d| < g$).[5]

Proposition: *Total quantities in both markets only increase with market entry if indirect network effects are relatively small. If $\theta > 1$, market entry leads to lower total quantities.*

In the symmetric case, total quantities are: $Q = nq_i = S = ns_i = \frac{n(1-c)}{n+1-\theta}$, respectively. Thus, the effect of market entry on optimal quantities is:

$$\frac{\partial Q}{\partial n} = \frac{\partial S}{\partial n} = \frac{(1-c)(1-\theta)}{(n+1-\theta)^2} \gtreqless 0, \tag{3.3}$$

which is negative for $\theta > 1$.

As long as network effects are relatively weak, tougher competition leads (as usual) to higher total quantities. Given the sum of network effects is relatively high, the *competition effect* is dominated by the, as we call it, *aggregated network effect*. This effect

[4]Market size is set equal to 1 in both markets in absence of network effects.

[5]As both network effects represent the interrelationship of the two markets the sum instead of the single effects is decisive for the quantities. Since each shift in quantities in one market has an effect on the quantity in the other market, feedback effects can be observed. The strength of the overall effect therefore depends directly on θ.

increases firm specific quantities through the market enlargement effect. In case of large network effects the increase in platform specific quantities is more valuable than an increase in market volumes caused by stronger competition. Further competitors entering the market, reduce the quantity of each single platform which results in lower quantities since network effects can be internalized only to a lower extent. The increase of total quantity by market entry is then overcompensated by the loss due to not internalized network effects.

Comparing the absolute changes in quantity of the standard Cournot model with our two-sided market Cournot model, the trade-off between competition and indirect network effects becomes clear. Defining ΔQ_C as the absolute change in quantity for one additional firm $(n+1)$ entering the market in the Cournot model and ΔQ as the absolute change in quantity for our model, we can calculate the indirect network effect for an additional firm entering the market as:

$$\Delta NE = \Delta Q - \Delta Q_c = \frac{(1-c)\theta(1-n^2-n-\theta)}{(n+2-\theta)(n+1-\theta)(n+2)(n+1))}, \tag{3.4}$$

which is always negative for $n > 1$. A new 2SP entering the market causes two effects: the competition effect which is, as in one-sided markets, always positive and the aggregate network effect which is always negative. For $\theta > 1$, when the interconnection between the two markets is strong enough, the effect induced by the indirect network effects dominates and the total quantity in the market decreases. Figure 3.1 shows both the competition and the network effect for two different θ.

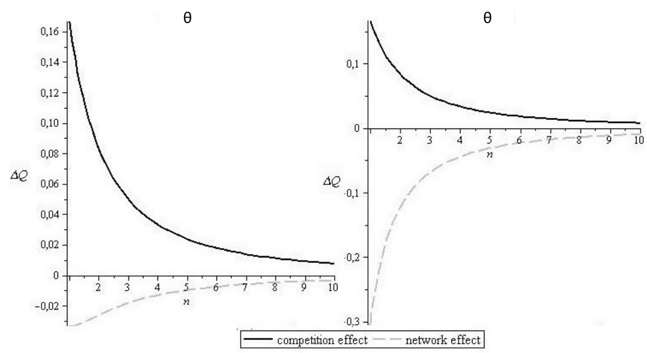


Figure 3.1: Network and Aggregate Competition Effect Depending on n for c=0

The effect on total quantity of an additional company entering the market is steadily decreasing in n. The network effect is always negative but approaching zero. The competition effect is always positive and also approaching zero with more firms entering. As long as $\theta < 1$, consumers on both markets benefit from market entry as total quantities increase.

3.2.2 Prices

Substituting optimal quantities into the inverse demand functions leads to optimal prices for both markets expressed as a markup on marginal costs:

$$p = c + \frac{(1-g)(1-c)}{n+1-\theta} \quad \text{and} \quad r = c + \frac{(1-d)(1-c)}{n+1-\theta}. \tag{3.5}$$

Markups for p (r) turn negative in case that g (d) exceeds one. Note, that even if the sum of network effects is limited to two, a single parameter is not limited to be smaller than one.[6] If $d \neq g$, prices differ and the market which exerts the relatively higher positive externality will be subsidized by the other. A platform charges the market with the stronger indirect network effect less or even a price below marginal costs.

Increasing network effects always lead to lower respective prices when $n \geq d$ ($n \geq g$). Since $\theta < 2$, only monopolists might have an incentive to raise prices with stronger network effects when $d > 1$ ($g > 1$). Thus, only monopolists are able to fully benefit from network effects.

Prices r_i and p_i only decrease with increasing number of firms as long as $d \leq 1$ or $g \leq 1$, respectively. Hence, prices will be higher under a more competitive market structure when one of the indirect network effects is strong. A seemingly more competitive market could therefore possibly end up in a less favorable situation in terms of prices, and market enlargement will also only take place to a limit extend.

Many customers of two-sided platforms are interested in relative instead of absolute prices. Referring to newspapers prices per recipient or prices per thousand recipients which are commonly known as *cost per thousand* is a more adequate measure. Calculating prices (r/q_i and p/s_i) yields:

[6] For $\theta > 2$ negative quantities would be possible in the monopoly case. We therefore allow for one negative price but exclude negative quantities.

$$\frac{r}{q_i} = \frac{(1-d)+c(n-g)}{1-c} \quad \text{and} \quad \frac{p}{s_i} = \frac{(1-g)+c(n-d)}{1-c}. \tag{3.6}$$

If marginal costs are zero relative prices simplify to $\frac{r}{q_i} = 1 - d$ and $\frac{p}{s_i} = 1 - g$. And relative prices are constant with respect to market entry as quantities vary with the same rate as prices as long as marginal costs are negligible. In case one network effect exceeds 1 the respective price will be negative which is not uncommon in two-sided markets. If marginal costs are not negligible, however, relative prices are increasing with the number of firms. That is, firm specific quantities decrease faster than absolute prices. Again, a more competitive market might end up in a less favorable situation.

3.2.3 Profits

Firm specific profits are:

$$\pi_i = \left(\frac{1-c}{n+1-\theta}\right)^2 (2-\theta)\,. \tag{3.7}$$

Individual profits decrease with market entry, as $\frac{\partial \pi_i}{\partial n} < 0$. Profits, however, increase with stronger network effects, as long as the market structure is monopolistic. In the duopol case, stronger network effects only lead to higher profits if $\theta < 1$. If $n > 2$ stronger network effects always have a negative impact on individual profits.[7]

An increase in indirect network effects lowers prices in oligopolies but only monopolies can fully internalise the market enlargement effect caused by stronger network effects. Thus, only monopolists can benefit from stronger indirect network effects in terms of profits in any case. With increasing total network effects prices fall faster than quantities increase, when $\theta > 1$. However, with $n > 2$ prices fall always faster than quantities increase. Therefore, increasing total network effects lead always to lower profits in oligopolistic markets.[8]

[7] $\frac{\partial \pi_i}{\partial \theta} > 0$ for $n = 1$, $\frac{\partial \pi_i}{\partial \theta} \gtrless 0$ for $n = 2$ and $\frac{\partial \pi_i}{\partial \theta} < 0$ for $n > 2$.

[8] This result is due to quantity competition and the market sized being one.

3.2.4 Market Entry

To analyze the impact of indirect network effects on market entry, the maximum number of firms entering the two-sided market is calculated. Assuming that 2SPs will enter the market as long as platforms make positive profits the number of firms be lower than the smallest integer which solves

$$n_{max} < (1-c)\sqrt{\frac{2-\theta}{F}} + \theta - 1. \tag{3.8}$$

As can be seen from equation (3.8) the maximum number of firms decreases as expected with fixed and marginal costs. In contrast, the number of firms is increasing in θ when network effects are small, i.e. when

$$\theta < 2 - \frac{(1-c)^2}{4F}. \tag{3.9}$$

Moreover, if marginal costs are zero, the optimal number of companies in the market gets one when θ approaches 2, so the market has a tendency towards a "natural" monopoly with large indirect network effects. If marginal costs are relevant and network effects are relatively large, the equilibria number of platforms decreases in θ.

Hence, small and moderate indirect network effects attract a larger number of companies. If network effects increase the maximum number of companies decreases and monopolies can be optimal.

3.2.5 Welfare Analysis

Each inverse demand function is shifted outward by the product of network effects and quantities (ds_i and gq_i). The reservation price is no longer determined by normalized vertical market size of 1 but by $1 + ds_i$ and $1 + gq_i$, respectively.

Firm specific consumer surplus for the content and advertising market is thus given by

$$KR_i^1 = KR_i^2 = \frac{1}{2}\frac{n(1-c)^2}{(n+1-\theta)^2}. \tag{3.10}$$

and total consumer surplus by

$$KR = \frac{n^2(1-c)^2}{(n+1-\theta)^2}. \tag{3.11}$$

Combining total consumer surplus with total producer surplus $n\pi_i$ yields total welfare:

$$W = \frac{n(1-c)^2(n+2-\theta)}{(n+1-\theta)^2}, \tag{3.12}$$

As indirect network effects lead to market enlargement, they always have a positive impact on social welfare ($\partial W/\partial\theta > 0$). The effect of market entry, however, is ambiguous. The impact of the number of competitors on welfare depends heavily on the size of the network effects. If network effects are large, welfare is monotonically decreasing with n. If network effects are below $\theta < 2 - \sqrt{2}$, there exists a maximum number of firms which is bigger than 1.[9] Otherwise a monopolistic market structure is desirable.

$\frac{\partial KR}{\partial n}$ shows that consumer welfare is always increasing with additional firms entering the market as long as $\theta < 1$, and decreasing otherwise. Consumers in both markets always benefit from market entry when network effects are small. In case that network effects are relatively large, consumer would lose from a further firm entering the market, as total quantities decrease with $\theta > 1$.

For total welfare, monopolies are almost always favorable with respect to indirect network effects. Again, only if the aggregate network effect is relatively small an oligopoly would earn a higher total surplus. In order for market entry to increase welfare, the number of firms in the market n must be smaller than a certain threshold, depending on θ:

$$n_W < \frac{2}{\theta} - 3 + \theta. \tag{3.13}$$

Figure 3.2 presents the number of maximum platforms when market entry is still socially desirable.[10] Taking welfare as well as consumer surplus into account, three areas can be distinguished regarding market entry: In area I, too few companies are in the market, both total welfare and consumer surplus would increase with further entry. In

[9] Without loss of generality, we fully abstract from fixed costs and concentrate entirely on the impact of indirect network effects.

[10] To obtain this figure we differentiated welfare with respect to the number of firms and then solved for the optimal number depending on θ.

area II, too many firms are in the market. Total surplus would therefore decrease (increase) with further firms entering (leaving) the market. Market entry, however, would increase consumers surplus. Thus, following a pure consumer standard, market entry in area II could also be preferable. In area III, again, too many firms are in the market, however, market entry would be detrimental for both, consumers and 2SPs.

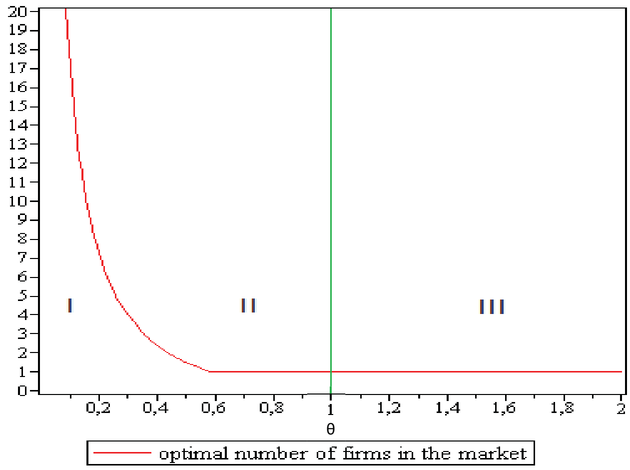


Figure 3.2: Maximum Number of Firms in the Market for Market Entry to still be Desirable

For large indirect network effects monopolies maximize both total welfare and consumer surplus. For smaller values, consumer surplus always increases with market entry, whereas welfare is maximized at a smaller number of firms.

3.3 Conclusion

This note analyzes the impact of indirect network effects in emerging two-sided markets on market entry as well as on welfare. The results show that market entry in two-sided markets depends on the strength of the interconnection between the two markets, i.e. the indirect network effects. When the two-sided nature of the market is only weak to moderate, if the indirect network effects are small or moderate, then the normal effects of market entry apply but are weakened. When indirect network effects are strong, i.e. the markets are strongly interrelated, market entry will not longer occur. Network effects then lead to some kind of a natural monopoly.

As indirect network effects lead to market enlargement, they always have a positive impact on total welfare. The effect of market entry, however, is ambiguous and depends heavily on the strength of the network effects. In case that network effects are large, total welfare may decrease with market entry and a monopolistic market structure may be desirable. Consumers, however, always benefit from entry due to market enlargement effects.

Overall, highly concentrated two-sided markets may be less of a problem in markets with strong network effects and may even lead to maximum total surplus. As monopolists are able to internalize network externalities best, monopolistic platforms may be able to produce highest effects of market enlargement and therefore highest utility for consumers. This positive effect may overcompensate dead weight losses from monopolization.

Chapter 4

The Influence of Advertising in Two-Sided Markets

4.1 Introduction

The Association of Surfing Professionals (ASP) World Tour[1] in surfing is strongly connected with its sponsors. Each event carries the name of one sponsor, e.g. *Quiksilver Pro Gold Coast* or *Billabong Pro South Africa*. The sponsor is in charge of the organization and logistics of the event, including commentators and its broadcasting. During the event, the surfers compete against each other and judges rate their performance. The judges are, however, independent from the sponsor and provided by the ASP.

Additionally, the event sponsors also sponsor surfers which compete at the ASP World Tour. Sponsors use events as an advertisement platform and surfers as an advertisement medium. Thus, the sponsor is interested in both: the audience of the event and the outcome of the event. The more audience the event has and the better the sponsor's surfers perform, the more attention their brand receives. This also implies that the event is more valuable for the sponsor, when their surfers perform better. Hence, an incentive for the platform may exist to distort the results to please the sponsor.

Comments from participating surfers indicate that such a problem might actually exists. The surfer Fredrick Pattachia, for example, was outraged by the commentators at the *Rip Curl Pro* in Bells Beach in 2010 after winning a heat (a competitive round). Pattachia, sponsored by *Quiksilver*, felt unfairly treated by the organizers of the event. In his view, his opponent, a team rider of the event sponsor, was clearly favored by the commentators, whose remarks were vividly heard by the audience, the surfers and the judges alike: "It's kind of like, you know, defeating us out there before we even paddle out."[2]. In 2009 an initiative between surfers and sponsors unsuccessfully tried to reform professional surfing from the scratch to approach this problem among other things. The 11th time World Champion in surfing Kelly Slater, who also took part in the initiative, addressed the issue in a more unsettling way: "The inherent problem with the ASP is that it doesn't own all its media rights. It's very fragmented. You have *Billabong*, *Quiksilver*, and *Rip Curl* owning all the media to all the events".[3]

The influence of the advertisement market on the outcome of sport events is, so far,

[1]The ASP is the Association of Surfing Professionals and is the governing body of the professional surf World Cup for men and women.

[2]Trans World Surf (2010), retrieved: http://surf.transworld.net/1000102214/ videos/freddy-p-unloads-on-bells-commentators/.

[3]Thomas, B. (2009), Kelly Slater Discusses The Rumored Rebel Tour, surfer, retrieved: http://www.surfermag.com/features/kelly-slater-breakaway-tour-trouble-asp/.

a problem that is paid little attention to. While home bias, referees' partiality (see e.g. Boyko et al., 2007; Carron et al., 2005 or Nevill and Holder, 1999) and the question of competitive balance (e.g. Zimbalist, 2002 or Fort and Maxcy, 2003) are frequently addressed, the influence of the advertisement market is an untapped field. Sponsorship and advertisement, however, often play an important role in financing sport events.

Most professional sports and teams are structurally organized as multi-sided markets. Teams or events are platforms connecting two different consumer groups. They offer entertainment to viewers and advertising space to companies. The more viewers they attract, the more prized they are for sponsors, as advertisers benefit from more viewers. Viewers on the other hand benefit directly from the information fed to them by the advertising sponsor, through better organized events or the better financial opportunities for the team to invest e.g. in players. Thus, the viewers and the advertisement market are connected via indirect network effects. The demand of one group increases with the size of the other group. The team or event acts as an intermediate platform connecting both groups.

Two-sided markets are a well-known phenomenon in media markets (e.g. Anderson and Gabszewicz, 2006 or Kaiser and Wright, 2006). But so far, the theory of two-sided markets is hardly used in sport economics. Budzinski and Satzer (2011) show that this theory can be an analytical framework in sport economics. Dietl et al. (2009) model professional sport leagues as two-sided markets. The leagues act as platforms allowing sponsors to interact with fans as potential customers. Neglecting the interconnection of the two markets leads to lower profits for sport teams. It also leads to a possible misjudgment of competitive balance paving way for wrong measures to be taken.

Two-sided markets carry the threat of having the content or service of the platform lean towards meeting the needs of the advertisement market. This is likely the case, when an advertiser is interested in the content or the service of the platform (Ellman and Germano, 2009). As the platform depends on the advertisement revenues, it is a profit maximizing strategy to bias the content towards the need of advertisement customers.

This paper uses data from the ASP World Tour to analyze the influence of the advertisement market over the results of the contest. The ASP, being a typical two-sided market with a service not underlying an objectively measurable benchmark and an advertisement market interested in the audience and the service itself, provides the opportunity of being tested to confirm whether the identity of the sponsor has indeed an influence over the results. Sport data have the advantage to be rich and clean, but the results are not always applicable to other industries (Fizel, 2006). The results, however, still give an insight to the mechanisms of sport events and to industries based on the same underlying structure.

The remaining paper is outlined as follows: First, a discussion why a bias can be expected in the ASP World Tour, hence the economic literature on biases is concisely reviewed and applied to the World Tour in surfing. In section 4.3, the ASP World Tour is briefly introduced, followed by the description of the available data and the empirical strategy. The results will then be presented. After showing that the results are robust to changes in the identification strategy, section 4.7 will discuss the difference between the theoretical and empirical predictions. The paper closes with a critical consideration of the results and what can be learned for the ASP World Tour and the literature of advertisement driven bias in general.

4.2 Bias Towards the Advertiser in Two-Sided Markets

The economic literature on bias is rooted in doubts about media companies reporting bare facts and whether they influence the viewers or readers. Mullainathan and Shleifer (2005) theoretically show that newspapers can distort contents to satisfy the beliefs of their readers. This is found to be stronger, when newspapers compete for readers. They also find that unbiased news coverage depends on the heterogeneity of the readers. Gentzkow and Shapiro (2006) find that competition may reduce a possible bias if readers cannot observe the true content. Bias, however, occurs in their model even though it is detrimental for all participants.

DellaVigna and Kaplan (2007) empirically analyze how the market entry of Fox News Channel affected voters. They find that Fox News had a significant and positive influence on the votes in favor of the Republican party. Gentzkow and Shapiro (2010) find that the preferences of the readers mainly drive the slant in content, and that newspaper owners had little influence over it. Dyck and Zingales (2003) show that stock prices react to news coverage, but they also find that journalist report in favor of companies in exchange for information.

A profit oriented bias, in contrast, arises out of the underlying two-sided structure of the market. Contents are distorted to maximize profit, and not to influence voters, please the source of information or the interests of the owner. Media platforms are typical examples. They connect the reader and the advertisement market. The dependence of the media platform on revenues from advertisement can lead to a distortion of their service on the reader market.

In a two-sided market model Ellman and Germano (2009) show that a monopolistic newspaper will always bias the news to satisfy the needs of advertisers. In their model, a newspaper sells contents to readers and advertisement space to companies. Advertisers are not just interested in reaching readers but are also interested in the news itself - as it influences the perception of the ads and consequently the effectiveness of their advertisement campaign. In this setting, the more important the advertisement revenues are for the newspaper, the more biased the content becomes. If the platform's dependence on advertisement revenues is very strong, readers get the newspaper for free, but the accuracy of its contents decreases to a minimum level. Only if there is no advertisement, the news are reported unbiased. This changes in a duopoly market: newspapers compete so fiercely for readers that they are unable to bias their contents. If, however, advertisers can credibly threaten to withdraw their ads, newspaper will again resort to manipulating their contents to please advertisers.

Empirically, this result is confirmed by Reuter (2002), Reuter and Zitzewitz (2006) and Dewenter and Heimeshoff (2012). The latter use data from German car magazines and find that the likelihood of a car getting tested in one out of two German car magazines positively depends on the advertisement share of its manufacturer. Reuter and Zitzewitz (2006) use data on mutual funds and find traces of advertising influence on recommendations. The higher the advertisement share of the respective mutual funds gets in the magazine, the bigger the distortion. This influence is strongest in magazines focused on mutual funds. In those with a more general focus and are published more frequently (i.e. New York Times or Wall Street Journal), the advertising influence on contents is negligible. In an earlier work, Reuter (2002) finds that wine rating depend on the advertisement volume of the producer in the wine magazines. He uses data from two different magazines, but only one allowed advertisement.

Profit oriented bias is a feature of two-sided markets and not solely limited to media markets. In the latter, the need for unbiased news is obvious and the ethics of journalism ought to prevent newspapers to slant their contents. The same should be applied in sports - the events should be designed to let the best athlete or team win.

4.3 The ASP World Tour

The ASP World Tour is the World Cup of professional wave riders. It is organized by the *Association of Surfing Professionals (ASP)*. During the season, it is held in up to 13 different locations around the world. On average, 10 contests are held during a competition year, which normally begins in February and ends in December. Each single event has an unique winner and all participating surfers earn World Cup points according to their final ranking. The surfer with the most World Cup points at the end of the season will be crowned *ASP* World Champion.

Each stop of the tour is organized as a tournament itself. Surfers compete in pairs or triples in a segment of the competition called heat. In each heat, the surfers have twenty-five to forty-five minutes to take on a maximum of fifteen waves. Every wave they take on will be scored independently on a scale of 0 to 10 by five judges. The two best waves of each surfer are added up, and the one who garners the highest score at the end of the heat, wins. The official criteria of judging a wave are: commitment and degree of difficulty, innovativeness and progressive maneuvers, combination of major maneuvers, variety, as well as speed, power and flow (ASP, 2012a). These guidelines are applied to each wave surfed.

The winner of each heat competes against winners of other heats, and the victor of the final heat is the champion of the event, earning the highest prize money and the most points in the World Cup race. All other surfers also earn price money and World Cup points according to their ranking.

In its current setting, the first and the fourth round are three-men heats. The winner of the first round proceeds directly to the third. The winner of the fourth round goes directly to the quarter finals. The two losing surfers of the heat proceed to round two and five and compete against a different surfer. This format had become mandatory since the *Hurley Pro* in 2010. Before adopting this setup, only the first round was a three-man heat, with the winner proceeding directly to round three, while in round two the losers of round one compete against each other. In 2009, the event management could choose formats: either adopting the latter's setting of a three-man heat in round one, or two-man heats with the non-winning surfer leaving the tournament right from round one, and the best seated surfers placed directly in round two. Six out of ten events had chosen this format in 2009. Figure 4.1 in the appendix shows the structure of a typical event.

Two events are slightly different from the others. The *Rip Curl* Search changes its location every year. The *Billabong* Pipeline Master, which is traditionally the last event of the season and takes place in Hawaii, is also part of the Triple Crown Challenge. This tournament consists of three separate events and has an unique winner. In this paper, only the ASP World Tour event is considered, however, more surfers participate in this event. See Table 4.9 in the appendix for an overview of all the events considered in this study.

Surfers have to qualify for the ASP World Tour. The Top 22 surfers from the current season re-qualify automatically for the next season. The rest will be filled with the top surfers in world ranking, except those in the Top 22 which are already qualified. Surfers that are not participating in the World Tour can earn points for the world ranking through ASP prime events (ASP, 2013). Those events can be regarded as the qualifying series.

Every event has one major sponsor, thereby carrying its name (i.e. *Rip Curl Pro Portugal* or *Hurley Pro*). The ASP provides judges for the event, but the sponsor provides everything else. The structure of the event leans heavily on the very close relationship between the platform and its sponsor. The separation of organization and judgment intends to clearly distinguish between the outcome of the event and the advertisement market. Table 4.9 in the appendix gives a detailed overview of the events in this study.

The ASP World Tour is organized as a two-sided market. Each event has one main sponsor. The more appealing the surf contest is, the more viewers it can attract. Viewers on the beach or over the web-cast can watch the event for free. The sponsor finances the event and is, in turn, interested in reaching out to a big audience. They are also interested in seeing their surfer performing well. The sponsor therefore receives attention through the event and through their participating surfers. Thus, the performance of the surfer also affects, as in Ellman and Germano (2009), the way the advertisement message is received, and, therefore, also the profitability of advertisement expenditures of the sponsor.

Moreover, the judging of the waves does not underlie an objective benchmark. The performance of the surfers is rated independently by five judges. Therefore, there exists no objective benchmark to evaluate the true performance of surfers and the judges' decisions may be influenced by their personal experience and preferences. The final score, however, is the average of five independent decisions. Since the judges represent the platform and are provided by the same, the platform theoretically has a direct influence over the results, making the design of the contest vulnerable to bias.

4.4 Empirical Analysis

4.4.1 Data

To empirically test the influence of the event sponsor over the outcome of the event, data provided by the *ASP* is utilized. For each tournament, an overview table shows the structure of the event and the results of every single heat. This data is broken down by rounds and heats. The name, nationality and the garnered points of participants are listed.[4] Furthermore, information about the event sponsor, location, time, weather and wind conditions are also detailed in it (ASP, 2012b).

Table 4.1 shows how many events were sponsored by each of the main companies[5]:

	2009	2010	2011	Total
Billabong	4	4	4	12
Hurley	1	1	1	3
Quiksilver	2	2	3	7
Rip Curl	2	3	3	8

Table 4.1: Number of Events by Sponsor

The ASP provides the profiles of 45 surfers (for 2009) and the Top 34 surfers (for 2010 and 2011) qualified for the tour, which includes their detailed professional and personal background. The dataset comprises of 120 surfers who took part in the tour and who participated in at least one of the three years mentioned above. The dataset also includes 85 other surfers which were, for example, invited as wildcard participants in certain events. For surfers who were not part of the tour the whole time, information about them were researched and derived from their personal webpage, respective ASP regional web pages, or from their sponsor's website.

The analysis uses data from the ASP World Tour For Men from 2009 to 2011. This provides a total of 3,738 heat-based observations. Out of those, 31 cases of injury

[4] See Figure 4.1 in the appendix for an event sample.

