Essays on the Industrial Organization of Pharmaceutical Markets

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For an intelligent woman named Barbara.

Acknowledgments

Sometimes it's a brief moment that tips the scales. To be honest, before that one day my future supervisor asked me if I would like to start a Ph.D. at his chair, I never thought of writing a dissertation. Now, five years later, I am happy to say: I did it. I would have to lie if I said it was never exhausting, but this made every step I've reached and every success I've achieved so much sweeter. Now the time has come to spend a moment to acknowledge all those, who supported me over the last years.

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Last but not least special thanks go to my first supervisor, Manfred Stadler. Thank you so much for seeing something in me that I didn't know about, for encouraging me and for tutoring me. Thanks to your support, this one student, who clung to her text cards during her first presentation in your colloquium, has grown and gained self-confidence. You have certainly tipped the scales.

Today I can say, that I did not only finish my Thesis but I also have learned a lot - in academics and about myself. Even if this chapter is finished, I'll always be curious about the world and its open questions or, to put it in famous words:

» I am just a child who has never grown up. I still keep asking these 'how' and 'why' questions. Occasionally, I find an answer. «
STEPHEN HAWKING

Tübingen, May 2022
Maximiliane Unsorg

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Chapter 1: Introduction

The economic research presented in this dissertation is motivated by current issues in health economics – a science in between the fields of economics, health sciences, politics and not at least medicine. This dissertation provides theoretical and empirical analyses of the interplay of intra-firm organization, inter-firm competition, market structure and regulation. The research aims to analyze competition on health care markets, to evaluate the effects of regulation on market outcomes and to interpret the policy implications.

This introduction gives a brief overview of each chapter with the respective research questions, key findings and the applied theoretical and empirical methodology. Since health care markets differ from "regular" markets for consumption or service goods in several dimensions, it proves to be useful to start with some basic information regarding the nature of the market in terms of the goods and services provided and the actors involved.

Usually, on health care markets not all participants have perfect information, for example patients (consumers) often lack information on the quality or efficacy of certain drugs. Therefore, medical services as well as drugs can be considered as experience goods. Patients themselves do not (perfectly) know what they need, i.e. which drug or treatment is most suitable for them. They have to trust in the expertise of the prescribing physician or the pharmacist due to information asymmetry. Additionally, the existence of brand-name drugs alongside with generic versions or even branded copies ("me-too") makes it even more difficult for patients to understand the differences. As brand-name drugs we consider those which bring therapeutic novelty and, therefore, obtain a period of patent protection. Generics or branded copies are (often cheaper) alternatives to the original drugs.

Usually, market participants are firms or producers on the supply side and consumers on the demand side. On health care markets, however, there are additional participants where some of them mediate between firms and consumers (patients). These are the government (politicians) and private or statutory health insurers, as well as physicians and pharmacists. Pharmacies are the crucial link between pharmaceutical producers and prescribing physicians on the one hand and patients on the other. Indeed, separation of prescription (by a physician) and dispersion (by a pharmacist) is necessary to avoid that possible profits might influence the prescription decision (Pauly et al., 2012). Patients are particularly vulnerable and need special protection, especially from an exhaustive search for the cheapest pharmacy to obtain their medication.

Health care markets are very seldom characterized by a polypoly on both market sides. Often we observe on the demand side many consumers (patients) and on the supply side only few suppliers or even a monopoly (Fleßa and Greiner, 2020). For example, a brand-name drug producer who is still under patent protection or a hospital which is the only one in a city or county and, hence, supply health care as a monopolist.

The government exercises different tasks on health care markets, as it can (i) act as supplier, e.g. a state hospital, (ii) regulate prices of drugs by implementing reference pricing or determining the insurance premia, and (iii) set up the framework and entry conditions on the market, e.g. with occupational licensing or freedom of establishment. According to that, Pauly et al. (2012) define the framework and rules which have to apply to health care markets. First, the financing has to be determined in terms of insurance types, i.e. either statutory or private health insurance. Second, the access to health care has to be controlled such that no overuse of drugs or health care services arises. Since patient's insurance covers (almost) all costs, market prices cannot send the right signals. And third, the payments from insurers to providers (physicians, pharmaceutical industry or other health care suppliers) have to be determined.

The most important exercise of health economists and policy makers is the analysis of supply and demand for health care goods and based on this analysis the coordination and distribution of those (Fleßa and Greiner, 2020). Health care has to be affordable and available to all patients, therefore, governmental intervention is necessary or even unavoidable sometimes. The main goal of health policy should be to secure the supply of health care, control for high qualitative standards and set incentives for innovative behavior. Every policy measure introduced should be evaluated on this basis. However, due to changes of circumstances, e.g. demographic developments, new diseases or rising expenditures, re-evaluations are often necessary.