[5] *Hang Loose* sponsors one event in Brazil in 2009.

transpired during their respective heat, so no points were given to them, rendering their individual observations unusable. This leaves 3,707 usable observations.

On average, a participating surfer garners 12.14 points per heat, whereas in both 2009 and 2011, the figure slightly rose to 12.3, but declined to 11.83 in 2010. On average, the winner of a heat beats his opponent by a margin of 3.25 points with a median of 2.57.

In 2009 and 2010, 48 surfers were listed in the ASP World Tour ranking (overall events), but due to a change of guideline, this number shrank to only 40 in 2011. 67 surfers are sponsored by one of the event sponsoring companies. The remaining surfers are sponsored by non-event sponsors such as Nike, Volcom, Rusty, Monster Energy Drink, Red Bull, O'Neil, Oakley, etc. About 14% of the heats were held in the home-base of the respective sponsor. On average, home-event surfers garnered 12.33 points per heat and have beaten their opponent by a margin of 3.40 points, although surfers not surfing at the home event of their sponsor achieved roughly the same with 12.11 points, and have beaten their opponent by 3.23 points.

The dataset comprises of different surfers competing at different events in various heats within each of the three seasons. Some surfers are qualified for the ASP World Tour for the entire period and have surfed in every event except when they are injured. Some are only qualified for a certain year, while others only surf at certain events. Within one event, a surfer can participate in up to eight heats. During the events, surfers get eliminated according to their performance, so ultimately, only two surfers get to compete in the finals to win the event. For each surfer, the result of every heat they participated in within the three-year period is observed.

Table 4.9 in the appendix gives an overview of all events used in the empirical analysis, listing the winner of the event, his sponsor, the number of participating surfers, the average points garnered and the event sponsor.

4.4.2 Empirical Strategy

The main hypothesis for the empirical analysis is that the major event sponsor has no influence over the results of the competition - that is, surfers sponsored, for example, by *Billabong* do not score better at an event sponsored by *Billabong*.

The identification of the effect of the sponsor over the results capitalizes on the fact that surfers qualified for the entire World Tour can be divided into two groups. The first group is sponsored by one of the four main event sponsors, while the second, by some other companies. Both groups are observed in different events, but only the first group could surf at events organized by their sponsor. Thus, the difference between the events is measured for both groups but also the difference between the groups. The difference between those differences is the effect of interest: The event dummies measure the difference between the events, while the dummy *Mainspons* (which is one if the surfer is sponsored by one of the four main sponsors) measures the difference between the groups. *Homeevent* is one when one of the surfers of the main sponsors participates at an event organized by its sponsor. The variable *Homeevent* identifies if surfers perform differently on the event of their sponsor as compared to other events.

This difference-in-difference approach takes into account the circumstance that numerous surfers are observed in various points of time. The fact that they surf on the events of other sponsors and their own sponsor makes it possible to measure the difference between the events. The second group, which is similar to the first group[6], accounts for factors between the events which cannot be attributed to *Homeevent* and to the influence of the advertisement market.

Surfers not qualified for the tour are pooled into off_tour. This separates surfers which attend the entire tour from those only surfing at certain events. Off_Tour_Home measures the effect of not qualified surfers, participating in an event organized by their sponsor. Through this, the variable of interest only captures the effect of qualified surfers. Not taking this into account could bias the results, as sponsors may give wildcards to surfers who fit the location or other purposes well. These surfers may score better because they were chosen for this event, and not because of some systematic influence the advertisement market possesses over the whole event.

Surfers from the country where the event takes place are identified by the variable *local*, to control for the possible advantages of being familiar with the spot and the surroundings. Hawaii is thereby treated as a separate country, and so is Puerto Rico. The United States are divided into three regions.

The variables $ThreeMenHeat$, *round* and *waveheight* control for both the structure of the event and factors specific to each heat. In some heats three surfers compete against each other and only one surfer emerge as the winner, thereby called $ThreeMenHeat$.

[6]The surfers in the second group are all qualified for the tour and are all sponsored by some company.

Round identifies the round of the tournament in which the heat takes place, while *waveheight* measures the average wave height within the competition date, as provided by the ASP. The *year* variable and the event dummies capture the time structure of the dataset. Those event and time specific variables also control implicitly for rule changes.

Finally, robust standard errors are used and clustered by each event to allow for unspecified intra-group correlation and control for possible heteroskedasticity.
For the analysis the main hypothesis - the main sponsor does not influence the outcome of the event - can be broken down into three testable hypotheses:

- H_1: The event sponsor has no systematic influence over the garnered points of the surfers.

- H_2: The event sponsor has no systematic influence over the likelihood to win a heat.

- H_3: The event sponsor has no systematic influence over the World Cup race.

H_1 and H_2 are at the heat level, while H_3 is at the event level. In the first two cases, the performance of surfers in a single heat is analyzed. For H_3 the data is aggregated to the event level.

The garnered points per heat are used in H_1. In the case of H_2, *win* is the dependent variable which is one if the heat was won and zero otherwise. Using a probit model the likelihood of winning a heat with a sponsor's influence is measured.

H_3 is addressed with an ordered probit model. The farther the surfer advances into the competition, the more points he garners for the World Cup race. In this analysis the influence of the advertisement market on the World Cup title is measured. The variable *max* is the round in which a surfer leaves the event. Event and heat specific variables like $ThreeMenHeat$, *round* and *waveheight* are dropped as they are only relevant on the heat level. The identification strategy, however, remains the same.

4.5 Results

Table 4.2 shows the result for the OLS regression. The dependent variable *pts* is the sum of the points from the best two waves each surfer took on in each heat.

Variable	2009	2010	2011	2009-2011
	pts	*pts*	*pts*	*pts*
Homeevent	0.18248	-0.03057	-0.14516	-0.09416
Mainsponsor	1.08640***	1.00645***	0.62944	0.91632***
Off_Tour_Home	-0.78681*	-1.33252	-2.04390*	-1.38946***
Off_Tour	-0.20451	-0.58613	-1.37755*	-0.69139**
Three Men Heat	-0.52493	-0.6687	0.03191	-0.17425
Local	0.36852**	0.43533	0.92826*	0.58530***
Event Dummy	yes	yes	yes	yes
Round Dummy	yes	yes	yes	yes
Year Dummy	no	no	no	yes
Constant	11.54621***	12.16177***	10.55307***	11.42231***
N	1159	1282	1266	3707
R^2	0.10735	0.14368	0.20265	0.11651

*** 1% level ** 5% level * 10% level

Table 4.2: Regression Analysis

Homeevent is not significantly different from zero in any of the years. The surfer from the four main sponsors, however, garner about a point more per heat on average, except in 2011 where this effect is smaller and not significant. Invited surfers, *Off_Tour_Home*, perform on average worse per heat. Surfers from the country where the event takes place achieve 0.59 points more, although in 2010, locals did not perform any better than other surfers. The fact that there are three surfers competing against each other shows no significant influence over the points.

H_1 cannot be rejected, event sponsor's surfers do not achieve more points as compared to other surfers. Surfers from either one of the four main sponsors do, however, garner higher points.

To win a heat, it is advantageous but not crucial to garner as many points as possible, only to end up having a higher score than the opponent. To favor certain surfers not the absolute score is important but to score better than the opponent in the respective event. The generated variable *wins* indicates if a heat had been won. The probit analysis tests whether the advertisement market has an influence over the likelihood of winning a heat.

Table 4.3 shows that H2 cannot be rejected, as surfers of the event sponsor perform not significantly better than other participants. In three-man heats, the likelihood to of winning decreases, as two surfers ultimately lose. Locals perform better, but only

Variable	2009	2010	2011	2009-2011
	wins	*wins*	*wins*	*wins*
Homeevent	0.141664	-0.134907	0.017814	0.005507
Mainsponsor	0.193824**	0.416580***	0.307421***	0.309279***
Off_Tour_Home	-0.306081	-0.292324	-0.663763**	-0.460371***
Off_Tour	-0.115342	-0.688341***	-0.526695	-0.349569**
Three Men Heat	-0.450401***	-0.544896***	-0.475004***	-0.478577***
Local	0.158711***	0.082838	0.149349	0.121052**
Event Dummy	yes	yes	yes	yes
Round Dummy	yes	yes	yes	yes
Year Dummy	no	no	no	yes
Constant	-0.114147***	-0.050432	-0.063551	-0.082740***
N	1159	1282	1266	3707
R^2	0.017893	0.048142	0.041877	0.033377

*** 1% level ** 5% level * 10% level

Table 4.3: Probit Analysis

in 2009 and over all years significantly. Surfers that were not qualified for the tour - *Off_Tour* - have a lower likelihood of winning a heat.

Once again, surfers of the four main sponsors perform better, that is, they have a higher likelihood of winning a heat as compared to other surfers in the tour. Surfing at the home event of its sponsor is not significantly different from zero in any of the years. Invited surfers *Off_Tour_Home*, however, have a lower likelihood to win a heat in 2011 and over all year. Table 4.6 in the appendix shows the marginal effects for the probit analysis.

Winning a single heat still does not necessarily have an impact on the World Cup race. The farther a surfer advances in each event, however, the more points he earns for the World Cup race. To analyze this, the data is aggregated to the event level. The generated dependent variable *max* indicates the round in which the surfer left the event, this is, when he either loses a knock-out round or emerges as the event's winner. This reduces the number of observations to 1,341 in the three years. Furthermore, heat specific variables such as *Three Men Heat* and *round* are left out due to the aggregation.

Table 4.4 shows the results for the ordered probit analysis. Again, surfers sponsored by one of the four sponsors leave the tournament at a later stage of the competition. This is significant in every year but not over all years. *Homevent* is again insignificant in

Variable	2009	2010	2011	2009-2011
	max	max	max	max
Homeevent	0.119107	0.227846	-0.056336	0.042837
Mainsponsor	0.310787***	0.243627***	0.462401***	0.333327
Off_Tour_Home	-0.341132*	-0.198842	-0.030223	-0.441957
Off_Tour	-0.784197***	-0.626558***	-1.309505***	-0.841199***
Local	0.114231	0.192022***	0.023764	0.126116
Event Dummy	yes	yes	yes	yes
Round Dummy	yes	yes	yes	yes
Year Dummy	no	no	no	yes
Constant	-1.199759***	-1.291553***	-2.097173***	-1.884132***
N	1341	496	432	413
R^2	0.047844	0.05626	0.050072	0.036896

*** 1% level ** 5% level * 10% level

Table 4.4: Ordered Probit

each of the observed years. While the whole group of event-sponsored surfers performs better, participating in their sponsor's event has no influence over the time they leave the event. Invited surfers, those sponsored by the event sponsor, left the event earlier, but this is only significant in 2009. Surfers who were not qualified for the tour performed worse in general.

Again, H_3 cannot be rejected. There is no evidence that the advertisement market has an influence over the round in which a surfer leaves the event and consequently on the World Cup race.

4.6 Robustness

The variable *Mainsponsor* separates the group of surfers, who get sponsored by one of the four main event sponsors from the other qualified surfers. The difference-in-difference approach uses this difference to control for factors that cannot be attributed to the variable of interest. Comparing the results of event sponsors' surfers in home events with other events, would fail to account for other unobservable differences in the events. As the second group of surfers are also sponsored by some other companies (non-event sponsors) and also had to qualify for the tour, it can be assumed that the same unobservable factors affect them in the different events as with the *Mainsponsor* group. This control group measures the effect without the change in sponsor.

Put differently, first the difference between the home events and the other events is measured. Second, the general differences in the events, measured by the control group, are subtracted. The identification of the variable of interest *Homeevent* therefore takes the separation of the two groups as given.

The selection of the surfers into the two groups, however, could be endogenous. The four main sponsors may generally invest more in surfing and draft the better surfers. Consequently, their surfers score better, not because they are under the wing of their sponsors, but rather, they were drafted by their sponsor for their talent and because of their track record in surfing. Nevertheless, the potential problem of endogeneity might be rather small, as all considered surfers had to qualify for the tour. Furthermore, all surfers are sponsored by companies active in the surfing (or sporting) business. But the variable *Mainsponsor* must still be interpreted with caution.

To check the robustness of the results, surfer-specific fixed effects for all qualified surfers are included. This, however, is inconsistent with the idea of difference-in-difference as the fixed effects interfere with the group effect; furthermore the group variable would be highly correlated to the fixed effects. Therefore, *Mainsponsor* is replaced by name dummies. All surfers that are not qualified for the tour are pooled under the dummy *off*.

Table 4.5 shows that the results for the variable of interest *Homeevent* remains qualitatively unchanged. It is not significantly different from zero in any of the years. The advertisement market still has no statistically significant influence over the results. *Off_Tour_Home* becomes insignificant in all years, meaning that this effect is captured by the fixed effects. Furthermore, the influence of *Local* in 2009 is not significant anymore.

The identification strategy for the likelihood to win a heat is identical to the previous analysis. Therefore, the same arguments apply. Here too, *Homeevent* stays unchanged insignificant for all and over all years. *Off_Tour_Home* also becomes insignificant (Table 4.7 in the appendix). *Local* and *Three Men Heat* remain fairly unchanged.

Same holds true for the ordered probit analysis, as shown in Table 4.8 in the appendix. No influence of the sponsor market on the results of the events is found. The effect of surfers from the same country where the event takes place also diminishes.

Variable	2009	2010	2011	2009-2011
	pts	*pts*	*pts*	*pts*
Homeevent	0.18684	-0.20842	-0.18107	-0.19041
Off_Tour_Home	0.19817	-0.17636	-1.59306	-0.46289
Three Men Heat	-1.09052**	-1.15931**	-0.2567	-0.49354**
Local	0.25146	0.43842	0.89894*	0.53964***
Name Dummy	yes	yes	yes	yes
Event Dummy	yes	yes	yes	yes
Round Dummy	yes	yes	yes	yes
Year Dummy	no	no	no	yes
Constant	12.47832***	13.50184***	10.77696***	12.53814***
N	1159	1282	1266	3707
R^2	0.21021	0.25912	0.27691	0.20146

*** 1% level ** 5% level * 10% level

Table 4.5: Regression Analysis with Name Dummies

Another problem associated with the difference-in-difference approach is autocorrelation, which might inflate the results (Bertrand et al., 2004). That is, with autocorrelation the influence can be overestimated and too often significant results are found. As no influence is found here, an overestimation would not be harmful as controlling for it would make the results even less significant. The outcome of seeing the sponsor market having no influence over the results of the ASP World Tour is even emphasized by this.

4.7 Interpretation and Implications

Surfers do not perform better in events organized by their sponsor. H_1 to H_3 cannot be rejected. This does not imply that there exists no sponsor influence in individual or isolated cases but that there is no systematic problem in general. Personal decisions of judges could be questionable but it is not a structural problem caused by the sponsor market.

This is in contrast to the theoretical findings of Ellman and Germano (2009) and the empirical results of Reuter (2002), Reuter and Zitzewitz (2006) and Dewenter and Heimeshoff (2012): A bias to please advertisers can be expected especially in monopolies with very close connection and dependence to the advertisement market. Three factors can be identified which may drive the result: transparency, competition for the sponsorship and impact on viewers.

Firstly, judgment decisions are taken much more frequently than e.g. rankings or tests in magazines. There are up to 13 events each year, with 7 to 8 rounds, 51 possible heats (averaging of 30 minutes each), and 36 surfers who are allowed to take on a maximum of 15 waves. The results are posted on the beach and online for webcast viewers. Furthermore, the heats can be replayed as videos on demand. Each of the judges' decision is observable and can be replayed without limits. Even though there is no objective benchmark to validate the points given by judges, supporters on the beach or on webcast are able to get an intuitive understanding of the judging. Commentators communicate their opinion about the points given by judges and surf magazines write about controversial decisions, making the judges' assessments comparable and easily auditable.

In comparison, the assessed magazines in Reuter and Zitzewitz (2006) varies in publication frequency - from daily to annually. In the case of New York Times (weekly) and the Wall Street Journal (daily) no influence was found. Reuter and Zitzewitz (2006) attribute this to their minimal share of advertisement from mutual funds. Another interpretation related to the results of this paper proposes that high publication frequency allows readers to better judge the recommendations (contents).

Readers can compare different recommendations, but it is more difficult to develop an intuitive understanding of the quality of the recommendations than to understand the points given to a wave. Similarly, to assess the quality of a car test (Dewenter and

Heimeshoff, 2012), a car magazine reader would have to drive different cars and redo these tests at least partially. In the case of bias on wine ratings (Reuter, 2002) this redo seems easier as only two or three wines have to be compared, but still the wines would have to be purchased, tried and compared to each other, which makes it more costly.

Additionally, the influence of the advertisers has to be assessed in all of those cases, perhaps not only in the current issue of the car or wine magazine but also over time. The effort a reader has to put in to distinguish a possible distortion of the results in favor of advertising clients is much bigger than that of ASP World Tour viewers.

Put differently, two information asymmetries are solved: First, viewers can evaluate the results almost as good as the platform can. This is not possible in the case of cars or mutual funds, the platform always knows better which car outperformed the rest in a test. Second, the sponsor of each event is clearly visible and the sponsors of the tour are also known. This makes the viewers easily able to detect impartiality to satisfy the interests of the sponsor.

The theoretical model by Ellman and Germano (2009) does not consider effects of repeated interaction between the consumer and the platform. They allow newspapers to build up reputation through a four stage game wherein newspapers choose their reporting strategy (first stage) before setting the copy price (second stage). In the third stage, readers decide to buy the newspaper, while in the final stage newspapers and advertisers negotiate over advertising price and quantities. Every stage is fully observable for the following stage, so newspapers commit to their reporting strategy before readers and advertisers decide. Other than this, the model has no dynamic component to it and cannot capture the effects caused by continuous repetition.

Moreover, a sponsor does compete for sole sponsorship of an ASP event. Ellman and Germano (2009) found that threats of withdrawing ads in a duopoly setting can make newspapers customize their content to please advertisers. The reason why an influence of the advertisement market over the results could be expected in the case of the ASP World Tour is that each event carries the name of one sponsor and that the sponsor is in charge of everything like organization, webcast, catering, etc., except of providing judges. In the three years considered, only one event was not sponsored by either *Quiksilver*, *Billabong*, *Rip Curl* or *Hurley*. In 2012, however, *O'Neil* joined as sponsor of an additional event. The event held in Brazil changed its sponsor from *Hang Loose* in 2009 to *Billabong* in 2010 and 2011, suggesting that an event's dependence on one certain company may not be as high. Competition for the sponsorship of events can reduce the incentive of distorting the results in favor of the advertisement market. Not only the competition between the platforms but also that between the advertisers can be crucial for the influence.

Finally, the damage done by the distortion of the results could be so severe that its monetary advantage can be eclipsed by the loss of trustworthiness of viewers, if not the viewers themselves. This is also considered in the model of Ellman and Germano (2009), where a minimal level of accuracy is defined at which the newspaper can keep a reader at a copy price of zero. If the distortion was stronger than even a copy price of zero would not be sufficient to attract readers. The model, however, does not predict full accuracy in that case.

Further Remarks

The results for *Mainspons* show that surfers of the four event sponsoring companies score better in the dataset. This, however, may not be a causal effect and should not be interpreted as a general problem or a hint of the sponsor's influence over the results. It shows, for example, that different companies pursue different strategies in drafting surfers. While *Billabong* and *Hurley* sponsor only a few surfers (5 and 4 respectively), *Quiksilver* and *Rip Curl* operate bigger surf teams with 18 and 29 surfers in the specified three years, suggesting that the goal of the latter is not to just sponsor the best, but a wide variety of surfers. Furthermore, other aspects such as free surfing and video appearances are also important, so they do not just sponsor the elite competition surfers. The same goes for other companies that do not sponsor an event. Here, the various strategies of the different companies can cancel each other out. Some of these companies may sponsor better surfers than those sponsored by say, *Rip Curl*, but through the aggregation, this effect vanishes.

Locals benefit from the proximity of the event and the possibility of spending more time on the spot, thereby familiarizing themselves with the area and different conditions in it. Motivation factor for these locals can also be high since the local press puts more emphasis on them. They may perform better since they have the advantage of being familiar with the spot and the circumstance of not having to travel far.

4.8 Conclusion and Outlook

The fact that a surfer surfs at an event organized by his sponsor has no statistically significant effect on the performance of the surfer. This shows that the surfers of certain companies do not systematically benefit from the cooperation of their sponsor with the platform. The effect found in e.g. wine and car magazines cannot be found here.

In general, the ASP World Tour as a two-sided market is similar in the structure to magazines but different in some other characteristics. Both the content itself and the influence of the advertiser are easier to observe. Furthermore, the judges' decision is easier to evaluate and validate as compared to the examples pertaining to car or wine magazines. Even though there is only one sole advertiser for each event, the threat of withdrawing sponsorship is highly unlikely, as there are other brands interested in subsequent sponsorship. And finally, the potential damage a distortion could result to in the audience market might be too severe. Within this study, however, it is not possible to determine which of the effects has the greatest importance.

Two-sided markets with strong advertisement dependence is open to the possibility of distorting contents to please advertisers. Even if the connection of the platform with the advertisers is very strong, this does not automatically lead to biased results as predicted by theoretical literature. Special features of the platform and the service it offers can prevent the use of influence from the part of the advertisement market to the other market.

Both media and sports rely on financial resources generated from advertisement and sponsorship. The ideals of sportsmanship and good journalism make it necessary to consider the influence of the advertisement revenues. The previous literature shows evidence of a distortion to favor of the advertisement market. In contrast, this paper cannot confirm this notion.

4.9 Appendix

Variable	2009	2010	2011	2009-2011
Homeevent	0.14166	-0.13491	0.01781	0.00551
Mainsponsor	0.19382**	0.41658***	0.30742***	0.30928***
Off_Tour_Home	-0.30608	-0.29232	-0.66376**	-0.46037***
Off_Tour	-0.11534	-0.68834***	-0.5267	-0.34957**
Three Men Heat	-0.45040***	-0.54490***	-0.47500***	-0.47858***
Local	0.15871***	0.08284	0.14935	0.12105**

*** 1% level ** 5% level * 10% level

Table 4.6: Marginal Effects

Variable	2009 *wins*	2010 *wins*	2011 *wins*	2009-2011 *wins*
Homeevent	0.130945	-0.208927	0.007963	-0.040702
Off_Tour_Home	0.028482	0.232949	-0.412279	-0.117586
Three Men Heat	-0.846871***	-1.113484***	-0.802990***	-0.710620***
Local	0.115031**	0.117446	0.174046	0.122704**
Name Dummy	yes	yes	yes	yes
Event Dummy	yes	yes	yes	yes
Round Dummy	yes	yes	yes	yes
Year Dummy	no	no	no	yes
Constant	-0.130889	0.393116	0.010722	0.085968
N	1159	1282	1266	3707
R^2	0.094787	0.143094	0.106835	0.09487

*** 1% level ** 5% level * 10% level

Table 4.7: Probit Analysis with Name Dummies

Variable	2009	2010	2011	2009-2011
	max	*max*	*max*	*max*
Homeevent	0.092283	-0.187707	0.009526	0.011691
Off_Tour_Home	0.194708	0.491702	-0.177132	0.040996
Local	0.128903***	0.087791	0.217562	0.119536
Name Dummy	yes	yes	yes	yes
Event Dummy	yes	yes	yes	yes
Round Dummy	yes	yes	yes	yes
Year Dummy	no	no	no	yes
Constant	-1.763697***	-2.141299***	-1.815968***	-1.339514***
N	496	432	413	1341
R^2	0.17598	0.164856	0.112045	0.117532

*** 1% level ** 5% level * 10% level

Table 4.8: Ordered Probit Analysis with Name Dummies

Year	#	Event Name	Sponsor	Country	# Surfers	ØPoints	Winner	Country	Sponsor
2009	1	Quiksilver Pro Gold Coast	Quiksilver	AUS	48	12.55	Joel Parkinson	AUS	Billabong
2009	2	Rip Curl Pro Bells Beach	Rip Curl	AUS	48	12.06	Joel Parkinson	AUS	Billabong
2009	3	Billabong Pro Tahiti	Billabong	PYF	50	10.71	Bobby Martinez	USA	Monster Energy Drink
2009	4	Hang Loose SC Pro 2009	Hang Loose	BRA	48	11.52	Kelly Slater	USA	Quiksilver
2009	5	Billabong Pro J-Bay	Billabong	ZAF	48	11.23	Joel Parkinson	AUS	Billabong
2009	6	Hurley Pro Trestles	Hurley	USA	48	11.62	Mick Fanning	AUS	Rip Curl
2009	7	Quiksilver Pro France	Quiksilver	FRA	48	11.75	Mick Fanning	AUS	Rip Curl
2009	8	Billabong Pro Mundaka	Billabong	ES	48	11.37	Adriano DeSouza	BRA	Oakley
2009	9	Rip Curl Pro Search	Rip Curl	PRT	48	11.46	Mick Fanning	AUS	Rip Curl
2009	10	Billabong Pipeline Masters	Billabong	HAW	64	11.75	Taj Burrow	AUS	Billabong
2010	1	Quiksilver Pro Gold Coast	Quiksilver	AUS	48	12.01	Taj Burrow	AUS	Billabong
2010	2	Rip Curl Bells Beach	Rip Curl	AUS	48	11.36	Kelly Slater	USA	Quiksilver
2010	3	Billabong Pro Santa Catalina	Billabong	BRA	48	11.65	Jadson Andre	BRA	Oakley
2010	4	Billabong Pro J-Bay	Billabong	ZFA	48	12.42	Jordy Smith	ZAF	O'Neil
2010	5	Billabong Pro Tahiti	Billabong	PYF	48	10.56	Andy Irons	HAW	Billabong
2010	6	Hurley Pro Trestles	Hurley	USA	36	12.26	Kelly Slater	USA	Quiksilver
2010	7	Quiksilver Pro France	Quiksilver	FRA	36	9.61	Mick Fanning	AUS	Rip Curl
2010	8	Rip Curl Pro Portugal	Rip Curl	PRT	36	11.05	Kelly Slater	USA	Quiksilver
2010	9	Rip Curl The Search	Rip Curl	PR	36	11.97	Kelly Slater	USA	Quiksilver
2010	10	Billabong Pipeline Masters	Billabong	HAW	48	9.90	Jeremy Flores	FRA	Quiksilver
2011	1	Quiksilver Pro Gold Coast	Quiksilver	AUS	36	11.46	Kelly Slater	USA	Quiksilver
2011	2	Rip Curl Pro Bells Beach	Rip Curl	AUS	36	11.88	Joel Parkinson	AUS	Billabong
2011	3	Billabong Rio Pro	Billabong	BRA	36	11.66	Adriano DeSouza	BRA	Oakley
2011	4	Billabong Pro J-Bay	Billabong	ZAF	36	11.52	Jordy Smith	ZAF	O'Neil
2011	5	Billabong Pro Tahiti	Billabong	PYF	36	12.24	Kelly Slater	USA	Quiksilver
2011	6	Quiksilver Pro New York	Quiksilver	USA	36	12.19	Owen Wright	AUS	Rip Curl
2011	7	Hurley Pro Trestles	Hurley	USA	36	13.01	Kelly Slater	USA	Quiksilver
2011	8	Quiksilver Pro France	Quiksilver	FRA	36	10.98	Gabriel Medina	BRA	Rip Curl
2011	9	Rip Curl Pro Portugal	Rip Curl	PRT	36	13.25	Adriano DeSouza	BRA	Oakley
2011	10	Rip Curl The Search	Rip Curl	USA	36	11.92	Gabriel Medina	BRA	Rip Curl
2011	11	Billabong Pipeline Masters	Billabong	HAW	48	7.78	Kieren Perrow	AUS	Rhythm clothing

Table 4.9: Descriptive Statistics of Data - Source: ASP (2012b)

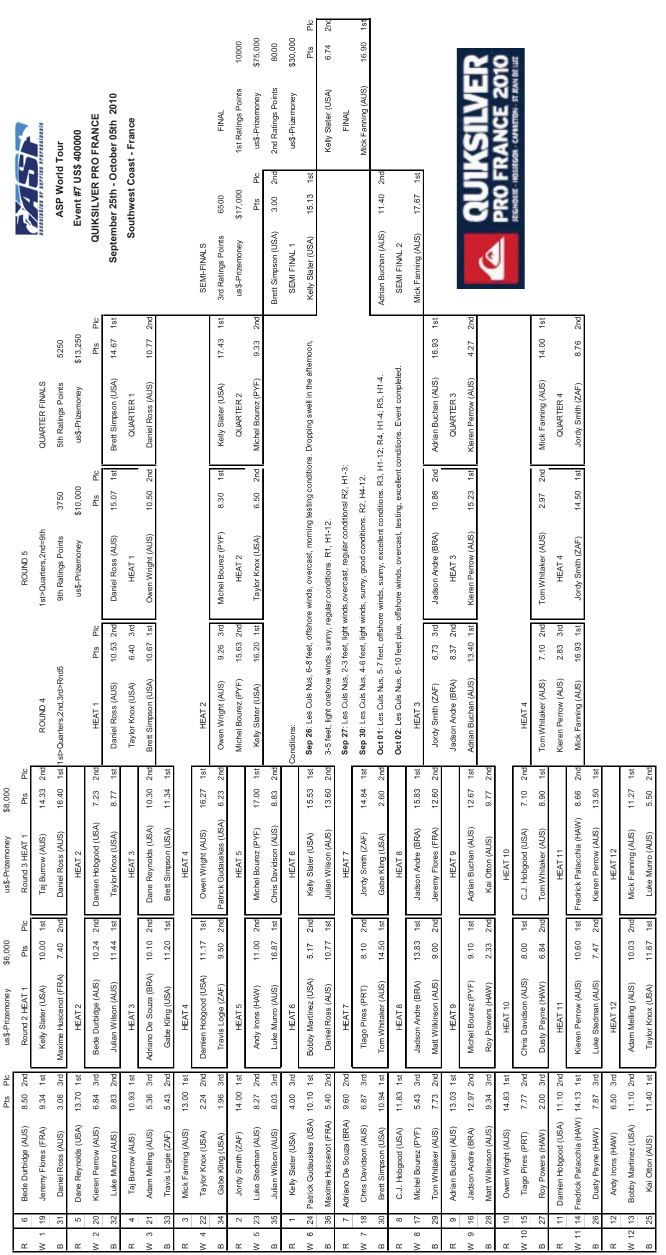


Figure 4.1: Quiksilver Pro France 2010 - ASP (2012b)

Part II

Energy Economics

Chapter 5

The Effects of Wind and Solar Power on Conventional Power Plants*

*This chapter is based on joint work with Veit Böckers and Leonie Giessing.

5.1 Introduction

European power markets are in transition towards a system based on low carbon generation. Prior to the introduction of renewable energy sources (RES), the generation mix of most countries consisted mainly of plants using coal, gas, oil, hydro and nuclear as the primary sources of energy, all of which are able to deliver power at a stable and reliable rate. The increasing public awareness on ecological issues, particularly the reduction of CO_2 emissions, forces power production to become greener and more sustainable. Regulations have been introduced to influence the choice of the primary energy resource.

Two types of policies set the stage for this more eco-friendly approach in the European electricity sector. The first is the introduction of a tradeable emission certificate system to internalize the cost of emission, the EU Emissions Trading System (EU-ETS). The second is the creation of support-schemes for power generation based on renewable resources, to incentivize the investment in more ecological power generation technologies. The European Union support framework sets a goal that at least 20% of the final energy consumption has to be covered by renewable energy resources by 2020. This analysis focuses on effects of renewable resources production promoted by out-of-market support schemes on market-based power generation.

Wind and solar are the most prominent renewable energy sources. Along with the regulated financial support, power production based on those RES usually also benefits from prioritized feed-in, guaranteeing them a permanent and secure revenue stream when they produce[2]. This is, operators of wind and solar power plants produce and sell power to the market whenever the wind blows or the sun shines. Even if prioritization were abandoned, near-zero marginal costs would still leave RES generation to be first feed-in, as all other technologies have at least the fuel costs to bear.

The need to take ecological issues into account is placed exogenously on power markets. This puts the competition among conventional power producers to the test. Conventional power plants have to incorporate the production of renewables. Their production decisions now also depend on the expected wind and solar power production. This may have a fundamental impact on the market design and security of supply.

This leads to a one-sided competitive relationship between conventional and RES power plants. RES production does not depend on the production decision of conven-

[2]Network operators can deny feed-in only for system reliability concerns.

tional power plants, but conventional power plants need to take RES production into account. Power production from renewables can be considered as an exogenous supply shock to the physical and commercial power system. The power market only has to cover the residual demand which is not already covered by renewable energy resources.

The effect of intermittent RES generation on conventional production and on the wholesale price of electricity is called the *merit-order effect*. The merit order of production ranks the available power plants in ascending order according to their marginal costs. The plants with the lowest marginal cost deliver power most of the time and are dispatched first. The higher the demand, the more expensive plants are utilized. Power price corresponds to the marginal costs of the last power plant that is still needed to cover demand. Power from renewable energy sources with prioritized feed-in and zero marginal costs will always be first to cover demand, leaving the conventional power plants competing for the remaining demand. Since RES production (like wind and solar) is intermittent, it cannot deliver a stable and reliable output because it is highly dependent on weather conditions; hence, it can have different effects on the merit order.

In theory, there is no clear cut answer as to which type of technology will be affected most. On the one hand, demand for power produced by conventional technologies is reduced, thereby also reducing the need to utilize power plants. The low marginal costs of RES production (or renewables) could therefore replace the most expensive peak plants. This would translate to lower power prices. On the other hand, demand for conventional plants is only reduced if the wind is blowing and the sun is shining, otherwise, the existing conventional plants will still be needed. The original merit order applies when there is little or no production from renewables and the merit order shifts to the right when they produce. Thus, the second effect of RES on the merit order is caused by its inherent unreliability. They do not reduce demand for conventional plants consistently, but depending on changing weather conditions. The residual demand, which has to be covered by the conventional power plants, is exposed to higher volatility. This reduces runtime and requires utilization of more flexible power plants. The most flexible plants, however, are also the most expensive plants in the merit order, which renders the lower marginal costs and less flexible plants to absorb the effect of renewables. If the output of RES generation is not high enough, mid-merit plants would be the most affected; baseload plants would still be needed to cover the steady demand; and flexible peakload plants would be utilized to balance the fluctuating production of wind and solar power.

Consequently, prices drop when RES produces and rise when the more flexible plants are needed.

We contribute to the current debate about the effects of support schemes for renewable energy resources by using data from the Spanish power market, to estimate the merit-order effect. We show the effect on the quantities sold to the wholesale market by the conventional production technologies during instances when renewable produce. We will also show how this influences the wholesale price. Hence, we take the merit order as the given structure and incorporate it into a structural vectorautoregressive (SVAR) model, i.e. we consider production of conventional power plants and price as endogenous and also take the time structure of the data into account. Wind and solar energy production are regarded as exogenous to the system, which reflects the current market situation with prioritized feed-in and support schemes.

We are able to identify and quantify the effect of wind and solar power generation on the wholesale price and on the quantities produced by each conventional power plant type, separately. This helps to understand how the current and future production mix is affected by the support schemes for renewable sources

The Spanish power market combines several characteristics which makes it very suitable for testing the merit-order effect. Renewable technologies need not compete in the power market as they are promoted through out-of-market support schemes. The energy production mix is made up by a large amount of RES production technologies, particularly wind and solar and the climate on the Iberian peninsula is very favorable for both wind and solar power production. Aside from this, the ample availability of data, especially on the production patterns of the different technologies, makes this analysis possible.

The rest of the chapter is structured as follows: Section two provides an introduction to the theory of power markets and the merit-order effect. Section three describes the Spanish power market. We then present the data used in section four prior to laying out the empirical strategy. The results are presented in section six. The analysis concludes in section seven.

5.2 Theoretical Background

To analyze the effects of intermittent production on the composition of the power plant fleet and the market design, we first provide a concise insight of the theoretical background of power markets to explain the merit-order effect. This is fundamental in understanding how non-market based RES production affects the mechanisms in the market, and in determining which conventional generation technologies will be affected most.

5.2.1 Peak-Load Pricing and the Merit Order of Production

Electricity has special characteristics which distinguishes it from other goods. It is a grid-bound good which is neither storable nor substitutable; its provision has physical limitations and its production has to equal consumption at all times. Furthermore, demand for electricity is periodic, varying substantially during the day and over the seasons of the year. Typically, demand reaches peak during the working hours of a weekday, but is relatively low during nighttime and on weekends. Depending on the geography and climate conditions, consumption patterns differ from summer to winter.

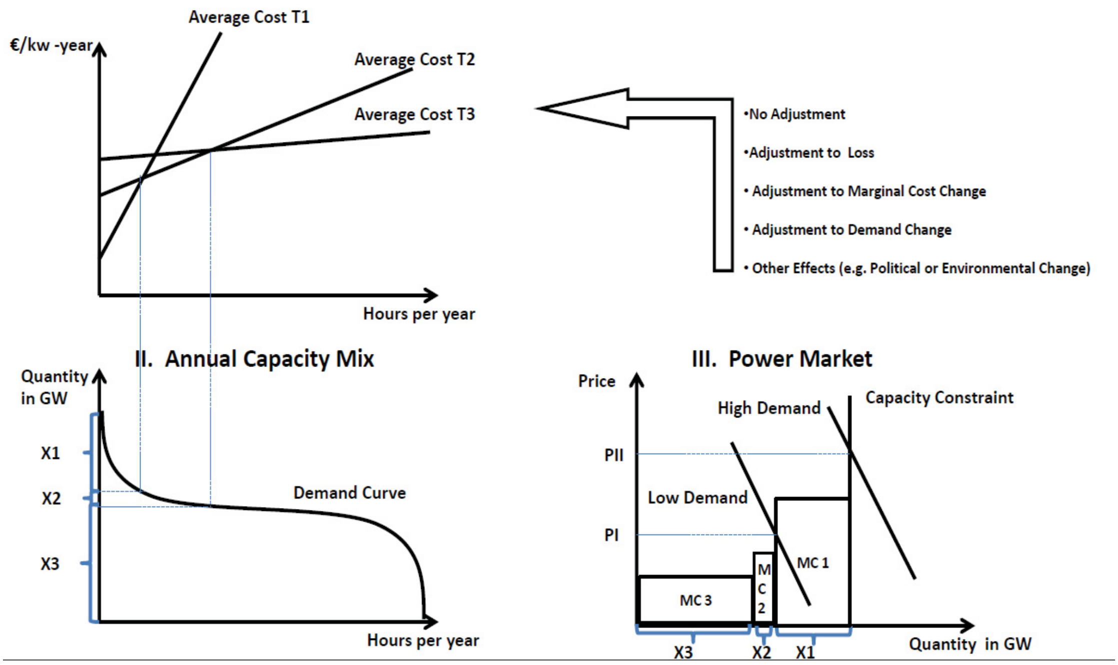
These features make power markets subject to peak-load pricing.[3] Crew et al. (1995) present a summary of the basic principle of peak-load pricing: Different production technologies are needed to satisfy the fluctuating demand. These technologies differ in marginal and fixed costs. The technology with the lowest marginal costs has the highest fixed costs, while the one with the highest marginal cost has the lowest fixed cost. Hence, technologies can be put in order according to their marginal costs. The cheapest technology serves any positive demand up to its capacity. The other technologies therefore, always have idle production capacities whenever demand can be at least partly covered by cheaper technologies. Hence, the price during peak-demand periods has to be such that it enables the most expensive production technologies to recover their variable and fix costs.

Ranking power plants according to their marginal costs is called merit order. In practice, the merit order consists of base-, mid-merit and peakload plants. Baseload plants usually consist of hydro, nuclear and lignite power plants, whereas mid-merit plants consist of coal-fired and combined-cycle-combustion gas turbines (CCGT). Peakload

[3] See Boiteaux (1960) and Williamson (1966) for some of the earliest works in this field.

plants usually consist of open-cycle gas turbines or plants fired with oil or gas. A cost overview and a confirmation of the chosen classification can be found in OECD (2010). The report covers the fixed and variable costs of a large set of production technologies and countries.

The merit order is not static, and adjustments in the power plant fleet take place constantly. Aside from the effect of renewable energy resources, various factors also affect the merit order. These adjustments are explained in a stylized example in the following figure.



Production Technologies T1, T2 and T3, Installed Capacities of T1 is X1, of T2 is X2 and of T3 is X3. Marginal Costs of Production for Technologies T1, T2 and T3 are MC1, MC2 and MC3. PI and PII indicate the equilibrium prices during low and high demand.

Figure 5.1: Static Optimal Capacity Choice and Peak-Load Pricing

An optimal capacity choice is made in a setting of perfect competition, merit order dispatch and a single-price auction. Three production technologies (T1, T2 and T3) are available to market participants. Based on the relationship between average costs and annual expected runtime of each production technology, an optimal plant mix for the provision of power exists. If the relative mixture of technologies is chosen optimally, its adaption to the expected yearly demand distribution yields a specific realization of the actual installed capacities (panel I and II).

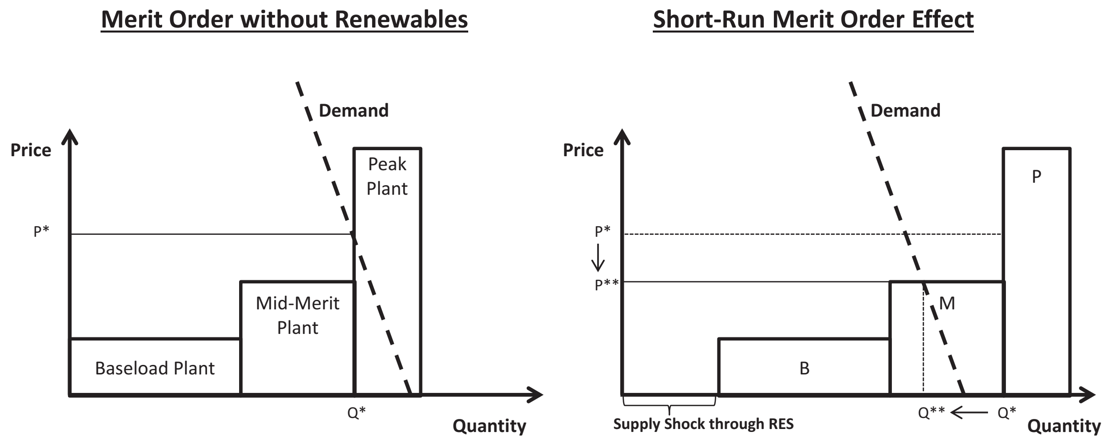
Given this capacity choice, market participants bid their available capacities into the market. The optimal bid is the respective marginal cost of the plant, if the level of competition is sufficiently high. Each time overall demand exceeds the individual capacity of a dispatched technology type, profits are generated for this plant type. During these times, plants will recover their annualized investment and fix costs. This creates a specific utilization of the existing production mix and price distribution (panel III).

Depending on this mechanism and factors such as policy changes, adjustments to the current power plant portfolio may become necessary (panel IV). This could lead to temporary or permanent shifts in the technology mix or even the crowding out of plants using certain primary fuels. For instance, a planned or unplanned plant outage is temporary and usually does not lead to a permanent change in the merit order. Changes in the variable costs can lead to either persistent or temporary alterations - so-called fuel switches - depending on the size and frequency of the fluctuations. In the energy market, variable costs mainly consist of fuel costs (input price plus transportation costs), ramping costs and, depending on the technology, costs of emission certificates. Possible fuel switches mostly occur between coal-fired and gas-fired power plants (Sunderkötter and Weber (2011) for a theoretical model and simulation). Persistent changes in the merit order can be caused by advances, such as process innovation or the development of a new production technology. Other reasons can include the depletion of a resource or the general prohibition of its usage (i.e. the nuclear phase-out in Germany).

5.2.2 Merit-Order Effect

The *merit-order effect* describes the effect of weather-dependent (intermittent) renewables on the wholesale power market, particularly on the composition of the plant fleet. The production of the most prominent renewable technologies, wind and solar, is dependent on the availability of wind and sun. As no other input factor is needed for production, the marginal costs are zero or near-zero. Hence, they are located at the leftmost part of the merit order (see Figure 5.2).

The production decision of renewables is not market based. Investment and feed-in are regulated and are independent from the market mechanism. To incentivize investment in RES technologies, different support schemes for renewable energies have been developed since the 1990's, varying widely in their character (Haas et al. 2008 and Haas et al. 2004 for an overview). These subsidies can be based on actual generation (per kWh) or on installed capacity. Sometimes also lower interest rates or tax credits are used to stimulate investment (Menanteau et al., 2003 and Haas et al., 2004). Support schemes can also be divided into price or quantity driven instruments. The former pays a fixed amount independent of the actual production, while the latter seeks to reach a desired level of generation. Most of these support schemes also allow technologies a prioritized feed-in of their generation. Consequently, the compensation of RES technologies is not market-based and the decision to produce and to invest does not depend on the conventional power plants' production decision. Hence, generation by renewables is independent from competition in the power market or from any other economic factors that should be taken into consideration by the conventional power plants. For conventional power plant owners, generation by renewables is an exogenous supply shock. Every time they produce, the demand which has to be covered by conventional plants is effectively reduced.



Base, Mid-Merit and Peak refer to the marginal costs of the respective production technology.

Figure 5.2: The Effect of Renewables on the Merit Order

The right side of Figure 5.2 shows the short-run merit-order effect as described i.e. by de Miera et al. (2008). Wind and solar power have zero marginal costs and are fed-in first; they shift the merit order to the right. Technologies with the highest marginal cost are crowded out, as they are no longer needed to satisfy demand. Price is also reduced as total demand becomes covered by cheaper technologies. Some empirical studies (such as Green and Vasilakos, 2010; the Spanish Renewable Energy Association, 2009; de

Miera et al., 2008; Sensfuß et al., 2008; Gelabert et al., 2011) find evidence for price decreasing impact of RES production.

The inherent weather dependence and unreliability of wind and solar power can, however, also affect mid-merit plants. The short-run merit-order effect only occurs when the sun shines and the wind blows, but this, as well, depends on the intensity of wind and solar radiation. The intermittent technologies reduce the demand for conventional power plants whenever the conditions are favorable, but conventional power plants have to cover the full demand, whenever wind and solar energy sources cannot produce. Put differently, the residual demand for conventional power plants fluctuates, depending on weather conditions and installed RES capacity.

The production of fluctuating renewables can therefore be interpreted as an increase in the uncertainty of demand for conventional power plants. Vives (1989) shows, in a general oligopoly setting, that firms tend to invest into more flexible technologies if there is an increase in basic uncertainty. This implies a shift towards more flexible and more expensive plants. The merit order shifts to the right whenever wind and solar power produce electricity and shifts back whenever they produce less or nothing. Depending on the magnitude of the RES feed-in baseload, plants can just be minimally affected as they still cover the steady demand. Mid-merit plants, which are more flexible, but still need sufficient runtime, can suffer the most, as peak plants can quickly adapt to different demand situations. In the long run, mid-merit plants may exit the market and the merit order may collapse to baseload and peak plants - which would, again, lead to higher power prices in periods without RES production.

Furthermore, the reduced number of price peaks affects all power plants. As the last power plant accepted in the auction to satisfy demand sets the price, all the other power plants to its left in the merit order earn a mark-up on top of their marginal costs. Baseload and mid-merit plants with relatively high fixed costs need a certain amount of high prices during the year and consecutive hours of runtime to cover the fixed costs. If peak load plants leave the market and the price level decreases, the profitability of all power plants in the merit order would also decrease. Also, the profitability of future investments in the power plant fleet will depend on the price level and will be influenced by this development.

Gelabert et al. (2011) conduct a study of the Spanish power market data. They analyze the effect of the Spanish *Special Regime* - which includes wind, solar, and other renewables, as well as smaller fossil fueled plants - on the wholesale price. The authors take into account the production of all other power plant types and find a negative price effect of renewables. The magnitude of the price effect, however, decreases over time. The quantity effect on the different production technologies is not considered.

Weigt (2009) could not confirm the crowding out of any specific conventional production technologies. Simulation studies by Bushnell (2011), Delarue et al. (2011) as well as Green and Vasilakos (2010), however, find the suggested switch to more flexible generation types as indicated by Vives (1989).

5.2.3 Market Design and RES

The merit-order effect also influences security of supply. Sufficient capacity needs to be ready to cover demand at any time. Power markets must provide investment incentives to attract the deployment of new capacities and to allow upgrade of existing plants. As the out-of-market support schemes influence the wholesale price and consequently the price signal to investors, it becomes questionable whether the energy-only market is capable of guaranteeing security of future supply.

Even without renewable energy sources it is unclear whether an energy-only market can attract sufficient investment. Cramton and Stoft (2005, 2006 and 2008) and Joskow and Tirole (2007) argue that the necessary number of high price spikes may not be realized. This so-called missing-money problem can lead to a permanent underprovision of installed capacity. To overcome this problem, it may be necessary to not only reimburse actual power production, but also the provision of capacity.

The increase of renewable power production is likely to intensify the missing-money problem. If either price peaks are cut or the runtime of power plants are reduced, the profitability of conventional power plants decreases. As conventional power plants are still needed to satisfy demand when there is little or no production by wind and solar, a market exit would jeopardize security of supply. Capacity payments can help keep essential plants in the market and attract sufficient further investment. The design of those capacity payments, however, can create other inefficiencies and disincentives (Böckers et al. 2011).

Another basic task of the market design is the production of cost-efficient energy. Out-of-market support schemes may also lead to inefficiencies in the technology mix.

Firstly, not letting the market decide which RES technology to support can lead to an excessive expansion of a certain technology type which is desired by policy makers; this, however, may not be the most efficient outcome in terms of achieving climate goals. Secondly, they lead to an adjustment in the remaining power plant fleet, but while the adjustment might be efficient under the prevailing conditions with renewable technologies, the resulting plant portfolio may nevertheless induce further costs.

Renewables have an impact on many aspects of the electricity wholesale market. We analyze which generation technology is affected by RES and to what extent. Quantifying this effect helps evaluate the market performance, renewable support schemes and the evolution of the security of supply.

5.3 Spanish Power Market

The Spanish wholesale electricity market consists of a day-ahead market, which is organized as a pool, and a number of intra-day and balancing markets. The pool is organized as a uniform-price auction with the bid of the most expensive power plant needed to satisfy the demand setting the price.[4] Although bilateral trading is possible, the majority of the electricity is bidden into the pool. In the period from 2008-2012, 61%- 69% were traded in the day-ahead market (OMIE, 2013 and REE, 2013a).

To meet the renewable energy targets set by the Spanish government and the EU, a support framework was established. The Spanish targets comply with the EU's goal of having at least 20% of the final energy consumption covered by renewable energy sources, by 2020 (Moreno and Garcia-Alvarez 2012). The legal promotion of renewable energy sources in Spain was initiated in 1980. The 'Law of the Electricity Sector' implementing the requirements of the European Directive 96/92/EC on the electricity market liberalization also established the *Special Regime*.

The *Special Regime* consists of renewable energy sources, conventional plants with a generation capacity of less than 50 MW and imports. It guarantees green power producers access to the grid as well as monetary support (Law 54/97). Royal Decree 2818 (RD 2818/1998) regulates the treatment of plants in the Special Regime and lays the

[4] On 1st July 2007 the Spanish and the Portuguese electricity markets were coupled to create the common Iberian electricity market, MIBEL (Mercado Iberico de Electricidad). Only the Spanish system is considered here.

foundation of the two support system currently in place.

The generators in the *Special Regime* can choose from one of two payment schemes which becomes binding for the following year. They can either opt for a time-dependent feed-in tariff (FIT), where generators receive a fixed total price per MWh fed into the grid, or bidding into the pool and receiving a feed-in premium depending on the market price. If the market price is too low, this so-called cap-and-floor system guarantees producers remuneration at floor level. If the market price exceeds cap level, the producer receives the market price itself. Between the cap and floor levels, the producer receives a premium on top of the market price. Additionally, the support levels in both payment schemes vary according to peak (8 a.m. until 12 p.m.) and off-peak (12 p.m. until 8 a.m.) times.[5]

Conventional power plants including hydro power plants with generation capacities of at least 50 MW are part of the so-called *Ordinary Regime*, and they either bid their power into the pool or trade bilaterally. To stimulate the construction of new production facilities and discourage the retirement of already existing plants, a system of administrative capacity payments was introduced. The so called *pagos for capacidad* was introduced in 2007 and it reformed the system in place since market liberalization. The underlying idea is to support the market mechanism to achieve the desired level of supply security. Depending on the current reserve margin, power plants receive a certain amount per installed MW for the first ten years of operation. The incentive decreases with an increasing reserve margin. If the maximum reserve margin of 30% is reached, the capacity payment will gradually decline to zero (Federico and Vives, 2008).

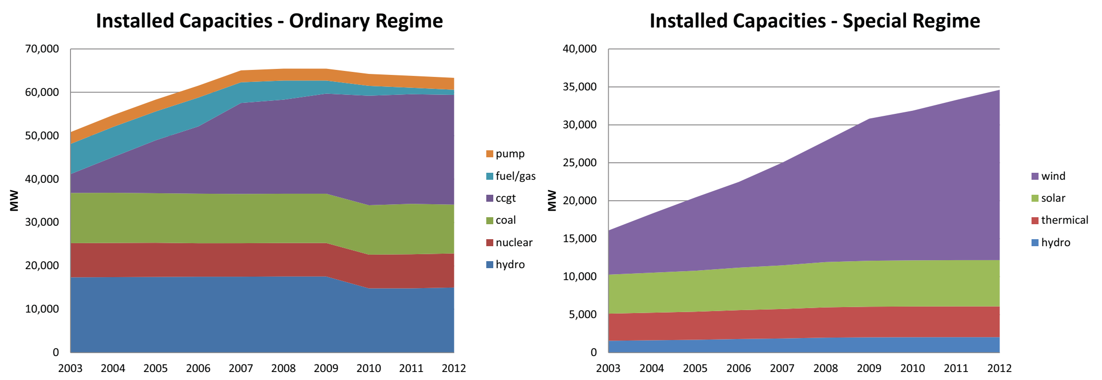
The generation mix in Spain has changed continuously since the liberalization in 1998 (see Figure 5.3). While the installed capacities of nuclear, coal and hydro power plants remained constant, those of fuel/gas plants declined over time; however, CCGTs and *Special Regime* installed capacities increased. The latter almost increased sevenfold - from 5,713 MW in 1998 to 38,953 MW in 2011 (Platts 2011), which is about 38% of the total installed capacities (REE 2009, 2013a).

Within the *Special Regime*, wind energy holds the largest share with 54%, but because of a reform in 2004 (RD 436/2004) solar energy production experienced signifi-

[5]For further information see RD 436/2004, RD661/2007, RD 1578/2008, RD 1565/2010 and RDL 14/2010. Detailed summaries and assessments of the Royal Degrees can be found in del Rio and Gual, 2007; del Rio Gonzalez, 2008 as well as del Rio and Mir-Artigues, 2012.

cant growth from 2006 to 2009. In a span of only two years (del Rio and Mir-Artigues, 2012) its installed capacity increased from 300 MW to 3,500 MW. The subsidies for solar generators almost tripled from €2.2 Billion to €6 Billion annually. Solar power producers received 40% of the total payments in the renewable support scheme, but it only accounted for 8% of its generation (Federico, 2011).

Figure 5.3 shows the development of both the *Ordinary Regime* and the *Special Regime*, in Spain. Hydro appears in both categories because small hydro plants with an installed capacity of less than 50MW are classified as *Special Regime*. CCGT power plants and wind power plants experienced the biggest growth. Note that the two graphs are scaled differently. *Special Regime* has now surpassed half of the installed capacity of the Ordinary Regime.



Source: Platts 2011, REE(2009,2013).

Figure 5.3: Installed Capacity for the Ordinary and Special Regime

5.4 Data

We analyze the Spanish power wholesale market from the period of 2008 to 2012. Data on Spanish demand, produced quantities[6] for each conventional fuel-type, i.e. nuclear, hydro, coal and gas, and generation from the *Special Regime* is publicly available. The latter is comprised of the production of solar and wind power as well as the generation of other renewable and non-renewable resources. We are, however, able to separate the

[6]Gas is subdivided into *cc*, which is a more efficient production type called combined cycle gas turbines, and *fuel/gas*, which includes the most expensive power plants running on either coal or gas.

Special-Regime generation in wind and solar and its other components. Furthermore, we use hourly electricity wholesale prices (OMIE, 2013 and REE, 2013a).

The installed capacities for each generation technology and the respective input prices are included as control variables i.e. prices for oil, gas, coal and uranium and European emission certificates (REE, 2009 and 2013; APX, 2013; Platts, 2011; Argus/McCloskey, 2013; UX Consulting, 2013; IEA, 2013; EEX, 2013). The input prices are available either on a weekly or weekday basis. Installed capacities are available on a yearly basis stated in MW (REE, 2009 and 2013).

Pooling all technologies in the Special Regime includes certain conventional and reliable plants (i.e., power plants with installed capacities of less than 50MW or RES technology such as biomass, which can deliver reliably). From this, we divide the *Special Regime* into its components: wind generation, solar generation and others. For wind data, we use the hourly wind forecast (REE, 2013a) and for solar data, we use the mean daily (actual) solar production[7] (REE, 2013) as there is no publicly available data on hourly solar production. To match the daily production of solar with the hourly data, we aggregate the data set to the daily average.

Spanish generation data supports the argument that wind and solar power have very low capacity credit. Their production depends on current weather conditions, so they cannot guarantee delivery at a reliable and stable rate. Very high production is followed by near zero feed-in. In 2012, the highest wind forecast in a single hour on record was 16,100 MWh while the lowest was only 174 MWh, which is less than 1% of the mean installed wind capacities, calculated on the basis of our dataset.

Table 5.1 shows the average, minimum and maximum wind forecast and solar production over the years. Production is measured in MWh and installed capacity, in MW. For both technologies, the difference between minimum and maximum production, as well as the mean production substantially fluctuates over time. This emphasizes the intermittent and unreliable character of those technologies.

Rainfall (measured in mm per m^2) and temperature are used as weather control variables (WeatherOnline, 2013). Solar and temperature are naturally higher correlated ($\rho = 0.49$) than solar and rain (*precipitation*), which are only weakly correlated ($\rho = -0.08$). The inclusion of temperature captures the effect of weather: higher temperatures are highly correlated with sunshine, but they may also affect conventional power

[7]Calculated as the sum of photovoltaic and thermal solar production.

Windforecast					
Variable	Mean	Std. Dev.	Min	Max	Inst. Cap. (MW)
2008	3,555.07	1,890.28	551.18	8,663.24	15,977
2009	4,086.87	2,159.91	597.94	10,471.94	18,712
2010	4,861.05	2,521.63	877.29	13,088.47	19,710
2011	4,736.95	2,572.58	941.53	12,013.12	21,091
2012	5,453.75	2,775.65	1,096.54	13,693.33	22,430
2008-2012	4,538.59	2,490.38	551.18	13,693.33	19,583 (Mean)
Solar production					
Year	Mean	Std. Dev.	Min	Max	Inst. Cap. (MW)
2008	275.05	135.39	83.33	541.67	3,628
2009	677.51	219.98	166.67	1,041.67	3,481
2010	778.88	309.95	208.33	1,416.67	4,189
2011	1,021.58	375.63	250.00	1,625.00	5,069
2012	1,297.36	465.38	333.33	2,125.00	6,218
2008-2012	810.05	470.64	83.33	2,125.00	4,450 (mean)

Table 5.1: Daily Windforecast and Solar Production

plants. Run-of-the-River Hydro plants, e.g., depend on the water level in the river; also other conventional plants use rivers for cooling. Not controlling for temperature would make the effect of solar generation biased, e.g. overestimating the effect of *solar* on *hydro*. The industry production index (OECD 2013) serves as Spain's economic performance indicator.

Table 5.2 gives an overview on the descriptive statistics of each variable used in our analysis.

Time Series	Variable Name	Obs	Mean	Std. Dev.	Min	Max	Source
Prices							
Power	Price	1827	47.12134	12.91916	2.466667	82.13042	OMIE(2013)
Oil	brent	1827	92.19025	24.57975	33.73	143.95	IEA(2013)
Gas	ttf_price	1827	20.42837	5.802648	7.2	40.1565	APX(2013)
Uranium	uxc_price	1827	52.51631	9.651544	40	90	UXC(2013)
Emission	eua_wprice	1827	9.446716	5.623614	0.015	16.865	EEX(2013)
Coal	coal_index	1827	104.4412	32.44161	56	224.75	PLATTS(2011),Argus(2013)
Quantity Sold at Power Exchange							
Hydro	q_hydro	1827	1588.825	901.0896	270.7	6472.296	OMIE(2013)
Pump	q_pump	1827	441.9877	287.1578	0	1407.283	OMIE(2013)
Nuclear	q_nuclear	1827	1593.403	653.9276	304.0917	5820.079	OMIE(2013)
Coal	q_coal	1827	1414.727	1079.746	0	5642.158	OMIE(2013)
CCGT	q_cc	1827	4778.429	2935.616	115.125	13200.96	OMIE(2013)
Fuel/Gas	q_fuel_gas	1827	528.4486	117.6727	205.5125	759.4125	OMIE(2013)
Demand							
Demand Power Exchange	q_demand	1827	22237.38	3337.577	13326.87	33503.61	OMIE(2013)
Special Regime Quantities							
Total Special Regime	specreg_actual	1827	9909.278	2818.552	4458.333	20166.67	REE(2013)
Power Exchange Special Regime	q_re_mercado	1827	10000.77	2656.686	4312.063	19861.38	OMIE(2013)
Wind Forecast	windforecast	1827	4538.593	2490.38	551.1765	13693.33	REE(2013)
Solar PV Total	solarpv_actual	1827	671.5015	316.9182	83.33334	1291.667	REE(2013)
Solar Thermal Total	solarthermal_actual	1827	138.5468	188.4821	0	833.3333	REE(2013)
Installed Capacities							
Hydro	hidro_inst	1827	14852.63	81.25765	14808	15014.72	REE(2009, 2013)
Pump	bombeo_inst	1827	2746.928	.1442007	2746.64	2747	REE(2009, 2013)
Nuclear	nuclear_inst	1827	7767.809	50.63277	7716	7852.98	REE(2009, 2013)
Coal	carbon_inst	1827	11408.85	152.5875	11247.61	11700	REE(2009, 2013)
Fuel/Gas	fuelgas_inst	1827	2272.678	1420.547	178.16	4401	REE(2009, 2013)
CCGT	cc_inst	1827	24106.2	1485.152	21677	25290.58	REE(2009, 2013)
Special Regime	especial_tot_inst	1827	33938.77	3541.956	28618	38884.52	REE(2009, 2013)
SR Wind	wind_spec_inst	1827	19582.89	2200.578	15977	22430.64	REE(2009, 2013)
SR Solar PV	solar_pv_spec_inst	1827	3685.364	422.1233	3207	4267.526	REE(2009, 2013)
SR Solar Thermal	solar_term_spec_inst	1827	764.902	681.7313	61	1949.97	REE(2009, 2013)
Other							
Precipitation	precipitation	1827	0.6109329	1.216827	0	15.875	Weatheronline(2013)
Temperature	temp	1827	18.70234	5.997503	5.334043	31.45833	Weatheronline(2013)
Industry Production	ind_prod	1827	84.97141	7.67428	75.28896	107.1877	NISS(2013)

Table 5.2: Descriptive Statistics of Data

5.5 Empirical Strategy

To estimate the effect of renewable generation on the wholesale price and the quantities produced by conventional power plants, the merit-order is used as the underlying structure. We endogenize each technology's produced quantity according to their rank in the merit order and the day-ahead price, in a structural VAR model. The quantity produced by each technology depends on the price and all the quantities produced by technologies to its left in the merit order. Production from renewable energies is treated as exogenous to the system. This reflects the current situation in Spain, with out-of-market support scheme for renewables. We also include demand, installed capacities, input costs for the different technologies, temperature and rainfall to control other exogenous influences not attributable to the effect of renewables. To capture seasonality and cyclic components, we include dummies for the days of the week (six), months (eleven) and years (four).

The six production technologies, in ascending order, based on their marginal costs, are: *hydro*, *nuclear*, *coal*, *CCGT*, *fuel/gas* and *pump* storage. *Hydro* and *nuclear* are baseload plants; *coal* and *CCGT* constitute the mid-merit order; and *fuel/gas* and *pump* storage are the peak plants. The ranking is based on information regarding the costs of power plants for the merit order from OECD (2010). The order is clear for most of the power plants. Fuel-switches mostly occur for coal and gas-fired plants as shown by Sunderkötter and Weber (2011), so we incorporate the change between the two technologies as a robustness check and change the order of *coal* and *CCGT* in an additional estimation.

Vector Y comprises the endogenous variables. X is the vector of demand-specific shocks as well as fuel-type specific input factors. The vector RES describes the quantity produced under the *Special Regime*:

$Y = (price, q_{hydro}, q_{nuclear}, q_{coal}, q_{ccgt}, q_{fuelgas}, q_{pump})$

$X = (Demand, Season, Installed\ Capacities, InputPrices)$

$RES = (SpecialRegime)$

The unrestricted VAR model therefore can be formalized as:

$$Y = A + BL(Y) + \Gamma RES + \Phi X + \epsilon \tag{5.1}$$

Figure 5.4 shows the underlying structure of the VAR model. The power plant with

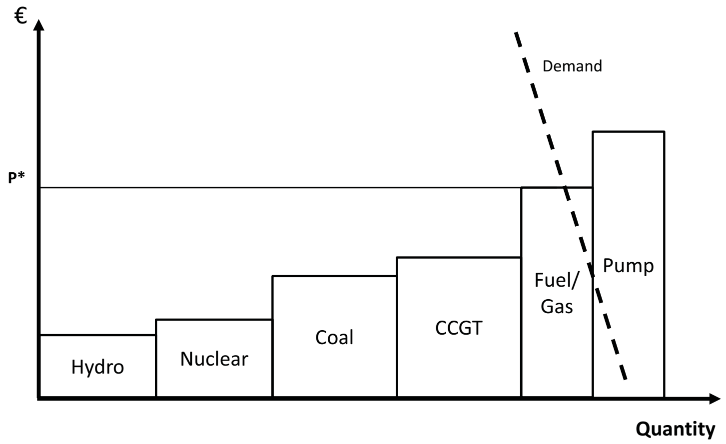


Figure 5.4: Merit Order

the highest marginal costs, which is still needed to cover demand, sets the price. All power plants to its left produce and earn money beyond their marginal costs.

This structure (Figure 5.4) translates into equations 5.2 to 5.8. Estimating the price equation, all technologies are relevant. The equation for each technology, however, only considers technologies on its left in the merit order. The coefficients of power plants, to its right in the merit order, are constrained to zero. For instance, the production decision of a nuclear plant is not directly affected by that of a coal-fired plant as it has higher variable production costs. The opposite is true for the coal plant. If the cheaper technologies are already covering the whole demand, then the coal plant will not be dispatched. To control for temporary shifts within the merit order, we include the input prices for all power plant types and the price for emission certificates.

The inclusion of the production of the aggregated *Special Regime* does not uniquely identify the effect of intermittent technologies. It also comprises of small conventional power plants and renewables which can produce comparatively reliable, like waste or biomass. To split the *Special Regime* into its components, we use the wind forecast instead of the actual production as for the bidding behavior of the conventional plants only the forecast, and not the actual production, is relevant (Jonsson et al., 2010). The same is true for *solar*, but since forecasts are not publicly available, we use the daily averaged actual solar production provided by the market operator.

$$\begin{aligned}
LnP_t &= cons_{pr} + \textstyle\sum_{i=1}^{k} \beta_{pr,1,i} LnP_{t-i} + \sum_{i=1}^{k} \beta_{pr,2,i} Hydro_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{pr,3,i} Nuclear_{t-i} + \sum_{i=1}^{k} \beta_{pr,4,i} Coal_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{pr,5,i} CCGT_{t-i} + \sum_{i=1}^{k} \beta_{pr,6,i} Fuel/Gas_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{pr,7,i} Pump_{t-i} + \Gamma_{pr} RES_t + \Phi_{pr} X_t + \epsilon_{pr,t}
\end{aligned} \tag{5.2}$$

$$Hydro_t = cons_h + \textstyle\sum_{i=1}^{k} \beta_{h,1,i} LnP_{t-i} + \Gamma_h RES_t + \Phi_h X_t + \epsilon_{h,t} \tag{5.3}$$

$$\begin{aligned}
Nuclear_t &= cons_n + \textstyle\sum_{i=1}^{k} \beta_{n,1,i} LnP_{t-i} + \sum_{i=1}^{k} \beta_{n,2,i} Hydro_{t-i} \\
&+ \Gamma_n RES_t + \Phi_n X_t + \epsilon_{n,t}
\end{aligned} \tag{5.4}$$

$$\begin{aligned}
Coal_t &= cons_c + \textstyle\sum_{i=1}^{k} \beta_{c,1,i} LnP_{t-i} + \sum_{i=1}^{k} \beta_{c,2,i} Hydro_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{c,3,i} Nuclear_{t-i} + \Gamma_c RES_t + \Phi_c X_t + \epsilon_{c,t}
\end{aligned} \tag{5.5}$$

$$\begin{aligned}
CCGT_t &= cons_{cc} + \textstyle\sum_{i=1}^{k} \beta_{cc,1,i} LnP_{t-i} + \sum_{i=1}^{k} \beta_{cc,2,i} Hydro_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{cc,3,i} Nuclear_{t-i} + \sum_{i=1}^{k} \beta_{cc,4,i} Coal_{t-i} \\
&+ \Gamma_{cc} RES_t + \Phi_{cc} X_t + \epsilon_{cc,t}
\end{aligned} \tag{5.6}$$

$$\begin{aligned}
Fuel/Gas_t &= cons_f + \textstyle\sum_{i=1}^{k} \beta_{cc,1,i} LnP_{t-i} + \sum_{i=1}^{k} \beta_{f,2,i} Hydro_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{f,3,i} Nuclear_{t-i} + \sum_{i=1}^{k} \beta_{f,4,i} Coal_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{f,5,i} CCGT_{t-i} + \Gamma_f RES_t + \Phi_f X_t + \epsilon_{f,t}
\end{aligned} \tag{5.7}$$

$$\begin{aligned}
Pump_t &= cons_p + \textstyle\sum_{i=1}^{k} \beta_{pu,1,i} LnP_{t-i} + \sum_{i=1}^{k} \beta_{pu,2,i} Hydro_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{pu,3,i} Nuclear_{t-i} + \sum_{i=1}^{k} \beta_{pu,4,i} Coal_{t-i} \\
&+ \textstyle\sum_{i=1}^{k} \beta_{pu,5,i} CCGT_{t-i} + \sum_{i=1}^{k} \beta_{pu,6,i} Fuel/Gas_{t-i} \\
&+ \Gamma_{pu} RES_t + \Phi_{pu} X_t + \epsilon_{pu,t}
\end{aligned} \tag{5.8}$$

$$q_{special\_regime} = q_{solar} + q_{wind} + q_{other_{SR}} \tag{5.9}$$

The short-run merit order effect is based on the guaranteed feed-in of renewables and their lower marginal costs. The higher volatility of the residual demand, which has to be covered by the conventional power plant fleet, is, in contrast, due to the dependence of wind and solar power on weather. To show the effect of the intermittent renewables, we use both the entirety of the *Special Regime* (Model I) and its components (Model II).

Power generation by conventional power plants is constrained by the installed capacity of the different technologies. Installed capacity is only available on a yearly basis and is included as exogenous variables. Since power plant construction is tedious and installed capacities do not fluctuate heavily, this might not be very restrictive.

Demand is assumed to be exogenous to the VAR system. This is common practice in power markets (e.g. Gelabert et al., 2011). Demand may not be entirely price inelastic, but not all customers are exposed to real time wholesale prices; and even those who are, can be quite inflexible. Households have habitual patterns of consumption and are not subject to real-time pricing[8] since they have fixed contracts with their energy suppliers. The tourism industry, an important sector in Spain, is also quite inflexible in terms of electricity consumption. Energy intensive producers, like a steel mill (wherein the cost of production is highly dependent on electricity price) may be able to react more flexibly to price changes. An interruption of production during peak-price times, however, may be more costly than continuous production. Stopping production will only be profitable for very high price changes. In our dataset, the average price change, compared to the preceding hour, is 3.20€/MWh with a standard deviation of 3.93, 50% of the price changes are smaller 1.98€/MWh and 99% of the price changes are smaller than 18.21€/MWh. The reaction to those price changes can therefore be assumed as rather small.

We also test for exogeneity of demand in the price equation using the Davidson and MacKinnon (1981) test.[9] The null hypothesis of exogeneity is not rejected. The test is based on an instrumental variable approach and is described in appendix 5.8.

Davidson&MacKinnon	Coef.	Std. Err.	t
Demand	.0000257	.0001469	0.17

Table 5.3: Exogeneity Test for Demand

Solar data is only available on a daily basis. Aggregating the production data to the daily level underestimates the effect of solar, as solar production depends on sunshine, which only occurs between sunrise and sunset. In a second estimation, we therefore

[8]Weighted by industry branches, the energy industry contributes 13.04% to the Spanish industry production; intermediate and capital goods impact the index by 37.7% and 20.64%, respectively. The rest constitutes non-durable and other consumer goods, 24.21% and 4.41% (NISS, 2013).

[9]The test is repeated for different specifications, the test results remain qualitatively unchanged in all settings.

only take into consideration the hours between dawn and dusk.[10]

Before estimating the model, all the included time series are tested for the existence of unit roots. We use the augmented Dickey-Fuller (Dickey and Fuller, 1979) and Phillips-Perron (Phillips and Perron, 1988) test (see appendix Table 5.8) and find that the price time series, the input prices (except for the price for uran) and the industry-production index are I(1) variables, thus we take the first differences of those variables, which are all found to be I(0). For the price time series we take the logarithm LnPrice which is also found to be I(0). For all other time series, the null hypothesis that the variable follows a unit-root process can be rejected. We used the results of Schwarz's Bayesian information (SBIC) and Hannan and Quinn Information Criterion (HQIC) for the lag order selection.[11]

We also used the Hannan-Quinn and the Schwarz-Bayes information criteria for the lag length selection of the whole VAR model. Eight and three lags, respectively, are found for the simultaneous lag length selection by the information criteria. From an economic point of view, a short lag length is preferable. As the dynamics over the year and during the week are captured by the seasonality dummy and we also aggregated the data to the daily level, only the previous days should have an immediate impact. Thus, for the reported results, the SBIC lag length is chosen; the result remains qualitatively unchanged for the higher lag order and is available upon request.

After estimating the restricted VAR model, we used the Lagrange-multiplier test (Johansen, 1995) to test for autocorrelation. We found some persistent autocorrelation in the residuals Newey and West (1987) standard errors are used to allow for autocorrelation up to a certain lag length. As proposed in Newey and West (1987), the lag length for the correction is chosen as the integer of $4(T/100)^{\frac{1}{4}}$ whereas T is the number of observations in the dataset. Results are robust to higher number of lags.

[10] Sunrise and sunset time is for Madrid (TheWeatherChannel.com, 2013).

[11] We also tested for cointegration of the endogenous variables. As only the price series is integrated of order one and all other time series (except the input prices) are I(0) the economic interpretation of the cointegration test is misleading. The fact that there exists one or several linear combination of the variables that is I(0) does not necessarily mean that they follow a common equilibrium path, when several of the time series are already I(0). Furthermore, we also take the logarithm of price which is found to be I(0).

5.6 Results

We are interested in the effect the exogenous variables *Special Regime* and *wind*, *solar* and *other RES* on the endogenous merit order. Table 5.4 reports the results for those variables in each of the seven equations. The first two columns show the estimated equation and the dependent variable in this equation. The other columns show the price or quantity impact of a 1-MWh increase of either *Special Regime*, *wind*, *solar* or *other RES* the respective equation. In model I the results for the whole *Special Regime* are reported. Model II shows the influence of the components of *wind*, *solar* and *other RES*.

Overall, the *Special Regime* decreases the price. A one MWh increase in *Special Regime* generation decreases the price by 0.003% - that's a decrease of 3% for an increase of one GWh. This effect is induced by *wind*. On the contrary, an increase in the production of *solar* and *other RES* increases the price.

The effect on the merit order is negative for all technologies but insignificant for *nuclear*. Again, *wind* is the driving force behind this result. An increase in *wind* energy production reduces the generated quantities of all technologies significantly - except for *nuclear* (model II). The results for *solar* and *other RES* are ambiguous.

	Model I	Model II		
Eq./ Dep. Var.	Special Regime	Wind	Solar	Other RES
(2) LnPrice	-0.0000306***	-0.0000318***	0.0000545***	0.0000160*
(3) Hydro	-0.0223019***	-0.0291984***	-0.0094671	0.0898763***
(4) Nuclear	-0.0004307	0.0000257	-0.047776	-0.0018914
(5) Coal	-0.0933551***	-0.0974866***	0.1093186	-0.0696695*
(6) CCGT	-0.1982958***	-0.3461214***	-0.2825958**	-0.1358050**
(7) Fuel/Gas	-0.0013968**	-0.0016611**	-0.0015485	0.0044956*
(8) Pump	-0.0183483***	-0.0196749***	0.0013187	0.0201682**
N	1824	1824	1824	1824

Level of Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 5.4: Impact of Special Regime and its Components

An increase of 1-GWh in *solar* production increases the price by 5.45%, whereas only *ccgt* plants are significantly affected negativ in the merit order. Also, 1-GWh increase decreases CCGT plants' production by 282.60 MWh. The same is true for *other RES*: the price increases with an increased production. Production by mid-merit plants, such as *coal* and *ccgt*, decreases; but *hydro* and peakload plants (*fuel/gas* and particularly *pump*,) benefit from more power fed-in by *other RES*.

Note that the model controls for the influence of temperature and rain. Aside from the effect of renewables, weather conditions can also cause fluctuations in the generation of conventional plants. A long drought could, for example, lead to lower water levels in rivers. This forces power plants to reduce their production as cooling water becomes scarce.

The effect of *solar* is contrary to expectations. Renewable generation reduces the demand which has to be covered by conventional power plants. Additionally, *solar* can only produce when the sun shines - which is mainly during peak hours, thereby cutting off price peaks. Figure 5.5 shows the price effect of one GWh increase of single RES generation technologies.

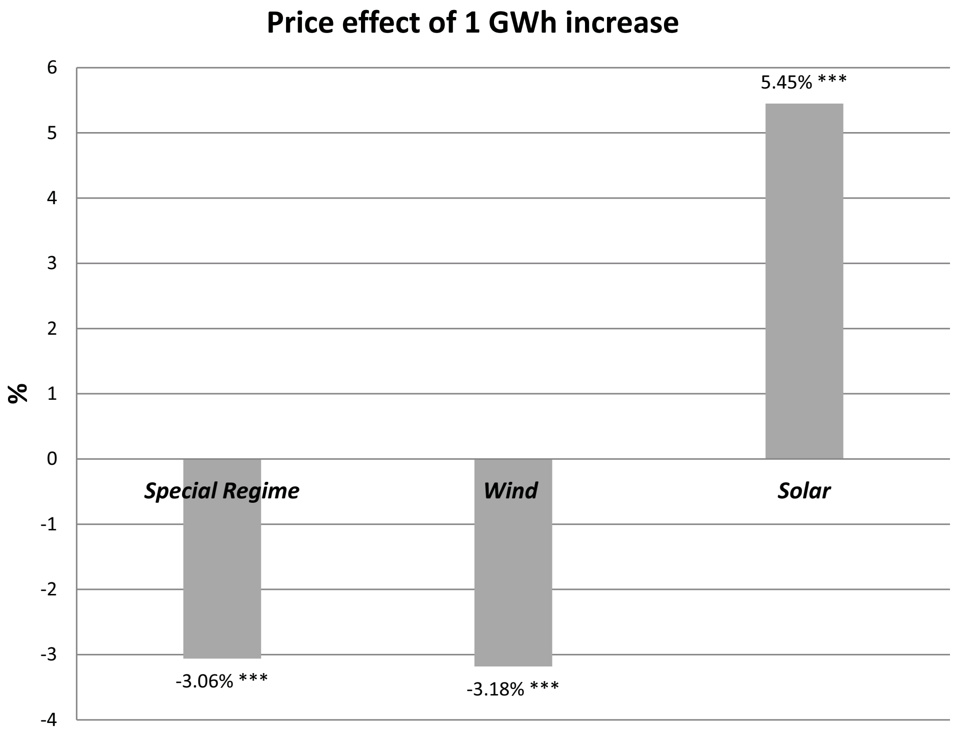


Figure 5.5: Price Effect of Renewables

The effect of *solar* is largest in magnitude and offsets the negative price effect of *wind*. An increase of 1 GWh, however, is relatively much larger and is more unlikely to happen for *solar* than for *wind*. The average production of *solar* over all years was 0.81 GWh, only in 2011 and 2012 did it reach an average production of over 1 GWh over the whole year (see Table 5.1). Thus, an increase of one GWh is equal to twice the current production. In the case of *wind*, an increase of 1 GWh constitutes only 22% of its average production in the specified five years, which is still a substantial but also a more likely increase.

Not all technologies are affected to the same extent. Figure 5.6 shows that in contrast to the prediction of the short-run merit order effect (e.g., de Miera et al. 2008), it is not the peak plants suffer the most, but the mid-merit plants. The prioritized feed-in of renewables effectively reduces the demand to be covered by conventional power plants, but baseload plants seem to be minimally affected if not totally unaffected; moreover, the flexible peak plants seem to reduce their quantities only to a small extent, which leaves mid-merit plants the ones absorbing the influence of renewable on the power market.

The positive price effect of *solar* cannot be explained by the effect on the merit order in Table 5.4. The production of *solar*, however, is only available on a daily basis. As we also aggregate the hourly production data and the price to the daily average, we underestimate the effect of solar power. *Solar* can only produce during daytime but the aggregated data on quantities produced and the price, also contains night hours when it is impossible to produce solar energy. Table 5.5 therefore shows the effect of *solar* during daylight hours.[12]

The effects for the whole *Special Regime* become more distinct during daytime, except for *fuel/gas* which is no longer significant; but *nuclear* now produces significantly less. The same is true for *wind*: the effect becomes stronger for most technologies as well as for the *price*, but the influence on *fuel/gas* diminishes during daytime. The aggregation to daytime is not very meaningful for wind power, but roughly coincides with the peak hours in Spain.

Interestingly, *solar* now affects *nuclear* and *ccgt* negatively and statistically significant, and the production of *pump* increases, when the feed-in by *solar* increases. This

[12]We took the hours between sunrise and sunset for Madrid for each day to determine the hours of possible production by *solar*. Before we aggregated the data to the daily level using all 24 hours, now we only use the daylight hours to aggregate data to the daily level. Note that we have data on quantities produced within the merit order and windforecast on a hourly base.

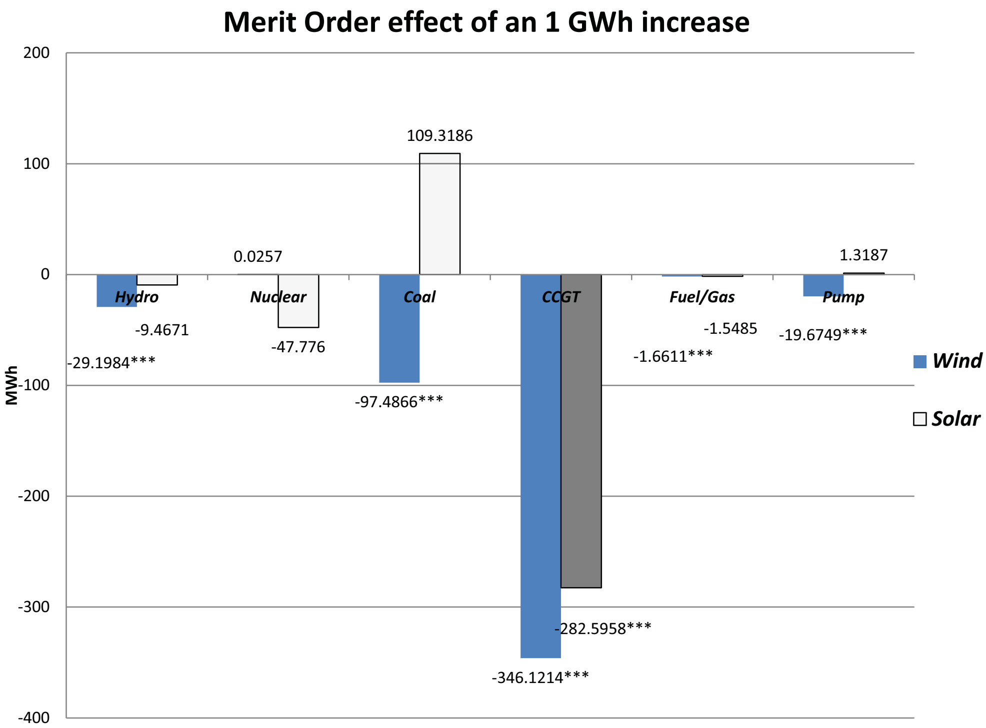


Figure 5.6: Merit Order Effect of Renewables

means that the mid-merit order, and to a smaller degree baseload, reduce their production because of daytime solar power production, making more expensive and more flexible peak plants benefit from the effect of unsteady generation.

The same is true for *other RES*, where the peak plants produce more, and the other plants in the merit order, except for *hydro*, reduce their production when generation increases. *Other RES* has been quite stable and predictable in production.

The results remain qualitatively unchanged for fuel switches between coal and gas-fired power plants (Sunderkötter and Weber 2011) and for higher order of lags.[13]

[13]Results are available upon request.

	Model I	Model II		
Eq. Dep. Var.	Special Regime	Wind	Solar	Other RES
(2) LnPrice	-0.0000398***	-0.0000454***	0.0000749**	0.0000467***
(3) Hydro	-0.0852349***	-0.1027663***	-0.1064387	0.2087144***
(4) Nuclear	-0.0145175***	-0.0030491	-0.3305512***	-0.1640257***
(5) Coal	-0.1607183***	-0.1502956***	-0.1011762	-0.3522494***
(6) CCGT	-0.2419864***	-0.4194985***	-0.4965494***	-0.2241564***
(7) Fuel/Gas	0.001901	0.0005658	0.0116572	0.0224018***
(8) Pump	-0.0304683***	-0.0385795***	0.1444175***	0.0654165***
N	1824	1824	1824	1824

Level of Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 5.5: Impact of Special Regime between Sunrise and Sunset

5.7 Conclusion

This chapter analyzes the impact of power generation, based on renewable resources, on wholesale power prices and conventional power generation in Spain. The data set contains information on daily averages of actual production and quantities sold at the Spanish power exchange from 2008 to 2012.

We estimate a structural vector autoregressive model, using the merit order as the underlying structure. The empirical evidence suggests that the merit order effect is not as simple as theory predicts. The main driver of renewable resources is wind power, which exhibits the expected negative impact on prices and on the quantities produced by conventional plants. On the contrary, solar power has a positive effect on wholesale prices.

Given the merit order of production, mid-merit plants are affected more than peakload or baseload plants. As the share of renewable energy resources is not yet large enough, baseload plants may not be affected as of now. The residual demand is still sufficiently large for those plants to run for most of the hours during the year. Peakload plants, on the other hand, may easily adapt to the higher volatility of the residual demand, leaving mid-merit plants to suffer the most from increasing RES production. If these findings still hold for higher shares of RES in power generation, then mid-merit power plants could be potential candidates for a market exit.

The Spanish market design already includes capacity payments for the availability of generation capacity. These could become insufficient, if CCGT and coal-fired power plants' runtimes continue to decline. If CCGTs will be crowded out in the long run, adjustments to the market design may be necessary, but this would depend on ecological goals, preferences regarding the power price and security of supply.

To guarantee security of supply, conventional power plants have to cover demand whenever unusual or unexpected weather conditions reduce wind and solar production to a minimum level. Depending on the weather condition, certain power plants may have to operate on standby for long periods during the year or even longer. Inability to cover full demand in times when production by renewables unexpectedly drops can lead to blackouts in situations of scarcity. As much as power production by renewable resources is ecologically desirable, security of supply is as essential for the industry and society.

In general, sophisticated capacity mechanisms might be necessary to complement energy-only markets to guarantee security of supply or to prevent certain technologies from leaving the market. This, however, leads to high costs of introduction and requires a European-wide change of the market design. Furthermore, this will also have substantial influence on competition (Böckers et al. 2011). While some markets like PJM in the United States have decided to implement a full-blown capacity market, the UK has abandoned such a mechanism. This unclear development of the different market designs will increase uncertainty, but since investments in power plants are, by nature, long term, investors will need a stable environment with little changes in market design.

The current support schemes often promote investments in certain technologies, independent of any inefficiency caused in the generation mix. The ultimate ecological goal is to reduce carbon emission and make power production more sustainable, not the promotion of certain production technologies. If conventional power plants are priced out of the market, problems inherent to the energy-only market (such as the missing-money problem) may be emphasized. Changes in the market design - aimed to stimulate investment in conventional resources or to prevent those technologies from leaving the market - may be necessary. These market designs are typically more restrictive and they induce higher costs to consumers.

5.8 Appendix

Test for exogeneity of Demand

Using demand and supply can cause simultaneous causality problem if demand cannot be considered exogenous to the supply system. As actual demand is mostly unobservable, equilibrium prices and quantities are considered for estimation. In equilibrium supply and demand are equal and a regression of quantities on prices will not help to identify whether the supply or demand function has been estimated. To solve the identification problem demand or supply specific factors are included. Since we are interested in estimating the price supply function, we estimate the demanded quantity. Important factors for demand are the economic performance of a country, e.g. energy-intensive industry, seasonal and temperature effects (REE 2013b) as well as exogenous demand shifters like holidays. Therefore, we assume demand to be a function of the price, past demand, economic factors, etc.:

$$D = F(price,\ past\ demand,\ economic\ factors,\ weather,\ season,\ holiday). \quad (5.10)$$

We use industrial production as an economic performance indicator, and average daily temperature, rainfall, and dummy variables for seasons and public holidays. The simultaneity bias also depends on the elasticity of demand. If demand was entirely price inelastic, the problem would be negligible. We estimate demand using:

$$\begin{aligned} D &= cons + \sum \alpha_d D_{t-i} + \alpha_y Year_y + \alpha_m Month_m + \alpha_j Day_j + \alpha_5 Ind\_Prod \\ &+ \alpha_6 temp + \alpha_7 Precipitation + \alpha_8 Holiday + residual \end{aligned} \quad (5.11)$$

To test for exogeneity of demand we use the Davidson & MacKinnon (1989) test.[14] The null hypothesis of exogeneity is not rejected (see Table 5.6); and since exogeneity is not rejected, we include demand in our estimation.

[14]The test is repeated for different specifications the test results remain basically unchanged.

Davidson&MacKinnon	Coef.	Std. Err.	t
Demand	.0000257	.0001469	0.17

Table 5.6: Exogeneity Test for Demand

Table 5.7: Results for Unit Root Tests - Daily

Variable	Dickey-Fuller (SBIC) constant	Dickey-Fuller (SBIC) trend	Dickey-Fuller (HQIC) constant	Dickey-Fuller (HQIC) trend	Phillips-Perron (SBIC) constant	Phillips-Perron (SBIC) trend	Phillips-Perron (HQIC) constant	Phillips-Perron (HQIC) trend
price	-3.359**	-3.413**	-2.892**	-2.939	-6.923***	-7.182***	-7.240***	-7.530***
lnprice	-5.814***	-5.870***	-4.674***	-4.719***	-9.886***	-10.006***	-10.224***	-10.359***
q_demand	-4.903***	-6.604***	-4.098***	-5.429***	-12.992***	-17.496***	-14.878***	-19.832***
solar	-2.871**	-3.706**	-2.384	-2.810	-4.901***	-7.931***	-4.936***	-8.352***
windforecast	-15.721***	-16.578***	-13.861***	-14.688***	-19.373***	-20.186***	-19.039***	-19.849***
q_other_REE	-3.963***	-4.962***	-3.963***	-4.962***	-23.915***	-27.865***	-23.915***	-27.865***
sr_total	-14.076***	-14.235***	-14.076***	-14.235***	-18.478***	-18.620***	-18.478***	-18.620***
q_hydro	-4.456***	-4.746***	-3.564***	-3.876**	-6.191***	-6.543***	-6.996***	-7.411***
q_pump	-5.152***	-7.884***	-5.152***	-7.884***	-19.401***	-25.858***	-19.401***	-25.858***
q_nuclear	-5.940***	-6.420***	-4.805***	-5.233***	-12.369***	-13.484***	-13.659***	-14.955***
q_coal	-5.232***	-5.240***	-5.097***	-5.116***	-13.892***	-14.244***	-15.912***	-16.325***
q_cc	-3.209**	-6.204***	-2.816*	-5.259***	-12.829***	-21.014 ***	-14.579***	-22.798***
q_fuelgas	-7.811***	-7.811***	-7.811***	-7.811***	-9.572***	-9.570***	-9.572***	-9.570***
brent	-1.299	-1.739	-1.299	-1.739	-1.283	-1.679	-1.283	-1.679
ttf_price	-2.683*	-2.895	-2.420	-2.664	-2.716*	-2.927	-2.571*	-2.784
uxc_price	-3.950***	-3.717**	-3.950***	-3.717**	-3.937***	-3.538**	-3.937***	-3.538**
eua_wprice	-1.840	-1.428	-1.840	-1.428	-1.819	-1.393	-1.819	-1.393
coal_index	-1.629	-1.624	-1.558	-1.550	-1.380	-1.390	-1.401	-1.412
d.brent	-42.031***	-42.027***	-42.031***	-42.027***	-42.031***	-42.027***	-42.031***	-42.027***
d.uxc_price	-10.626***	-10.711***	-10.626***	-10.711***	-42.803***	-42.867***	-42.803***	-42.867***
d.ttf_price	-26.921***	-26.922***	-26.921***	-26.922***	-43.701***	-43.694***	-43.701***	-43.694***
d.eua_wprice	-40.884***	-40.918***	-40.884***	-40.918***	-40.884***	-40.918***	-40.884***	-40.918***
precipitation	-18.188***	-19.004***	-4.120***	-4.449***	-21.449***	-22.324***	-29.968***	-30.019***
temperature	-4.023***	-3.991***	-4.023***	-3.991***	-4.649***	-4.623***	-4.649***	-4.623***
ind_prod	-1.128	-1.109	-1.128	-1.109	-1.126	-1.112	-1.126	-1.112
d.ind_prod	-30.222***	-30.224***	-30.222***	-30.224***	-42.714***	-42.713***	-42.714***	-42.713***

Null hypothesis: variable contains a unit root - level of Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 5.8: Exogeneity Test for Demand

Variable	Dickey-Fuller (SBIC) constant	Dickey-Fuller (SBIC) trend	Dickey-Fuller (HQIC) constant	Dickey-Fuller (HQIC) trend	Phillips-Perron (SBIC) constant	Phillips-Perron (SBIC) trend	Phillips-Perron (HQIC) constant	Phillips-Perron (HQIC) trend
price	-14.001***	-13.998***	-11.753***	-11.749***	-45.543***	-45.538***	-45.851***	-45.859***
lnprice	-43.038***	-43.063***	-13.588***	-13.607***	-43.038***	-43.063***	-43.038***	-43.062***
q_demand	-7.995***	-9.299***	-8.098***	-9.470***	-37.050***	-37.879***	-37.073***	-37.959***
solar	-16.329***	-16.324***	-12.265***	-12.323***	-40.487***	-40.481***	-37.195***	-37.187***
windforecast	-39.444***	-39.494***	-39.444***	-39.494***	-39.444***	-39.494***	-39.444***	-39.494***
q_other_REE	-35.705***	-35.715***	-11.859***	-11.897***	-35.705***	-35.715***	-38.455***	-38.439***
sr_total	-40.358***	-40.426***	-28.646***	-28.726***	-40.358***	-40.426***	-40.354***	-40.423***
q_hydro	-13.444***	-13.729***	-10.192***	-10.798***	-33.998***	-33.986***	-35.489***	-35.643***
q_pump	-34.157***	-34.172***	-34.157***	-34.172***	-39.752***	-39.752***	-39.752***	-39.752***
q_nuclear	-9.912***	-10.215***	-8.541***	-9.231***	-45.748***	-46.371***	-47.044***	-48.737***
q_coal	-13.519***	-13.531***	-7.692***	-7.742***	-39.002***	-39.008***	-38.855***	-38.859***
q_cc	-12.132***	-12.215***	-9.526***	-9.851***	-38.139***	-38.169***	-40.213***	-40.556***
q_fuelgas	-11.397***	-11.497***	-9.819***	-11.355***	-35.389***	-35.410***	-34.753***	-35.730***
brent	-1.299	-1.739	-1.299	-1.739	-1.283	-1.679	-1.283	-1.679
ttf_price	-2.683*	-2.895	-2.420	-2.664	-2.716*	-2.927	-2.571*	-2.784
uxc_price	-3.950***	-3.717**	-3.950***	-3.717**	-3.937***	-3.538**	-3.937***	-3.538**
eua_wprice	-1.840	-1.428	-1.840	-1.428	-1.819	-1.393	-1.819	-1.393
coal_index	-1.629	-1.624	-1.558	-1.550	-1.380	-1.390	-1.401	-1.412
d.brent	-42.031***	-42.027***	-42.031***	-42.027***	-42.031***	-42.027***	-42.031***	-42.027***
d.uxc_price	-10.626***	-10.711***	-10.626***	-10.711***	-42.803***	-42.867***	-42.803***	-42.867***
d.ttf_price	-26.921***	-26.922***	-26.921***	-26.922***	-43.701***	-43.694***	-43.701***	-43.694***
d.eua_wprice	-40.884***	-40.918***	-40.884***	-40.918***	-40.884***	-40.918***	-40.884***	-40.918***
precipitation	-18.188***	-19.004***	-4.120***	-4.449***	-21.449***	-22.324***	-29.968***	-30.019***
temperature	-4.023***	-3.991***	-4.023***	-3.991***	-4.649***	-4.623***	-4.649***	-4.623***
ind_prod	-1.128	-1.109	-1.128	-1.109	-1.126	-1.112	-1.126	-1.112
d.ind_prod	-30.222***	-30.224***	-30.222***	-30.224***	-42.714***	-42.713***	-42.714***	-42.713***

Null hypothesis: variable contains a unit root - level of Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 5.9: Results for Unit Root Tests - Daylight

Chapter 6

Oil Prices and Inflation: A Stable Relationship?*

*This chapter is based on joint work with Ulrich Heimeshoff and Heinz-Dieter Smeets.

6.1 Introduction

Commodity prices have been in the center of economic analysis for a long time, especially those related to energy production and consumption (see Kilian, 2008a and Hamilton, 2003, 2009 for overviews). Energy consumption holds an important share in the overall consumption in most industrialized countries. On average, households in Germany use about one third of their consumption expenditures for housing and energy.[1] Furthermore, crude oil, one of the most important commodities, is used in various forms for various purposes: for power generation, heating, and producing fuel. As a result, oil prices have serious effects on peoples' everyday lives and on the performance of several industrial sectors.

Another character of oil price is volatility, making it vary over time and differ from other prices. The time series shows sharp spikes in both directions as well as time periods characterized by very low volatility and corresponding stable price levels (Serletis, 2012).

Due to its economic importance, oil price also had significant effects on price levels in past periods. Since price level stability is the most important task of many central banks around the world, they need to carefully think how to react to increasing oil prices to stay within their set inflation targets. This became very clear with the increasing oil price that occurred before the start of the 2007 great financial and economic crises and its subsequent turbulences, as well as the increasing demand from fast growing countries such as China and India (see, e.g. OECD, 2011). In a recent study, Wurzel et al. (2009) estimate that a 10 US$ increase in the price of oil could reduce economic activity by two tenths of a percentage point and raise inflation by roughly two tenth of a percentage point in the first year after the shock and by another one tenth in the second year.[2]

For monetary authorities, however, it only makes sense to react to an increase in oil prices when there is a stable relationship between it and the general price level and when the effects had become sufficiently considerable. Since Hamilton (1983), it is well known that in many cases, only increases in oil price have significant effects on the economy as most recessions after World War II had been preceded by sharp increases of oil prices.

[1]See Statistisches Bundesamt (2010). Expenditures for housing and energy are summarized in one category by the German statistical office.

[2]The effects have been calculated using the OECD global model.

In contrast, there is less empirical evidence of positive effects of decreasing oil prices on the macroeconomy, which is usually found to be much weaker than effects of increasing oil prices. In a recent paper, Verheyen (2010) showed that the link between commodity prices and CPI inflation in the U.S. was much closer in the 1970s and 1980s than they are in the 2000s. Kilian (2008b) suggests that even in the 1970s, exogenous oil supply shocks are not a major reason for persistent inflation. His estimation is based on the dynamic effects of oil price shocks on CPI inflation over the post-1973 period. In their seminal paper, Bernanke et al. (1997) conclude that it is not oil prices that have caused negative effects on the economy, but the endogenous response of central banks accounted for most of the negative effects on economic activity.[3] Herrera and Pesavento (2009) find a decreasing influence of monetary policy during the so called "Great Moderation", mitigating the effects of oil price shocks.

Measures taken by central banks to countervail inflation have to be based on sound analysis. Monetary policy needs some time to take full effect. If the relationship between oil prices and the price level is not stable over time, a reaction of the central bank may come to nothing or even produce unintended effects. It would be detrimental to take mid- or long-term measures to counter the inflation caused by a temporary shock.

Credibility is very important for central banks, as their monetary policy measures are crucial for decision makers in financial and real markets. To a certain extent, hedge fund strategies, plants' location decisions, and even peoples' choices of when to buy a new home or new a car via credit financing depend on the measures taken by the central bank. It is therefore important for central banks to not only gain creditability, but to maintain it. The rules versus discretion debate (see Barro and Gordon, 1983) also support this notion. It emphasizes that unexpected monetary policy measures may just have temporary effects. Most central banks, therefore, commit themselves to a strategy focusing on price stability to reach the goal of permanent credibility. The Federal Reserve in the U.S. also takes general economic conditions into account.[4] Thus, frequent reactions on oil price fluctuations, which are often very hard to predict, would not be in line with central banks' efforts to keep their credibility. Taylor (1993) phrases:

[3] Other authors doubt these results (see e.g., Carlstrom and Fuerst, 2005 as well as Kilian and Lewis, 2011).

[4] In the aftermath of the financial crisis in Europe the European Central Bank also considers the state of the economy much stronger than the German Bundesbank and even the ECB itself did it in former years.

"Operating a monetary policy in the face of an oil-price shock is difficult and deserves particular study."

If central bank's announcements are not at least, to a certain extent, predictable, they may lose public trust. Thus, depending on the state of the economy, central banks only act in the aftermath of very considerable oil price shocks (Taylor, 1993).

Hence, it is important to take the time structure of the relationship between oil prices and inflation into account and adjust policy accordingly. The aim of this paper is to analyze the dynamic interrelationship between oil prices and the price level in Germany over time. To test for the possibility of unstable relations, we use rolling windows to perform Granger causality tests using the basic oil price series and shock variables to allow asymmetric effects of positive and negative changes in oil prices in our sample. Our results show that the relationship between oil prices and the price level is by no means stable over time. Periods when the price of oil Granger-causes the aggregated price level are followed by periods without any statistically significant relationship.

6.2 Methodology

6.2.1 Estimation and Testing

Our analysis is based on a Vector Autoregressive (VAR) Model, which captures the monetary side of the economy.[5] The model takes the form:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_3 y_{t-3} + Det. + u_t, \quad for \ \ t = 1 \ , ..., T. \tag{6.1}$$

The vector y_t is defined as follows:

$$y_t = (oil_t, p_t, M3_t) \,, \tag{6.2}$$

where oil_t is the monthly oil price, p_t is the monthly German price level, and $M3_t$ is the aggregated German money supply, also on a monthly basis. We are primarily interested in the effects of oil price changes on the price level, but we also include money supply

[5]VAR-models and Granger-causality tests are two of the most used instruments to analyze effects of oil price shocks as well as monetary policy effects in general. A survey of the most common approaches applied in the analysis of monetary policy effects can be found in Walsh (2010).

to take into account possible measures taken by the central bank to changes in oil prices. The vector u_t includes unobservable errors following the usual assumptions (Lütkepohl, 2004: 88). *Det.* includes deterministic variables.[6]

Feedback from the macroeconomic variables to oil prices is negligible, as Germany is a small open economy compared a country like the United States. Kilian and Vega (2011) have also shown that even for the U.S., energy prices in general and especially oil prices can be treated as predetermined variables in the short run. Thus, by using monthly data for a small economy and by following Kilian and Vega (2011), our analysis is not likely to suffer from identification problems.

Our analysis proceeds in three steps: First, choosing the lag order of the VAR model based on information criteria and commencing with Granger causality tests for the whole time period.[7] In the second step, using rolling windows of 48 months' of data to allow for variations in Granger causality between the variables over time.

After applying unit root and cointegration tests to our data, we find that all variables are integrated of order one and are also cointegrated. Granger causality tests in cointegrated VARs are somewhat different from testing in standard VAR models, as the usual Wald statistic cannot be used. Toda and Philips (1993 and 1994) have shown that the standard Wald statistic is not consistent when a cointegration relationship exists. To overcome the problem, Toda and Yamamoto (1995) suggested a simple solution: estimating the underlying VAR(p) model for the lag order p+1. This modification restores the distribution of the test statistic, making standard Wald tests applicable again.

In the third step we decompose the oil price series into positive and negative shocks following Hamilton (2003) and Engemann et al. (2011). The definitions of positive and negative oil price shocks are as follows:

$$shock\_pos_t^+ = \max\left[0, 100 \times \ln \frac{x_t}{\max\left(x_{t-1}, ..., x_{t-6}\right)}\right] \tag{6.3}$$

$$shock\_neg_t^- = \min\left[0, 100 \times \ln \frac{x_t}{\min\left(x_{t-1}, ..., x_{t-6}\right)}\right] \tag{6.4}$$

Using this method, we calculate the magnitude of shocks within the oil price series.

[6] As deterministic variables a time trend and eleven monthly dummies are included to control for factors not attributable to movement of the endogenous variables.

[7] See Hamilton (1994) for a description of these procedures.

The first shock variable only includes positive oil price shocks, while the second, negative ones. Only substantial price changes are considered as a shock, that is, when the price is higher or lower than every monthly price in the past six month.

It is important to distinguish between positive and negative oil price shocks. Earlier empirical literature shows that only positive oil price shocks have significant (negative) effects on economic activity. To analyze oil price shocks, the log change of oil prices was originally used as a symmetric shock variable (Hamilton, 1983). In the more recent literature, Hamilton (1996) and (2003) assumes that oil price shocks are asymmetric and nonlinear. In Hamilton (2003), a shock is defined as a substantial price increase, that is, if the current price is higher than the previous year's maximum. He uses quarterly data and defines a shock, when the current price is higher than the last four previous prices.

To decompose the price series of oil into positive and negative shocks, we generally follow Hamilton's (2003) method but define the magnitude of a shock according to that of Engemann et al. (2011), wherein we also have chosen six months as the reference point, since according to them, the price must be higher or lower than every price in the previous six months to be qualified as an oil price shock.

We include the shock variables in our basic VAR, which now takes the following form:

$$x_t = B_1 x_{t-1} + B_2 x_{t-2} + ... + B_p x_{t-p} + e_t, \quad for \;\; t = 1 \;, ..., T. \tag{6.5}$$

The vector x_t includes four variables

$$x_t = \left(shock\_pos_t^{+}, shock\_neg_t^{-}, p_t, M3_t \right). \tag{6.6}$$

We adjust our basic VAR from step one (Equation 6.1) and replace the oil price time series by our two shock variables. For the error term e_t we assume the standard properties again. We run Granger causality tests using the shock variables for the whole sample as well as the rolling window methodology to test if the interrelationship between the price level and oil price shocks changes over time.

The shock price variables are, by definition, stationary variables, which we include in levels in the VAR model (Equation 6.5). The VAR model is estimated using lag orders calculated by information criteria. As a result of the time-series properties of the shock variables, there is no cointegration relationship between the shock series and the price level.

6.2.2 Data and Variable Construction

The aim of our study is to test for potential changes in the interrelationship between oil prices and the price level in Germany. Therefore, we use the longest monthly times series we could obtain for our variables. The dataset starts in January 1970 and ends in August 2010[8]. All variables are included in the logarithms.

First, we tested for unit roots in the time series (in logarithms) using Augmented-Dickey-Fuller (1979) as well as Philips-Perron (1988) tests. All series in our dataset, including the logarithm of prices, are found to be integrated of order one, excluding the shock variables.[9]

Second, by using the Johansen trace test, we show that there exists a cointegration relationship between the oil price, price levels and the money supply $M3$. Hence, there is a long run equilibrium relationship between the variables, meaning that they return to a common equilibrium path in the long run.

Rank Test (Johansen)			
Eigenvalues	0.328	0.014	0.003
Hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace Test	201.500	8.223	1.550
p-values	0.000	0.763	0.384
LR-Test (weak exogeneity)			
Rank	oil_t	pn_t	$M3_t$
1	0.195	131.029***	58.201***
LR-Test (variable exclusion)			
Rank	oil_t	pn_t	$M3_t$
1	3.385*	44.435***	61.033***

Level of Significance: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 6.1: Cointegration Test

[8]Monthly oil price is the West Texas Intermediate taken from St. Louis Fed (2011), unadjusted monthly price level and monthly money supply $M3$ for Germany from Ecowin (2011).

[9]The results can be found in Table 6.4 in the appendix.

To further analyze this long-run relationship, we conduct a likelihood ratio test (Juselius, 2006) to test for weak exogeneity. Taking $rank = 1$ as given, the null hypothesis that the oil price is weakly exogenous cannot be rejected (see Table 6.1). The test, however, clearly rejects the weak exogeneity for the price level and $M3$. This means that the oil price influences the long-run relationship but the adjustment to the long-run equilibrium is mainly driven by the price level and money supply. Testing for exclusion of the oil price shows that the null hypothesis that exclusion is possible can be rejected at the 10% level. This shows that the price level and the money supply are the main drivers in the long-run equilibrium path; however, there is no clear cut evidence that the oil price is not necessary for the cointegration relationship.

6.3 Results

6.3.1 Granger Causality Tests

We start our analysis with a standard Granger causality test based on our three variable VAR using the whole sample (see Hamilton, 1994: 302-307, for a detailed discussion of the methodology). The Akaike and the Hannan-Quinn information criteria are used to calculate optimal lag orders (see Lütkepohl, 2005: 148-153) which is found to be two. As reported in the methodology section, we estimate the VAR model using a lag order one unit higher than estimated by information criteria to get valid Wald test statistics. Hence, following this approach by Toda and Yamamoto (1995) we use three lags for estimation of the VAR model.[10]

We do not report the VAR results, only the Granger causality tests.[11] The latter are based on the original lag length. The results of the test are reported in Table 6.2.

The Granger causality test shows that for the whole sample period, oil prices on average do not influence price levels and money supply in the sense of Granger's definition. The null hypothesis of no causality is not rejected (see Table 6.2).

Next, Granger causality tests, using rolling windows are applied. This gives a more detailed picture of the dynamic interrelationship between oil price and the price level,

[10]To control for possible autocorrelation we use Newey and West (1987) standard errors, which allow to control for autocorrelation up to a certain number of lags. Lag length for autocorrelation correction is chosen to be $4(T/100)^{\frac{1}{4}}$ with T being the number of observations in the dataset (Newey and West, 1987).

[11]The estimation results for all VAR models are available from the authors upon request.

$oil_t \rightharpoonup$		
Variable	pn_t	$M3_t$
χ^2	9.58	0.84
$P > \chi^2$	0.002	0.3588

Table 6.2: Granger Causality Test

as well as oil prices and money supply. We use windows of data spanning four years (48 months) and test for Granger causality in every sub period. Results are reported in Figure 6.1. If the price of oil in the preceding period was Granger causal, then the pink line takes the value one and zero if otherwise. The preceding 48 months are then additionally shaded in grey color to visualize the period for which the significant influence was found.[12]

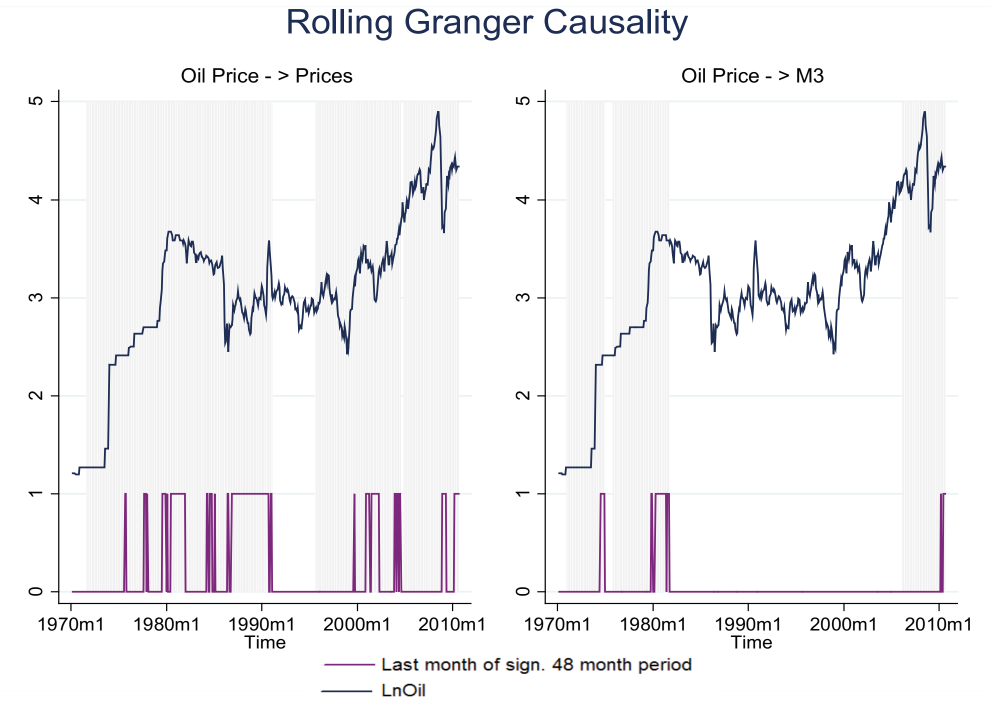


Figure 6.1: Granger Causality Tests using Rolling Windows

[12]In this case the null hypothesis that lags of the price of oil were jointly zero in the respective equation can be rejected at the 1% level.

Oil prices clearly Granger cause price levels during the period starting from the mid-1970s to the early 1990s. The relationship was quite strong especially in the mid-1980s, but this relationship disappeared in the early 1990s. At around the start of the turn of the millennium, oil prices again Granger cause price levels. This relationship remained significant for some of the 48-months windows until the end of the dataset.

We also do not observe a stable relationship between oil prices and money supply over time (right hand side of Figure 6.1). We find causal relations in the late 1970s, and at the very end of our dataset. From the early 1980s to the late 2000s, no significant relationship is found. The significant relationship during the 1970s and early 1980s is in line with central banks' strategies during these periods of high inflation: central banks tried to stabilize their economy through expansive monetary policy via increasing money supply in the 1970s, but pursuit the opposite strategy during in the late 1970s and early 1980s (see Richter, 1999 for Germany and Orphanides, 2004 for the U.S.).

The significant periods at the end of our sample have to be treated with caution. There, changes in money supply are not due to increasing oil prices but a reaction of the central bank to turbulences caused by the financial crisis that started in 2007. The increase of money supply during this period should not be attributed to the parallel increasing oil prices.

Taking stock, it should be noted, that we cannot assume stable effects from oil prices on price levels and money supply over time. Instead, a case to case inspection of the relationship should be applied.

6.3.2 Analysis of Asymmetric Oil Price Shocks

Figure 6.2 shows the two generated time series of positive and negative oil price shocks using the method of Engemann et al. (2011). Positive oil price shocks are defined as significant increases in oil prices. The highest peak is found in January 1974, which actually coincides roughly with the first oil crisis. Negative price shocks, on the other hand, are significant price decreases which are only found from 1980 onwards. Before that, only July 1970 fulfilled the criteria of being considered as a negative shock.

To analyze the impact of oil shocks on monetary variables, we again use a VAR model. Since the shock variables are found to be stationary, we include them in levels, the logarithms of price level and M3 in first differences, a constant and again a time trend

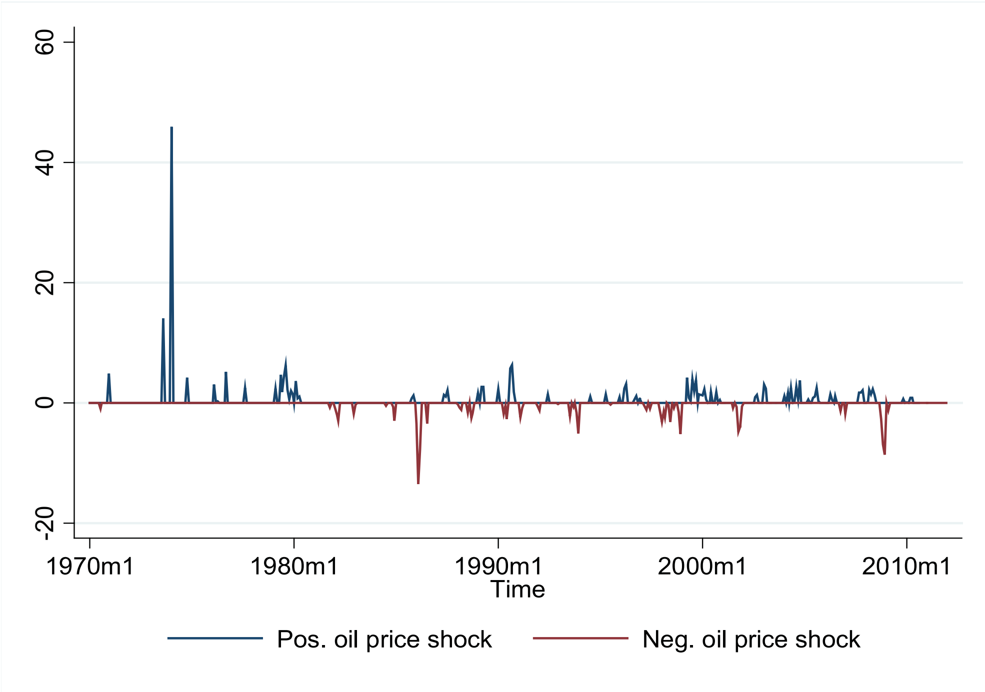


Figure 6.2: Positive and Negative Oil Price Shocks

and eleven monthly dummies. The SBIC criterion indicates one lag as an appropriate model order. Hence, one lag is included in the VAR model and is used for the Granger causality test. Since there are no negative shocks in the first ten years, we cannot use that period for the rolling Granger tests of the negative series. Again, we control for autocorrelation in the residuals with Newey and West (1987) robust standard errors.[13]

The test for cointegration is misleading in this case, as its original definition of cointegration refers to variables of the same order of integration. Meaning, that a linear combination of $I(1)$ variables is $I(0)$ or in general that a linear combination of $I(d)$ variables is $I(d-1)$. Nonetheless, extensions of the concept also include variables of different integration order, so the results have to be interpreted accordingly. We assume, however, that the shock variables and the two monetary variables by definition do not follow a common long-run trend, which is confirmed by the time series properties, and, as a result, we proceed with the VAR model. We first start using the whole sample.

[13] The lag length for autocorrelation is chosen as proposed by Newey and West (1987).

Oil Price Shocks

Looking at the whole period, neither the positive nor the negative oil price shocks are Granger causal for the aggregated money supply $M3_t$. Similarly, the positive shock variable is also not Granger causal for the price level over the whole period. But the null hypothesis that two lags of the negative oil price shock in the price level equation are jointly zero can only be rejected at the 5% level (see Table 6.3).

	$shock_t^+ \rightharpoonup$		$shock_t^- \rightharpoonup$	
Variable	Δpn_t	$\Delta M3_t$	Δpn_t	$\Delta M3_t$
χ^2	0.218	0.748	7.004	4.272
$P > \chi^2$	0.897	0.689	0.030	0.118

Table 6.3: Granger Causality Test

In the following sections, we use the asymmetric shock variables to repeat Granger causality tests using rolling windows of data from our sample. That is, we start in the first month of our dataset and estimate the model for 48 months, then we go one month further and estimate the model for the next 48 months and continue until the last available 48 month-period.

Positive Oil Price Shocks

To investigate the time structure and to identify periods were shocks had an impact on the monetary variables, we use again a rolling window of 4 years (48 months) and test for Granger causality. The areas shaded in grey again show the periods when the oil price was Granger causal for the respective variable. Aside from the logarithm of the oil price, the positive oil price shock is also plotted in Figure 6.3 (secondary y-axis).

Within the many time periods used in our sample, positive oil price shocks do not have significant impact on price levels and money supply. As for the price level, the late 1970s, the late 1980s and the recent time period was found to be Granger caused by a positive oil price shock. No influence was found between the 1990s and the mid-2000s despite the fact that there were also significant and frequent oil price shocks that occurred.

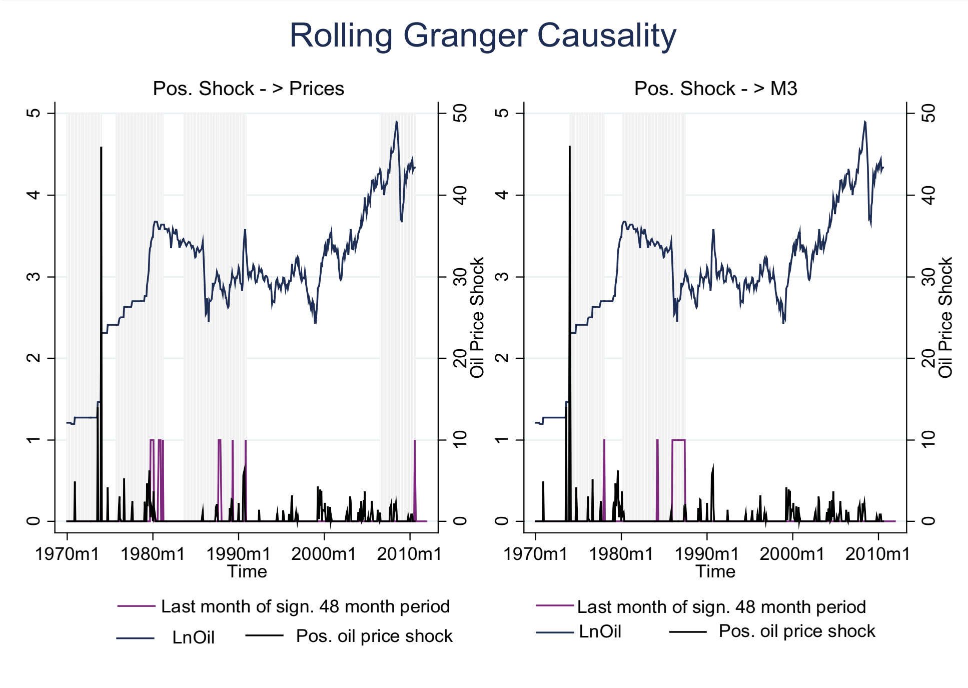


Figure 6.3: Granger Causality of Positive Oil Price Shocks

As for the money supply, the Granger causality test showed significant results only in the late 1970s and the 1980s. No influence of positive oil price shocks on the money supply in Germany was found after that. The results are in line with our tests from the previous section. The main difference is the lack of significant effects on money supply at the end of our sample.

The decomposition of the oil price series into positive and negative shocks allows a better identification of causality from oil prices on macroeconomic aggregates. We do not find significant effects of positive oil price shocks on money supply, which is line with actual strategies of central banks in recent times. Aastveit (2013) provides empirical evidence that the effects of oil price shocks on the economy depend on the reasons which caused the oil price shocks. It has important implications for monetary policy whether the oil price shock is driven by demand or supply. As a result, a per se rule how to react to an oil price shock is not appropriate. Central banks, however, always have to consider the trade-off between keeping price levels stable and corresponding (negative) effects on the overall economy (Natal, 2012).

Negative Oil Price Shocks

Negative oil price shocks are defined as significant decreases in oil prices, that is, when the oil price is lower than it has been in the previous six months. As mentioned above, these shocks did not occurred between 1970 and 1980, and only an analysis of the period beyond that date is possible.

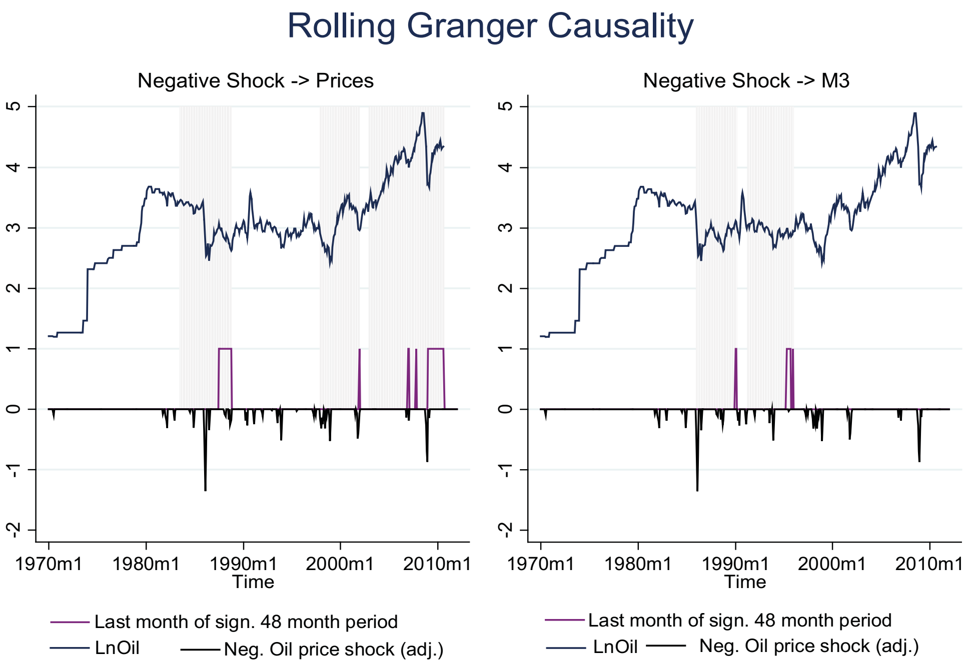


Figure 6.4: Granger Causality of Negative Oil Price Shocks

For the price level, the decrease of the oil price in the mid-1980s, along with that during the time around the turn of the millennium and the recent time are found to be significant. The first and the latter time periods experienced the two most substantial negative price shocks[14]. As for decade 2000, the most significant negative price shock was experienced during the aftermath of September 11th.

[14]Note, we adjusted the magnitude of the negative price shocks in the graph to enhance readability.

In contrast, money supply in Germany is found to be influenced by negative oil price shocks in Granger's definition, but only in the time between the late 1980s and 1990s when the price levels were not found to be significantly influenced. Significant effects following the aftermath of the September 11 attacks are not related to long lasting effects in oil prices. The immediate effects of the attacks were a spike in oil prices, but this receded to pre 9/11-levels quite quickly (Makinen, 2002). The world's most prominent central banks (the Federal Reserve and the European Central Bank), immediately implemented expansive monetary measures immediately to avoid long lasting negative effects on the economy (see Makinen, 2002 and Welteke, 2001). This might be reflected in the short run significant effect that we find in our data.

In both cases, no stable relationship is found. In contrast to the existing literature, we found some influence of negative oil price shocks on price levels and money supply in Germany. Compared to our results using the non-decomposed oil price series, but in line with the analysis of positive oil price shocks, we do not find significant effects at the end of our sample. Expansive monetary policies had not been caused by oil price turbulences, but by the financial crises that started in 2007. We checked our results using different lag orders of the underlying VAR model, but our overall findings of no stable relationship between oil prices, price level, and money supply still holds.

6.4 Conclusion

Increasing volatility of commodity prices and increasing price levels, especially for crude oil during the last years, were characteristics of macroeconomic turbulences at least since 2007.[15] Since then, there have been lively debates whether oil prices have significant influence on price levels and whether this can be a good indicator of future inflation. Central banks would have just reacted to changes in oil prices and could have had a robust measure of future inflation.

Using VAR models and Granger causality tests over the whole sample, as well as rolling windows of data, we show that there is no stable interrelationship between oil prices and the price level or the money supply. Oil prices should not be used as a major indicator of future inflation. There is no need for central banks to react a priori to oil

[15] This is also reflected in the index of energy security risk for the U.S. which shows sharp increases since the early 2000s (see Institute for 21st Century Energy, 2012).

price changes.

Our results are also in line with the broader literature on oil prices and macroeconomic activity. Blanchard and Gali (2010) provide evidence that oil price shocks create much less serious problems for economies in the 2000s than back in the 1970s. The calculations by Wurzel et al. (2009) reach similar conclusions. In a policy note, the OECD (2011) concludes, that at current low levels of inflation and low inflation expectations, reactions of monetary authorities on changes in oil prices may not be necessary.

6.5 Appendix

Test	Lags		$z(t)$
		oil_t	
ADF	2	Levels	-2.579
	2	First differences	-14.368***
Philips-Perron	2	Levels	-2.357
	2	First differences	-21.622
		$M3_t$	
ADF	7	Levels	0.6452
	7	First differences	-22.208***
ADF	11	Levels	-1.855
	11	First differences	-4.754***
Philips-Perron	7	Levels	-1.918
	7	First differences	-22.208***
Philips-Perron	11	Levels	-1.882
	11	First differences	-22.742***
		pn_t	
ADF	2	Levels	-1.313
	2	First differences	-13.358***
ADF	6	Levels	-1.623
	6	First differences	-8.735***
Philips-Perron	2	Levels	-0.466
	2	First differences	-21.393***
Philips-Perron	6	Levels	-0.681
	6	First differences	-21.553***

Table 6.4: Results of Unit Root Tests

Part III

Cartels

Chapter 7

Do Buyer Groups Facilitate Collusion?*

*This chapter is based on joint work with Hans-Theo Normann and Luis Manuel Schultz.

7.1 Introduction

Legal joint-market institutions like buyer groups, trade associations or industry-wide information systems are a rather common phenomenon. Both EU and US law allow for such exemptions from the general cartel prohibition.

At the same time, it is well known that illegal cartels often abuse legal joint-market institutions as a platform for their activities. In their meta study, Levenstein and Suslow (2006, p. 69) find that "between a quarter and a half of the cartels in U.S. cross-section studies report the involvement of trade associations". Schultz (2013) obtains a similar figure for Germany where nearly 56% of all illegal cartels detected and fined by the Federal Cartel Office between 1958 and 2002 used legal joint market institutions for its organization.

Also the policy makers are aware that legal joint market institutions can be abused for collusion. The new EU *Guidelines on Horizontal Co-operation Agreements* (Guidelines, 2011, p. C 11/4) argue that

> *"Horizontal co-operation agreements can lead to substantial economic benefits ... [They] can be a means to share risk, save costs, increase investments, pool know-how, enhance product quality and variety, and launch innovation faster. On the other hand, horizontal co-operation agreements may lead to competition problems. This is, for example, the case if the parties agree to fix prices or output or to share markets. ... The Commission, while recognizing the benefits that can be generated by horizontal co-operation agreements, has to ensure that effective competition is maintained taking into account both adverse effects on competition and pro-competitive effects."*

Buyer groups are an important and frequent example of legal joint market institutions.[1] They exist when competitors in the downstream market purchase at least part of their inputs jointly. With joint procurement, a buyer group may obtain economies at the

[1] Other examples include joint ventures. Cooper and Ross (2007) analyze theoretically how joint ventures or strategic alliances between two or more firms in one market can serve to facilitate collusion in another possibly unrelated market. Goeree and Helland (2010) empirically analyze the collusive effect of RJV and product market performance.

procurement level better than individual firms are able to.[2]

The main competition concerns about buyer groups in the *Guidelines* (p. C 11/45) are as follows:[3]

- "If downstream competitors purchase a significant part of their products together, their incentives for price competition may be considerably reduced." (point 201)
- "Buying power of the parties to the joint purchasing arrangement could be used to foreclose competing purchasers by limiting their access to efficient suppliers." (point 203)
- "[S]erve as a tool to engage in a disguised cartel, that is to say, otherwise prohibited price fixing." (point 205)

In this paper, we investigate the anti-competitive effects of buyer groups and, specifically, the relevance of the points in the *Guidelines*. For a repeated Cournot oligopoly game, we theoretically show that mutual dependence in buyer groups facilitates tacit collusion, as suggested by the *Guidelines* (2011). On top of that, repeated game arguments also support point 203 in that closed buyer groups which have the power to exclude specific firms from the group facilitate tacit collusion even further. Finally, a buyer group often brings along a legal platform for communication, which according to point 205 can be abused for illegal explicit conspiracies.

From a theoretical perspective, our analysis of buyer groups which have the power to exclude specific firms from the group introduces an interesting novelty. In the theory of infinitely repeated games, the deviator as well as the cheated-upon players often endure the same low payoffs during the punishment path. This is the case for Nash trigger strategies as well as optimal penal codes (Abreu, 1988) and other punishments.[4]

[2] The analysis of the exact channel through which buyer groups obtain better conditions in procurement is not part of this research (see e.g. Snyder, 1996; Normann et al., 2007). We explore the effect on downstream collusion *if* buyer groups procure more cheaply. See Salvatore and Miklos-Thal (2012) for a related issue.

[3] Another concern listed in the *Guidelines* is that buyer groups may reduce the range or quality of products they produce.

[4] With perfect monitoring, the punishment paths are, of course, never triggered and only serve as a threat. In game with imperfect monitoring (Green and Porter, 1984), the punishment path is occasionally carried out.

Exclusion from a buyer group, by contrast, allows for pinpointed, targeted punishments of deviations where the punishing (cheated-upon) players have higher payoffs than the punished players. Behaviorally, such targeted punishments which favor the punisher may be more likely to be observed.[5]

We test the repeated game predictions in experiments (see Normann and Ruffle, 2011, for a recent overview). Specifically, we run five experimental treatments in a three-firm Cournot framework to identify the effects of (i) joining a buyer group, (ii) being able to exclude firms from the group, and (iii) being able to communicate with other firms in the buyer group.

Our results show that buyer groups do facilitate tacit collusion when they have the power to exclude a single firm from the group. We also identify communication as a main driver for increased collusive outcomes. Altogether, we confirm the policy makers' concerns with buyer groups.

7.2 The Model

7.2.1 Demand and Cost

We employ the following Cournot oligopoly market. There are n firms, indexed from $i = 1, ..., n$. Let q_i denote firm i's output and industry output is $Q = \sum_{i=1}^{n} q_i$. Inverse demand is assumed to be linear

$$p = \max\{a - Q, 0\}. \tag{7.1}$$

Firms procure at constant marginal production cost, c_i. Marginal cost can either be low ($\underline{c}$) or high ($\overline{c}$). Hence, firms' profit functions are

$$\pi_i = (p - c_i)q_i \tag{7.2}$$

with $c_i \in \{\underline{c}, \overline{c}\}$.

[5]In the experimental literature, Ostrom et al. (1992) and Fehr and Gächter (2000) have introduced individually targeted punishments in public-good games, and they have shown that they support cooperation. This has triggered a huge literature which we discuss below. On the issue of punishment of non-compliant behavior versus bonuses for compliance, see Nosenzo et al. (2013).

Before deciding on their output, firms have to decide whether they wish to join a buyer group. Participation in the buyer group (or the exclusion from it) affects firms' marginal costs. We will present and analyze the buyer group decisions in detail below; but first, we solve for the Nash equilibrium of the Cournot oligopoly.

7.2.2 Static Nash Equilibrium of the Cournot Oligopoly

Suppose there are $n - m$ low-cost firms and m high-cost firms, $0 \leq m \leq n$. Firm i's first-order condition is $a - Q - c_i = q_i$, for $c_i \in \{\underline{c}, \overline{c}\}$. Adding up the n FOCs and solving for Q, we obtain a Nash equilibrium (N) industry output of $Q^N = (na - (n-m)\underline{c} - m\overline{c})/(n+1)$. Hence we get

$$q_i^N = \begin{cases} \dfrac{a - (m+1)\underline{c} + m\overline{c}}{n+1}, & \text{if } c_i = \underline{c} \\ \dfrac{a + (n-m)\underline{c} - (n-m+1)\overline{c}}{n+1}, & \text{if } c_i = \overline{c} \end{cases} \tag{7.3}$$

for firm-level equilibrium outputs. We assume henceforth that cost differences are not too large, so that the high-cost firms still procure a positive amount: $a + (n-m)\underline{c} - (n - m + 1)\overline{c} > 0$.

As will become clear below, the following three constellations regarding the marginal cost parameters are relevant for our setup. If $m = 0$, all firms have low costs ($c_1 = c_2 = ... = c_n = \underline{c}$) and we have

$$\underline{q}^N = \frac{a - \underline{c}}{n+1}. \tag{7.4}$$

If $m = n$, all firms have high costs ($c_1 = c_2 = ... = c_n = \overline{c}$) and we obtain

$$\overline{q}^N = \frac{a - \overline{c}}{n+1}. \tag{7.5}$$

With $m = 1$ high-cost firm and $n - 1$ low-cost firms, we obtain

$$\underline{q}^E = \frac{a - 2\underline{c} + \overline{c}}{n+1}, \quad \overline{q}^E = \frac{a + (n-1)\underline{c} - n\overline{c}}{n+1} \tag{7.6}$$

where we use the superscript E as it can refer to a buyer group variant where one firm is *excluded*. We use $\underline{q}^E$ and $\overline{q}^E$ for the outputs of the low-cost firms and the high-cost firm, respectively.

In all cases, Nash equilibrium profits are obtained by squaring the equilibrium outputs. That is, we have $\underline{\pi}^N = \left(\underline{q}^N\right)^2$, $\overline{\pi}^N = \left(\overline{q}^N\right)^2$, $\underline{\pi}^E = \left(\underline{q}^E\right)^2$ and $\overline{\pi}^E = \left(\overline{q}^E\right)^2$. Note that $\underline{\pi}^E > \underline{\pi}^N > \overline{\pi}^N > \overline{\pi}^E$.

7.2.3 Buyer Group Participation

Before playing the Cournot game, firms may establish an input-purchasing group which affects their procurement cost. We consider two variants, the open buyer group and the closed buyer group.

In the case of the *open buyer group*, firms simply face a binary decision whether they wish to join the group. If at least $n - 1$ firms join the group, the in-group firms procure at low marginal cost, $\underline{c}$, whereas a firm which does not join, procures at high costs, $\overline{c}$.[6] If $n - 2$ or fewer firms decide to join, all firms have high marginal cost.

There are two types of equilibrium outcomes with the open buyer group: either all firms join and have low cost or $n - 3$ firms or fewer firms join and all firms have high cost. To see this, note that joining the buyer group is a weakly dominant strategy as a firm always benefits from having lower costs. Specifically, if $n - 2$ or $n - 1$ of the other firms decide to join, firm i finds it strictly worthwhile to join since $\underline{\pi}^N > \overline{\pi}^N$ and $\underline{\pi}^N > \overline{\pi}^E$; otherwise, i is indifferent. Here, a subgame perfect Nash equilibrium outcome has all firms joining the group and then choosing outputs of $\underline{q}^N$ and earning $\underline{\pi}^N$. If $n - 3$ or fewer other firms join the group, firm i is not pivotal and is thus, indifferent between joining and not joining. Hence, a second subgame perfect Nash equilibrium outcome (in weakly dominated strategies) involves $n - 3$ or fewer firms joining the group; not joining is a best reply here, and the buyer group is not established. (To be precise, there are many pure-strategy equilibria of this type, all of which have $n - 3$ or fewer other firms joining the group.) In the open buyer group, it cannot be an equilibrium that only $n - 1$ or $n - 2$ firms join the group.

In the case of the *closed buyer group*, the participation subgame consists of two stages. First, firms decide whether they wish to join the group. Second, provided all n firms join the group, firms decide whether they wish to exclude some firm (if any). Stage one is as above: if at least $n - 1$ firms join the group, the group is established. Stage two

[6] The motivation for this setup is that buyer groups must have a minimum size to be able to procure cheaper than single firms. To allow for outsiders to the buyer groups, we decided not to demand that the entire industry is required to join the group.

is only relevant if all n firms join the group. In that case, each firm can suggest one firm (if any) for exclusion from the group. If $n-1$ firms agree to exclude a firm, the targeted firm is excluded from the group. Suggestions for exclusion can be made only once and they are made simultaneously. The impact on production costs is the same as with the open buyer group: firms in the buyer group procure at low marginal cost whereas a firm which was excluded or which did not join the group in the first place procures at high costs.

The equilibrium analysis of the buyer-group-participation decisions in the closed buyer group is as follows. The first stage is as in the open buyer group. One equilibrium outcome involves all firms joining, and one equilibrium outcome has at most $n-3$ firms joining. Now assume all firms join the buyer group. Since $\underline{\pi}^N < \underline{\pi}^E$, $n-1$ firms find it worthwhile to exclude the remaining firm. Thus, in the subgame where all n firms join, the equilibrium involves the exclusion of one firm which then faces high marginal cost. There are n pure-strategy equilibrium outcomes of this type (and possibly also mixed-strategy equilibria), however, firms may face a coordination problem when deciding which firm to exclude. Finally, when no group is established, there is no second participation stage as no firm can be excluded.

7.2.4 The Repeated Game

Consider now infinitely many repetitions of the above oligopoly market. Time is indexed from $t = 0, ..., \infty$ and firms discount future profits with a common factor δ, where $0 \leq \delta < 1$. To investigate the stability of a possible cartelization of the market, we will look for a subgame perfect equilibrium where firms manage to sustain the symmetric joint-profit maximum by threatening to revert to a static Nash equilibrium in the case of a deviation (trigger strategy).

The symmetric *joint-profit maximum* is as follows. The profit maximum can be obtained only if all firms have low costs, thus all firms must join the buyer group and no firm must be excluded.[7] Outputs are

$$\underline{q}^C = \frac{a-c}{2n} \tag{7.7}$$

and

$$\underline{\pi}^C = \frac{(a-c)^2}{4n} \tag{7.8}$$

are the profits in the symmetric joint-profit maximum. Since firms have the same costs, any asymmetric division of the joint-profit maximum would be implausible and more difficult to sustain in the repeated game.

Consider now *defection* from the symmetric joint-profit maximizing outcome. The defecting firm will procure the best reply to $(n-1)\underline{q}^C$ at low cost, which is

$$\underline{q}^D = \frac{(a-c)(n+1)}{4n}, \tag{7.9}$$

and

$$\underline{\pi}^D = \frac{(a-c)^2(n+1)^2}{16n^2} \tag{7.10}$$

is the defection profit.

Next, we derive the minimum discount factor required for collusion. Collusion is a subgame perfect Nash equilibrium if and only if

$$\frac{\underline{\pi}^C}{1-\delta} \geq \underline{\pi}^D + \frac{\pi^P\delta}{1-\delta} \tag{7.11}$$

where π^P is the punishment profit following a deviation. Solving for δ, we find

$$\delta \geq \frac{\underline{\pi}^D - \underline{\pi}^C}{\underline{\pi}^D - \pi^P} \equiv \delta_0 \tag{7.12}$$

The feasibility and type of the buyer group affects the static Nash equilibrium and therefore π^P and δ_0.

We now analyze the δ_0 for three different cases: exogenous buyer group (labeled

[7]Note that it does not pay for $n-1$ firms to exclude the n^{th} firm and then collude on outputs. The argument is the same as in the merger paradox of Salant, Switzer and Reynolds (1983), even though the excluded firm has high cost here. For a reasonably low number of firms, we find that $\underline{\pi}^C$ is larger than the profit from colluding among $n-1$ against one high-cost firm playing non-cooperatively.

"baseline"), open buyer group, and closed buyer group. The exogenous buyer group case serves as a benchmark for the standard Cournot oligopoly case, so we assume that all firms have low costs here, or that $\pi^P = \underline{\pi}^N$ in this case. We find

$$\delta_0^{baseline} = \frac{(n+1)^2}{(n+1)^2 + 4n} \tag{7.13}$$

With the open buyer group, there are two static Nash equilibria as possible punishment strategies: all firms joining is an equilibrium but not setting up the group by not joining is also a subgame perfect Nash equilibrium. As not establishing a buyer group is a subgame perfect Nash equilibrium, it is a credible threat in the repeated game and it is also the harshest Nash punishment in this case. We therefore have $\pi^P = \overline{\pi}^N$ as a plausible punishment of a trigger strategy here. With the closed buyer group, excluding a firm is a static Nash equilibrium and thus a credible threat. Excluding the deviator is firstly the harshest punishment in this case and, moreover, it also resolves the coordination problem of which of the n firms shall be excluded. So we have $\pi^P = \overline{\pi}^E$ here.

To sum up, we find that collusive (C) and defection (D) profits are the same in all three variants but punishment payoffs (N, E) differ; specifically, we have $\underline{\pi}^N > \overline{\pi}^N > \underline{\pi}^E$. Thus we obtain:

Proposition. *For the minimum discount factor required to sustain the joint-profit maximum as a subgame perfect Nash equilibrium with Nash reversions, we find*

$$\delta_0^{baseline} > \delta_0^{open\ buyer\ group} > \delta_0^{closed\ buyer\ group} \tag{7.14}$$

that is, open buyer groups facilitate collusion, and closed buyer groups facilitate collusion more strongly than open buyer groups.

Our result depends on the assumption of trigger strategy reversions to a static Nash equilibrium. With harsher (optimal) punishments (Abreu, 1988), buyer groups may not have an impact. Note, however, that we have a repeated extensive-form game here. As pointed out by Mailath et al. (2006), the logic of simple penal codes fails in repeated extensive-form games. How harsher punishments work in repeated extensive-form games is an open question.

The proposition does *not* depend on the assumption that firms attempt to achieve the joint-profit maximum. One can show that (7.14) holds for any level of collusive output (that is, quantities between $\underline{q}^N$ and $\underline{q}^C$). This implies that even for discount factors lower than $\delta_0^{\text{closed buyer group}}$, some level of collusion can be sustained; however, the level of output is always lowest (most collusive) for the open buyer group and highest for the case of the baseline setup.

7.3 Design

We want to assess the collusive impact of buyer groups along two dimensions. One dimension is that buyer groups allow for more severe punishment strategies than standard oligopolies, as in points 201 and 203 of the *Guidelines*. Hence, we have the treatments exogenous buyer group (Baseline), open buyer group, and closed buyer group. The second dimension is that buyer groups legally enable communication between firms. This communication may be used for collusive agreements ("cartel in disguise", point 205). Here, we have the variants Talk and NoTalk. Table 7.1 summarizes the treatment design.

Treatment	Baseline	Open_NoTalk	Closed_NoTalk	Open_Talk	Closed_Talk
Cost	$\underline{c}$	$\underline{c}$ or $\overline{c}$	$\underline{c}$ or $\overline{c}$	$\underline{c}$ or $\overline{c}$	$\underline{c}$ or $\overline{c}$
Buyer Group	exogenous	open	closed	open	closed
Communication	no	no	no	yes	yes
Stage 1	-	entry	entry	entry	entry
Stage 2	-	-	-	chat	chat
Stage 3	-	-	exclusion	-	exclusion
Stage 4	quantity	quantity	quantity	quantity	quantity
# Participants	27	36	21	33	21

Table 7.1: Treatments

The communication treatments were designed as follows. Subjects were allowed to communicate with one another for 40 seconds in every period of the experiment via typed messages, using an instant-messenger communication tool. Subjects were free to post as many messages as they liked, but they were not allowed to identify themselves or to post offensive messages. Subjects were aware that they communicated to the whole group, but not to individual group members or subjects outside the group. The limit of

40 seconds was sufficiently long for the communication phase as most talk ended before the 40-second period was over.

Note that subjects were only allowed to communicate at the buyer-group stage. The instructions regarding this point read "you are free to talk about whatever you wish, however, you must not explicitly agree on targets regarding the output decisions" (see the Appendix). We chose this implementation and the specific formulation because it is relatively close to the Article 101 of the European Treaty of Rome (which prohibits explicit agreements between firms that restrict competition) and Section I of the Sherman Act (which has a similar content). It is clear to subjects that communication about output targets is possible but not allowed.[8]

We expected the Closed treatments to be of considerable complexity. One reason is that the group participation decision plus exclusion decision preceded the output decision. In the first period, players had to decide whether to exclude a firm even before playing the quantity game. We therefore decided to begin the Closed treatments with seven rounds of the Open buyer group treatment. After the seven rounds, the Closed buyer group mechanism was introduced and used for the rest of the game (see below). In order to account for the restart effect implied by this design, we also began with seven rounds in Open and Baseline, although the treatment was not changed after the initial phase in these variants. The seven periods were announced in the introduction and we paid subjects for them. Below, we only report the data after the seven initial rounds.

From the beginning, our aim was to analyze the anti-competitive effects of buyer groups, particularly the effects of a punishment instrument and communication. We, therefore, dismissed the option of implementing a cartel authority in the lab, although we considered it. A modeled cartel authority which investigates with a certain probability and, given a violation, imposes fines according to some rule would have complicated our design without adding any further insights into our main analyzed issues.[9]

[8]This is also the reason we did not conduct a second baseline treatment with communication. Absent a buyer group decision, it would be implausible to allow for communication which, however, must not concern output decisions. Moreover, already in the Open_Talk treatment, it is trivial to discuss the decision to join (in fact, almost all subject always do so). An additional treatment without the buyer-group decision would not yield any additional insights.

[9]While several laboratory experiments on leniency (Apesteguia et al., 2007; Hinloopen and Soetevent, 2008; Bigoni et al., 2012) have successfully conducted experiments with such a cartel authority in the lab, such a design faces several difficulties in our case. One difference is that subjects in the leniency experiments explicitly choose to communicate, knowing this may be penalized. In the case of communication

The buyer-group decisions were implemented exactly as described in the model section. In the *open buyer group*, firms simply decide whether they wish to join the group. In the *closed buyer group*, firms first decide whether they wish to join the group and, given that all firms join, firms decide whether they wish to exclude a firm (if any).

The Cournot oligopoly model was employed with the following parameter values

$$n = 3, \quad a = 130, \quad \underline{c} = 10, \quad \overline{c} = 22. \tag{7.15}$$

These values are motivated as follows. At least three firms are needed to create buyer groups with the option of exclusion. Collusive outcomes without communication do typically not occur with more than three firms (Huck et al., 2004), hence $n = 3$ gives us a good chance to observe treatment effects. We chose the difference between $\underline{c}$ and $\overline{c}$ to be salient, such that being part of the group or being excluded from it has a sound effect on participants' payoffs. On the other hand, the difference must not be too big such that an excluded (or non-joining) firm still procures $\overline{q}^N > 0$. This is the case with $\underline{c} = 10$ and $\overline{c} = 22$.

All treatments were implemented as a repeated game (fixed-matching scheme). After the initial seven periods, there were at least 20 periods in all treatments. From the 21^{st} period onward, a random stopping rule determined whether the experiment would go on or stop. We chose a continuation probability of 2/3 higher than the highest δ_0 calculated in section 7.5 so that players can sustain the joint maximum in all treatments . The actual number of periods were not determined ex ante and thus differed between sessions (between 21 and 28 periods).

In every period, the feedback given to subjects was as follows: Subjects were first informed about the buyer group participation decisions. In the open buyer group treatments, subjects were told, for example, "all firms decided to join the buyer group. All firms have low cost in this period", and similarly in the case where one firm did not join. In the closed buyer group treatments, subjects were told which firms joined the buyer and afterward they could decide if and whom to exclude. An additional feedback was

in a buyer group, the opportunity to talk is always there, and it is legal; only certain content is illegal. This, however, requires that the experimenters actively monitor the communication content and intervene immediately in any period of violation. This may contradict the notion of participant anonymity. Also, given that up to 24 subjects simultaneously produce chat content (which can be rather cryptic), such immediate on-screen content analysis and intervention does not seem practical.

given before the quantity decision, for example if firm 3 was excluded “firm 1 and firm 2 are still in the buyer group.".

7.4 Procedures

The experiment was framed as follows. In the instructions (see Appendix), subjects were told that they would act as a firm which, together with two other firms, serves a market repeatedly. They were asked to purchase units of a fictitious good. In each period, the number of units procured was automatically set equal to the number of units sold on the downstream market (no inventory). We told them the input price of the good was either 22 or 10. In Baseline, the input price was said to be 10 throughout.[10]

We further described that subjects had the option to “join a buyer group” and how this choice affected their production cost. Next, we described the quantity decision. We told subjects that higher aggregate output would lower the market price, and that for aggregate output levels of 130 or more the price would be zero. We did not provide payoff tables or further details of the functional forms. Instead, subjects had access (in each round) to an on-screen profit calculator. As Requate and Waichman (2011) show, the use of a profit table or a profit calculator yield indistinguishable results in Cournot experiments.

After having read the instructions, participants could privately ask questions. Before the start of the experiment, subjects were asked to answer several control questions. Then the actual experiment began.

The experiments were computerized, using Ztree (Fischbacher, 2007). Recruiting was done with the ORSEE (Greiner, 2004) online recruiting system.

The experiments were conducted at the laboratory of the Duesseldorf Institute for Competition Economics (DICE). In total 138 subjects participated in sessions with 12 to 24 participants. We conducted one or two sessions per treatment which yields between 7 and 12 independent triopoly groups per treatment. (We aimed for seven or eight triopoly

[10]In order to keep the Baseline treatment comparable to the other treatments, we mentioned in the instructions that “the input price is usually 22” but “since you and the other two firms are in a buyer group” the price is 10. Hence, strictly speaking, Baseline is not a standard triopoly in terms of the frame but takes into account the aspects of buyer groups that characterizes the other treatments. As we will see below, the data in Baseline do not differ from previous three-firm Cournot experiments. Hence, it appears redundant to conduct a further neutrally-framed triopoly treatment.

groups per session / treatment; if the number of groups in a session was lower due to subjects not showing up, we conducted a second fully-fledged session.)

Participants were students from various departments, many from fields other than economics or business administration. The monetary payment was computed by using an exchange rate of 1,500 "points" for one Euro and adding a flat payment of 4 €. Subjects' average earnings were 21.24 € including the flat payment. The sessions lasted between 60 and 90 minutes.

7.5 Benchmarks and Hypotheses

To begin with, we state the numerical predictions for the parameters of the design. For the δ_0 of the repeated game, we obtain

$$\begin{aligned} \delta_0^{\text{baseline}} &= 0.57 \\ \delta_0^{\text{open buyer group}} &= 0.50 \\ \delta_0^{\text{closed buyer group}} &= 0.35 \end{aligned} \tag{7.16}$$

Table 7.2 states the static Nash equilibria and the symmetric joint-profit maximizing outcome.

These theoretical benchmarks suggest hypotheses regarding the impact of the buyer groups. From the Proposition and the δ_0 in (7.16) values, we expect buyer groups to facilitate collusion, more strongly so for the closed buyer groups. With this hypothesis, we follow the common interpretation that a lower minimum-discount factor makes collusion easier.[11]

Hypothesis 1. *Buyer groups facilitate collusion, and closed buyer groups are more collusive than open buyer groups.*

[11]Note that the discount factor implied by the termination rule (2/3) is higher than all δ_0 in (7.16). This suggests that, theoretically, players can sustain the joint maximum in all treatments. Our hypothesis is based on the observation that play in experiments depends on the magnitude of the punishment payoffs in that affects the likelihood of collusion in the direction predicted by theory (see e.g. Rapoport and Chammah 1965). Dal Bó and Fréchette (2011), show that being an equilibrium action may be a necessary condition for cooperation when the supergame is repeated many times.

output	$\underline{q}^C$	$\underline{q}^N$	$\overline{q}^N$	$\underline{q}^E$	$\overline{q}^E$
	20.0	30.0	27.0	33.0	21.0
profit	$\underline{\pi}^C$	$\underline{\pi}^N$	$\overline{\pi}^N$	$\underline{\pi}^E$	$\overline{\pi}^E$
	1,200	900	729	1,089	421

Table 7.2: Benchmarks. Note: “C” refers to the collusive (joint-profit maximizing outcome), “N” is the symmetric low-cost static Nash equilibrium, and “E” refers the static Nash outcome where one firm is excluded.

As for the impact of communication, it is more difficult to derive a prediction from repeated game theory. As has been noted in the literature (see Harrington, 2008; and Whinston, 2008), the incentives to adhere to collusive agreements are often the same with and without communication because communication between players cannot be enforced. This implies that the set of equilibria in repeated-game oligopoly is the same regardless of whether firms talk. Hence, at face value, repeated game theory frequently does not predict an effect of communication.

Communication, however, may help to coordinate on a collusive equilibrium (see Crawford and Sobel, 1982; and Farrell and Rabin, 1996, for a review). In repeated games, there are many collusive equilibria and therefore firms face a coordination problem. Cheap talk seems useful as it can enable firms to coordinate on a certain equilibrium. Firms can talk about aggregate output targets, individual market shares, and punishment strategies for cases of deviations. Firms may, for example, coordinate on a punishment strategy (not setting up a buyer group at all, or excluding a deviator in the closed buyer groups). Thus, we expect communication to have a positive effect on cooperation.[12]

Hypothesis 2. *Industry output will be lower in the treatments with communication.*

[12]Several experiments have shown that communication can improve cooperation in dilemma games. To what extent communication helps depends on the format of the communication. One-sided communication (like unilateral price announcements) typically loses its impact over time (Holt and Davis, 1990; Cason, 1995) whereas multilateral communication can lead to persistently higher prices (see the posted offer markets with face-to-face communication in Isaac et al., 1984). See Brosig et al. (2003). Crawford (1998, p. 294) argues that multilateral communication has a “reassurance effect” which helps to coordinate on more efficient equilibria. Since our communication treatments employ open, free and simultaneous communication, we expect communication to lead to lower outputs. See also the meta study of Balliet (2010). Cooper and Kühn (2013) analyze communication in a two-stage game of conditional cooperation.

Our hypotheses can be put together and imply rankings of industry outputs for our treatments. We have two predicted rankings as our hypotheses do not predict a ranking of outputs for Closed_NoTalk vs. Open_Talk. We should either observe

$$Q^{\text{Baseline}} > Q^{\text{Open\_NoTalk}} > Q^{\text{Closed\_NoTalk}} > Q^{\text{Open\_Talk}} > Q^{\text{Closed\_Talk}}$$

or

$$Q^{\text{Baseline}} > Q^{\text{Open\_NoTalk}} > Q^{\text{Open\_Talk}} > Q^{\text{Closed\_NoTalk}} > Q^{\text{Closed\_Talk}}.$$

7.6 Results

7.6.1 Overview and Main Results

Table 7.3 provides a summary statistic of our experiment. It reports the share of firms having low costs, the average output per firm, and the average output per firm when all firms have low costs.

Almost all firms joined the buyer group in the two Open treatments, as predicted. As a player cannot lose from joining, this may not seem surprising. This finding, however, also implies that rejecting the buyer group (that is, at least two firms not joining) was not triggered as a punishment—although this may still have served as a threat. Also in Closed_Talk, all firms joined almost all the time and there seem to be hardly any exclusions. By contrast, in Closed_NoTalk, the frequency of low-cost outcomes is significantly lower than in the other treatments (ranksum tests, all $p < 0.001$, two-sided). It appears that firms were occasionally excluded, possibly as a punishment. We will return to this issue in Section 7.6.2.

Next, we take a look at the average outputs in Table 7.3. We observe one of the two predicted rankings of average outputs, and we can reject the null hypothesis that the ranking of average outputs are random.[13] Outputs for the Baseline and Open_NoTalk

[13] We have five treatments and $5! = 120$ possible rankings. Two of the 120 rankings are consistent with our Hypotheses. As one of the predicted rankings materializes, we can reject the null hypothesis of random rankings at $p = 2/120 = 0.0167$.

	Baseline	Open_NoTalk	Closed_NoTalk	Open_Talk	Closed_Talk
share low cost firms	(100.00%)	99.90%	82.50%	99.50%	99.80%
avg. q	29.57	29.21	27.63	22.34	20.49
avg. q low cost firms	29.57	29.18	28.58	22.26	20.52

Table 7.3: Outputs and Share of Low-Cost Firms. Note: in Baseline, the share low cost firms is 100% by design.

treatments are rather close to the static Nash equilibrium of 30. Both treatment variables have the predicted effects. Confirming Hypothesis 1, the closed buyer groups cause slightly collusive outputs compared to the open buyer groups. Supporting Hypothesis 2, the possibility of communication in the Talk treatments causes a substantial reduction of output.

The left-hand side of Figure 7.1 shows results of (unrelated-sample) ranksum tests. The figure reports two-sided p values. Average outputs differ significantly and in the direction predicted, except for Baseline and Open_NoTalk which do not differ significantly. The differences between the NoTalk and Talk treatments are highly significant.

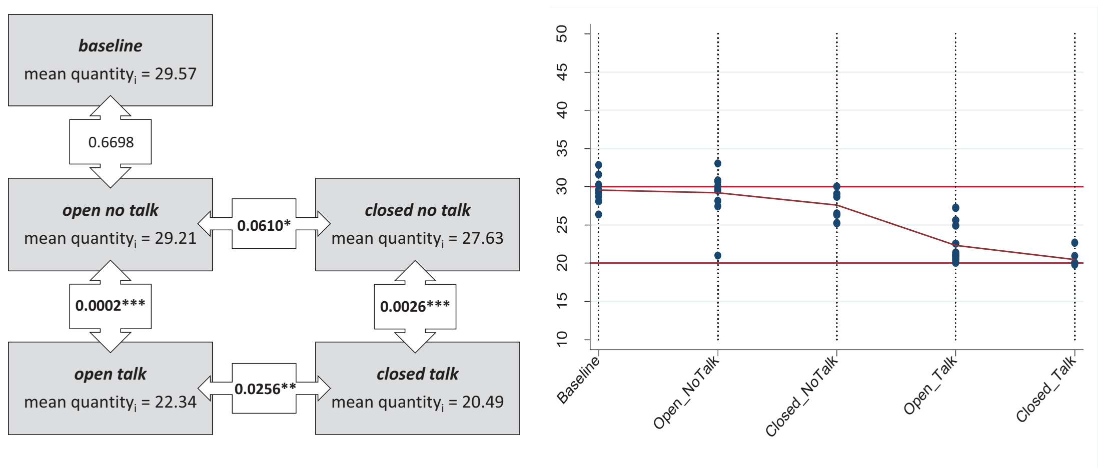


Figure 7.1: *Left-hand side: Ranksum tests, p values are two-sided. Right-hand side: Group means across treatments. Note: static Nash output is 30, joint-monopoly output is 20. Line connects treatment averages.*

The right-hand side of Figure 7.1 shows that group averages are sometimes heterogeneous within our treatments. In Baseline and Open_NoTalk, some groups have average outputs above the static Nash prediction, some below (as has been observed by Huck et al. 2004). The other treatments have averages between the static Nash level of 30 and the joint-profit maximizing level of 20. Without communication, only one group managed to sustain an output level close to the collusive level of 20.

Variable	(1)	(2)
buyer group	-0.309	-0.309
closed	-1.717***	-1.717***
talk	-6.969***	-6.969***
period		-0.076***
constant	29.565***	30.366***
N	2700	2700
*** 1% level	** 5% level	* 10% level

Table 7.4: Panel Regression Analysis of Firm-Level Outputs.

The regressions in Table 7.4 provide further—and at least partial—statistical support for both Hypotheses. We used a random-effects panel estimator and clustered the standard errors by each group in each treatment. The *constant* represents the Baseline treatment. The dummy *buyer group* is equal to one in all Open and Closed treatments. Not supporting Hypothesis 1, we find that a buyer group per se does not facilitate collusion, as indicated by the insignificance of *buyer group*. Consistent with Hypothesis 1, *closed* buyer groups significantly facilitate collusion, and, consistent with Hypothesis 2, the impact of *talk* is significant and substantial. There is a significant negative trend time captured by the *period* variable which is, however, not very large. [14]

7.6.2 Closed Buyer Groups

In this section, we will take a detailed look at the Closed treatments. The possibility to exclude firms from the buyer group supports collusion, although the magnitude of the

[14]To test for autocorrelation a Wald test is used (see Drukker, 2003 and Wooldridge, 2002). The null hypothesis no first-order autocorrelation has to be rejected in both cases (1) $P > F = 0.0042$ and (2) $P > F = 0.0042$. Using Newey-West standard errors and allowing for first-order autocorrelation, leaves the results qualitatively unchanged.

effect is small compared to the effect of communication. How do firms make use of the possibility to exclude?

	Closed_NoTalk	Closed_Talk
Exclusion suggested	67.22%	1.67%
Exclusion-suggestion successful	51.24%	28.57%

Table 7.5: Suggestion and Exclusion

Table 7.5 shows that the inclination to suggest exclusion and actual exclusions differ strongly between Talk and NoTalk treatments. While in Closed_NoTalk exclusion was suggested in two-thirds of all possible cases, this figure is less than 2% of the cases (corresponding to seven suggestions) in Closed_Talk. The possibility to talk apparently strongly decreases the willingness or need to exclude a firm from the buyer group. In the NoTalk treatment, about half of the cases where exclusion was suggested were also successful (51.24%), but 28.57% in the Talk treatment (which corresponds to two of seven suggestions or one successful case of exclusion only). This underlines the finding that chat-negotiations lower competition and the need for punishment.

As there are many attempts to exclude in Closed_NoTalk, this raises the question of who gets excluded. Underlying our hypothesis of the repeated game analysis is that a deviator—a high-output firm—gets excluded in the subsequent period. We therefore take a look at cases where exactly one firm in a group had the (strictly) highest output in period $t-1$. Among those cases, there were 62 observations of successful exclusion. The firm with the highest output in $t-1$ gets excluded 24 cases (38.71%) which is only slightly more often than random (33.33%). (In Closed_Talk we had only one case of successful exclusion anyhow.)

Table 7.6 shows the results of probit regressions analyzing (1) whether firm i gets excluded and (2) whether firm i wants to exclude another firm (that is, suggests another firm). The variable $L1.max\{0, q_i - q_{-imax}\}$ indicates to what extent firm i had the largest output in the previous period; it is zero if i did not have the largest output. Regressor $L1.max\{0, q_{-imax} - q_i\}$ shows by how much firm i's output was below that of the other firms in $t-1$; it is zero if firm i had the largest output in the previous period.

Variable	(1)	(2)
$L1.max\{0, q_i - q_{-imax}\}$	0.022	0.023
$L1.max\{0, q_{-imax} - q_i\}$	-0.023	0.026*
excluded $t-1$	0.971**	0.212
excluded_before	0.609	-0.051
talk	-7.09	-4.143***
period	-0.016	0.037**
constant	-1.564***	-0.011
N	741	741
*** 1% level	** 5% level	* 10% level

Table 7.6: Panel Probit Analysis on (1) who gets excluded and (2) who wants to exclude, clustered at the group level.

The results in Table 7.6[15] indicate that having the largest output in $t-1$ does not significantly increase the likelihood of being excluded. $L1.max\{0, q_{-imax} - q_i\}$ does, however, increase the likelihood of wanting to exclude. Having been excluded in $t-1$ significantly increases the probability of being excluded in t. The impact of *talk* is as expected from the above summary statistics.

	(1)	(2)	(3)	(4)
talk	-8.806***	-8.820***	-7.860***	-7.887***
excluded	-9.810***	-9.229***	-10.423***	-9.833***
period	-0.014	-0.032	-0.047	-0.064
other_excluded		1.211*		1.183*
excluded_before			3.326**	3.269**
cons	29.465***	28.985***	28.723***	28.265***
N	780	780	780	780
*** 1% level	** 5% level	* 10% level		

Table 7.7: Panel Regression Analysis of Firm-Level Output for Closed treatments

The regression analysis of outputs in the Closed treatments in Table 7.7 shows how firms respond to exclusion in their output decisions[16]. Being excluded (and hence having high costs) strongly and significantly reduces output in all four regressions. If another firm in the market has been excluded (*other_excluded*) only moderately increases out-

[15]Results remain qualitatively unchanged when using a linear probability model.

[16]The test for autocorrelation in panel data (see Drukker, 2003 and Wooldridge, 2002) shows that in each specification the null hypothesis no first-order autocorrelation cannot be rejected: (1) $Prob > F = 0.6779$; (2) $Prob > F = 0.7246$; (3) $Prob > F = 0.5799$; (4) $Prob > F = 0.6176$.

put, although this is significant at the 10% level. Having been excluded at any point before period t (*excluded_before*) substantially and significantly increases output. As we have virtually no cases of successful exclusion in Closed_Talk, all these effects are driven by the Closed_NoTalk data.

In Closed_NoTalk, exclusion is very often suggested and is frequently also successful. It is, however, not necessarily the high-output firms that get excluded. Rather, it appears that exclusion suggestions are somewhat random but, if they are successful, the same firms are likely to get excluded again. This may suggest that firms use the exclusion mechanism in the sense of the static Nash equilibrium and not as a repeated game punishment. On the other hand, low-output firms are significantly more likely to suggest an exclusion - which is consistent with our repeated game analysis. In Closed_Talk, exclusion occurs less frequently. It appears that communication is a substitute for exclusion.

At first sight, our findings regarding exclusion in Closed_NoTalk appear to stand in contrast to the large effect punishment possibilities have in public-good games (e.g., Fehr and Gächter, 2000). In these experiments, players can reduce targeted players' income at a cost. In contrast to our game, the punishments cannot be part of an equilibrium in a one-shot game or finitely repeated game. In public-good games with punishment, high levels of cooperation often occur. In our experiments, the effect is only moderate. It should be noted, however, that high degrees of cooperation are not observed throughout in public-good games with punishment (Nikiforakis and Normann, 2007). Moreover, as in our experiments, sometimes the "wrong" players get punished (Cinyabuguma et al., 2006). Finally, our mechanism is probably more complicated, not at least as punishment depends on the coordination of two players against one. Altogether, the differences to the literature on public-good games with punishment are perhaps not grave in the end.

7.6.3 The Talk Treatments

In the Talk treatments, we told subjects in the instructions that "you are free to talk about whatever you wish, however, you must not explicitly agree on targets regarding the output decision". This design is aimed at two research questions. Do subjects abuse the prohibition of explicit agreements? And: through which channel do they achieve near-perfect collusion?

We analyzed the communication data according to whether there was an agreement, and if so, whether it was about an explicit quantitative target or merely a non-quantitative statement.[17] Specifically, we looked for explicit quantity agreements (e.g., "we should agree on 20"), non-quantitative formulations (e.g., "we should buy less") or no agreement at all. A group was characterized accordingly if at least one piece of communication was an *quantitative* or *non-quantitative* agreement.

	(1)	(2)
closed	-1.846**	-1.247
quantitative		-2.517***
non-quantitative		-1.024
constant	23.111***	25.254***
period	-0.074*	-0.033
N	1080	1080
*** 1% level	** 5% level	* 10% level

Table 7.8: Panel Regression Analysis of Firm-Level Outputs for Talk treatments, Clustered at the Group Level.

Out of the 18 groups we have in the Talk treatments, four groups (22.22%) made explicit quantitative agreements at least once. All groups made non-quantitative agreements at least once. It appears that buyer groups often abuse the group as a platform for agreements.

To analyze the effectiveness of these agreements we added the data on agreements to a regression[18] on outputs using the dummy variables *quantitative* and *non-quantitative*

[17]Note that this analysis deliberately falls short of a full categorical analysis of the chat at the individual or group level (see e.g., Charness and Dufwenberg, 2006; Cooper and Kühn, 2013). This would lead to quantifying the number of instances where particular types of statements occur, like threats or promises, which we would then correlate with output decisions. There are various problems with this type of analysis in our case. Most importantly, we have a repeated game whereas previous studies analyze one-shot interactions. For a repeated setting, we suspect that endogeneity problems will arise in that the chat content and output decisions are two sides of the same medal, and that the chat content is unlikely to be a quasi exogenous explanatory variable for market performance. A second problem is that previous economics experiments with content analysis focus on two-player games whereas our oligopolies have three firms. Fay, Garrod and Carletta (2000), however, suggests that groups with more than two players communicate in a fundamentally different way than two-player groups.

[18]We use Newey-West standard errors to control for first-order autocorrelation. The test for autocorrelation in panel data (see Drukker, 2003 and Wooldridge, 2002) shows that in each specification the null hypothesis no first-order autocorrelation can be rejected at the 10% level: (1) $Prob > F = 0.0945$ and (2) $Prob > F = 0.0983$. The results remain qualitatively unchanged.

(see Table 7.8). If a *quantitative* or *non-quantitative* agreement occurred in period t, these dummies were set equal to one from t until the end of the game.[19] We observe that *quantitative* and *non-quantitative* have the expected sign; *quantitative* has a larger effect than *non-quantitative* and only *quantitative* is significant. Finally, note that the constant in the regressions is significantly below the Nash benchmark of 30 (Wald test, $p < 0.001$). This indicates that communication per se has a moderate collusive effect on outputs even when we control for quantitative and non-quantitative agreements. Quantitative agreements, however, significantly intensify the collusive effect.

7.6.4 Welfare

We conclude the discussion of our results with some remarks on welfare. Assuming all firms procure at low cost, welfare (the sum of consumer and producer surplus) monotonically increases in industry output, Q. For our model, welfare is given by $Q^2/2+(a-\underline{c})Q$ as long as $c_1 = c_2 = c_3 = \underline{c}$. In Table 7.3, we saw that in all treatments except for Closed_NoTalk virtually all firms have low costs all the time.

Among our treatments, a social planner would prefer Baseline and Open_NoTalk to the two Talk treatments, and would prefer Open_Talk to Closed_Talk. Closed_NoTalk leads to lower outputs than Baseline and Open_NoTalk which are, moreover, inefficiently procured. Hence, we have a clear-cut policy conclusion against the Closed mechanism and against allowing for communication. Since only buyer groups can obtain the cost reduction, treatment Baseline is not feasible for a policy maker (unless he exogenously imposes the buyer group on firms) but Baseline would not imply better welfare than Open_NoTalk anyway. Overall, then, Open_NoTalk would be the policy maker's first choice.

7.7 Conclusion

In this paper, we analyze the collusive effects of buyer groups as an example of a legal joint market institution. Policy makers are aware that these institutions can be abused

[19]This seems warranted since communication can have strong hysteresis effects, that is, the effect of communication carries over to non-communication phases of experiments. See Isaac and Walker (1988) and Fonseca and Normann (2012).

for collusion, as reflected in the EU *Guidelines on Horizontal Co-operation Agreements* (Guidelines, 2011). Empirically, we know that they often serve as a legal platform for illegal collusion, however, it is unclear how this platforms are used to cartelize a market.

In our theory section, we show that the mutual dependence in buyer groups facilitates tacit collusion. There are two possible channels. First, the threat to abandon the buyer group altogether reduces the minimum discount factor required. Second, closed buyer groups which have the power to exclude specific firms facilitate tacit collusion more strongly. The analysis of the closed buyer group is novel in that it allows for individually targeted punishments which cost the deviator more than the punishing firms.

The experimental section of the paper (five treatments with three-firm Cournot oligopolies) partially confirms these predictions. Without communication, buyer groups per se do not facilitate tacit collusion, in contrast to the prediction. Supporting the theory, the threat resulting from the possibility to exclude a single firm from the buyer group does result in more collusive quantities. While this collusive effect is significant, it is not always the high-output firms that get excluded. Communication can very effectively support collusion, which is in line with previous experiments. Interestingly, communication even has a moderate collusive impact when firms do not abuse the communication stage for explicit quantitative agreements.

Altogether, we confirm the policy makers' concerns with buyer groups. While we do not find "reduced incentives" from joint purchasing (*Guidelines*, point 201), we do observe that excluding competitors from access to the low input prices is welfare detrimental (*Guidelines*, point 203). Finally, the *Guidelines* are right to suspect a "cartel in disguise" (point 205) because buyer groups enable legal communication between firms. Non-exclusionary buyer groups which limit the communication possibilities as far as possible are superior from a welfare perspective.

While competition authorities have become more effective at discovering and prosecuting explicit cartels, there has been far less progress with regards to more tacit forms of collusion. An effective policy for dealing with such forms of collusion has been, and will probably continue to be, identifying facilitating practices and either prohibiting them (in the case that there is no legitimate rationale for that practice) or using that practice - along with market evidence of collusion - to prosecute. Our research aims at understanding what those facilitating practices are: how they operate and what to look for are potentially very relevant with regards to policy.

Appendix

Instructions (translated from the German original, not intended for publication)

Welcome to our experiment.

Please read these instructions carefully. Please do not talk to your neighbors and be quiet during the entire experiment. If you have a question, please raise your hand. We will then come to your booth and answer your question personally.

In this experiment you will repeatedly make decisions and earn money. How much you earn depends on your decisions and on the decisions of two other randomly assigned participants. At the end of the experiment, you will get your profit paid in cash.

All participants receive (and are currently reading) the same instructions.

You will remain completely anonymous to us and to the other participants. We do not save any data in connection with your name.

* * *

In this experiment you will have to make decisions for one of three firms in a market. All three firms sell the same product. You have to buy the product from a supplier and then sell it to the customers. In each round, the quantity sold is equal to the purchased amount.

Throughout the whole experiment you will remain assigned to the same two other firms (or to the participants behind the firms, respectively).

All three firms will decide in each round:

1) Do you want to join a buyer group?
2) What quantity of the good do you want to buy?

The 1st decision:

The decision whether to join a buyer group determines the input price you have to pay per unit. Moreover, firms which have opted to join the buyer group are allowed to chat with each other after the first decision.

Through the joint purchase with one or two other firms, you and all other firms in the buyer group receive a discount. A buyer group can consist of two or three firms. One firm alone cannot form a buyer group, and there can be at most one buyer group in the market. In addition:

1. If no buyer group is established, the input price is 22 Talers per unit.
2. If a buyer group with two firms is established, the input price for the two firms in the buyer group is 10 Talers, and 22 Talers per unit for the outside firm.
3. If all three firms join the buyer group, the input price of all firms is 10 Talers per unit.

In each round you will be informed about the decisions of all firms regarding the buyer group (before the second decision).

Chat:

After the 1st decision you will be allowed to chat with the other members of the buyer group. What you talk about is up to you, however, you must not explicitly agree on targets regarding the output decision. The chat ends after 40 seconds.

The 2nd decision:

You have to choose the purchasing and therefore the sales quantity for your firm. This quantity must be between **10** and **50** units.

The following important rule applies. There is a uniform sales price for all firms in the market, which depends on the selected amount as follows; the greater the total amount of all firms, the lower the price you and the other firms receive in the market for the good. With each additional unit brought into the market, the sale price decreases by one Taler. If the total amount of all firms is 130 or above, the sale price is zero.

Your profit per unit sold is the difference between the sale price and the purchase price, which is (as shown) either 10 or 22 Talers. Note that you make a loss per unit purchased, if the sale price is below the purchase price of 10 or 22 Talers. Your total profit per round is equal to the profit per unit multiplied by the number of units sold.

For simulations of your potential profits, we will provide you with a **"Profit Calculator"**, which we will explain in detail before the start of the experiment.

Once all firms have made their decision you will receive a feedback on the quantity decisions of all three firms, the sale price, the profit you have made in this round, and your current total income for the experiment.

***

The experiment starts with **7 rounds**. Then there will be a change and you will receive new instructions.

As **start endowment** you get **6000 Taler**. This endowment will be offset against your profits and losses from all the rounds and at the end of the experiment, you get **1 Euro** per **1500 Talers** of your total income paid in cash.

2nd part of the instructions

From now on, all three firms have to take three decisions in each round, namely:

1) Do you want to join a buyer group? (as before)
2) Do you want to exclude a firm from the buyer group?
3) What quantity of the good do you want to buy? (as before)

You will still be assigned to the same two firms (or to the participants behind the firms, respectively) as before.

* * *

Now, after the chat, it may come to another decision:

If only two firms decide to join the buyer group or in case that no buyer group is established there is **no 2nd decision** and it continues with the 3rd decision as before. If **all three firms** have opted for joining the buyer group it comes to the **2nd decision**.

The 2nd decision:

In the 2nd decision it is possible to exclude a firm from the buyer group. For this purpose, any firm is able to suggest another firm. When two firms suggest the same firm, that firm will be excluded. The cost of firms inside the buyer group will still be 10 Talers per unit produced while the cost of the excluded firm will be 22 Talers. If no firm is excluded, all firms remain in the buyer group.

You will be informed about the exclusion decisions of all firms and will therefore also now your production costs. (Before the 3rd decision)

* * *

From now on, the experiment will last at least 20 rounds. Then, after each round, it is randomly decided if it comes to another round. The computer randomly chooses a number between 0 and 2. When it chooses "‘1"’ or "‘2"’ another round is played, when it chooses "‘0"’ the experiment is over.

Chapter 8

Conclusion

This dissertation covers six topics from the field of industrial organization in three parts. Each chapter contributes to the existing literature with new insights. The results, however, can never be comprehensive for a certain topic.

Media markets have changed substantially in the last two decades. Many new issues, especially regarding the treatment of market dominant Internet companies like Google or Facebook have come up. The dynamic and constantly changing environment makes it very difficult for policy maker to reasonably react to those new challenges. Chapter 2 to 4 cover three current issues in media markets: habituated behaviour of consumers, market entry in emerging two-sided markets and media bias.

In chapter 2 the impact of habit formation in media markets on the behaviour of a two-sided newspaper platform is analyzed theoretically. Using a simple dynamic approach we find that habit formation (as well as indirect network effects) leads to higher quantities and profits. Price setting, however, strongly depends on network as well as on habit effects.

Chapter 3 analyses the impact of indirect network effects in emerging two-sided markets on prices, quantities, profits and market entry assuming market enlargement induced by indirect network effects. Only if indirect network effects are small, the conventional results of market entry apply, although weakened. If, however, the interconnection between the markets is strong, tighter market structures or even monopolies can be optimal.

The aim of chapter 4 is to analyse a possible influence of the advertisement market on the results of the ASP World Tour in surfing. The close connection of the event with its sponsor, the interest of the latter in the outcome of the event and the observability of the results allow to test the existence of a profit oriented bias. In contrast to the theoretical and empirical predictions no significant influence from the sponsor over the outcome of the contest can be found. The high frequency of exposure and the observability of the decisions are the main reasons for that result.

Beside media markets, the dissertation also regards energy markets. Power markets have to guarantee security of supply and should deliver power economically. These two goals are not always compatible. This conflict is emphasized by the increasing share of power from renewable energy resources which affect the market but in turn do not depend on the market. On the other hand, oil prices affect the whole economy and central banks need to take the right measures to counteract a possible influence. To be able to do this, central banks need to know the time structure of the potential influence.

In chapter 5 the impact of renewable energy sources on the merit order and the wholesale price in Spain is estimated. We use a structural vector autoregressive model for the merit order of production and argue that wind and solar production are exogenous to the system. As expected, the effect is negative for the wholesale price and the produced quantities of most generation technologies. The estimated impact, however, is biggest for mid-merit plants. This finding sheds light on the theoretical discussion which power plants are affected most by renewable energy sources. The effect is also mainly driven by wind power. Solar energy increases wholesale prices as peak plants enlarge their production with more solar power.

Chapter 6 focuses on the impact of the oil price on the German economy. During the last years consumers faced high commodity price volatilities and especially dramatic changes in oil prices. Crude oil is by far the most important commodity as it is used for heating, transport and manufacturing. As a result, there is a renewed interest in the dynamic interrelationship between oil prices and price levels. Furthermore, in the monetary economics literature the question whether central banks should react to oil price shocks is discussed very controversial and still an open issue. In this study we go a step back and ask the question: Is there a stable causal relationship between oil prices and price levels in Germany over time in the sense of Granger? Without such stable relationship, central bank action following oil price shocks would not be justified in every situation. Chapter 6 provides evidence, that only for some periods between 1970 and 2010 oil prices cause price levels, but during most time periods there is no stable relationship.

Cartels are a central issue in competition economics. Competition authorities have become effective in discovering and prosecuting explicit cartels. With regards to more tacit forms of collusion, however, more research is needed to understand what facilitates collusive practices. The goal of Part III is to identify facilitating practices to enable competition authorities to either prohibit them or use them as further evidence to prosecute tacit collusion.

In this case, the experimental approach is very useful as empirical analysis cannot look inside cartels. The results may not be directly transferable to every real life situation but they may help to understand how cartelization works.

Chapter 7 explores whether legal buyer groups, in which firms purchase inputs jointly, facilitate collusion in the product market. In a repeated game, abandoning the buyer group altogether or excluding single firms from them constitute more severe credible threats, hence, in theory buyer groups facilitate collusion. We run several experimental treatments in a three-firm Cournot framework to test these predictions, and we also explore the impact communication has on buyer groups. The experimental results show that buyer groups lead to lower outputs when groups can exclude single firms. Communication is identified as a main factor causing collusive product markets.

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