The need for clear financing rules becomes evident when considering the demand side. Patients do not bear full cost of drugs or medical services, due to health insurance (statutory or private). Consequently, they do not take these costs into account when making their consumption decisions. In extreme cases, the allocation of resources is determined by the insurance premia instead of market prices, which cannot send the right signals for optimal allocation (Pauly et al., 2012).

The distortion between who bears the major part of costs and who consumes in combination with the fact that health insurers' expenditures are steadily increasing have led to a variety of health care reforms in Germany over the last 30-40 years. Table 1.1 provides an overview over the health care reforms relevant for this dissertation.

In the beginning of the 90's the main goal of the implemented health reforms was to reduce the expenditures of the statutory health insurance. In 1989 the first step in this direction was done by implementing a "first version" of a reference pricing system. Ever since therapeutic equivalent drugs, i.e. drugs treating the same disease, are clustered in one group for which a so-called reference price is defined. Patients demanding drugs with a price above the reference price have to pay the price difference out of their pocket. The aim is to set incentives for brand-name firms to decrease prices on the one hand and to make patients more price sensitive on the other. Today's reference pricing system in combination with a copayment of patients is in place since the law on modernization of the statutory health insurance came into force in 2004. The current system does not only aim at cost and expenditure reduction but also at introducing a more competitive environment. This governmental price regulation is analyzed in the second chapter of this dissertation.

Table 1.1: German Health Reforms

Year	Reform
1989	Health care reform act (Gesundheitsreformgesetz, GRG)
2002	Law on reducing drug expenditures of statutory health insurances (Arzneimittelausgaben-Begrenzungsgesetz, AABG)
2004	Modernization of the statutory health insurance (GKV-Modernisierungsgesetz)
2007	Law on strengthening competition (GKV-Wettbewerbsstärkungsgesetz)
2011	Reorganization of the pharmaceutical market (Gesetz zur Neuordnung des Arzneimittelmarktes, AMNOG)

Notes: Reported are only those policy reforms being relevant for this dissertation. A complete overview can be found in the database of AOK (2022). The abbreviation GKV denotes the statutory health insurance (Gesetzliche Krankenversicherung) in Germany.
Sources: Database of AOK (2022), own summary.

Chapter 2 *"Reference Pricing Systems on the Pharmaceutical Market"* is single-authored and has been accepted for publication in the German Economic Review (see Unsorg, 2022). This chapter theoretically analyzes the effects of the introduction of reference pricing for drugs in combination with a copayment of patients. I develop a theoretical model based on a duopoly market with vertically differentiated firms to analyze the effects of the indirect price regulation on market outcomes.

The two firms are differentiated in terms of the (perceived) quality, i.e. one firm produces a brand-name drug and the other one the generic alternative. The brand-name drug and the generic alternative treat the same disease and, therefore, are clustered in the same reference pricing group. Consumers with a high valuation consume the brand-name drug, while those with a lower valuation will consume the generic alternative. The stylized model allows to derive the effects not only on firms' prices but also on consumer and producer surpluses and expenditures. Furthermore, the welfare optimizing regulation is derived.

As intended, equilibrium prices decrease under reference pricing and a more competitive environment between brand-names and generics is induced. Indeed, generic usage is promoted and a larger proportion of the market covered. Patients consuming the generic drug benefit, while the loss in the producer surplus is mainly borne by the brand-name firm. Overall the introduction of a reference pricing system unambiguously increases welfare. Additionally, the approach of reference pricing is compared to a direct intervention in terms of a price cap.

Apparently, reference pricing and the copayment for patients are not sufficient to dampen the ever rising health care expenditures. In 2011 a large reorganization of the pharmaceutical market has taken place in order to reduce the expenditures of the statutory health insurance. The implemented reform requires pharmaceutical firms to negotiate prices of new drugs with the statutory health insurance before market entry. If firms can prove the therapeutic novelty of the respective new drug before market launch they are allowed to set the drug's price without being subject to reference pricing for a certain period. This reform has put a lot of pressure on the pharmaceutical firms since it dampened the profit margin significantly and the need to reduce (production) cost has grown. This topic in combination with complex intra-firm organizational structures in the pharmaceutical industry has motivated the research idea presented in the third chapter.

Chapter 3 *"Manager Delegation, Owner Coordination and Firms' Investment in Automation"* is based on joint work with Manfred Stadler (see Stadler and Unsorg, 2022). The chapter develops a theoretical multi-stage game combining different existing approaches of industrial organization to analyze the effects of intra-firm structures on the competitive strategies of firms in the market. Firms are characterized by a mixed ownership structure with independent owners and common ownership via institutional owners. Furthermore, owners delegate all operational decisions like investments in cost-reducing activities, capacities and prices to specialized managers.

The issue of common ownership is of non-negligible importance. In 2018 the German Monopolies Commission has emphasized the increasing influence of common ownership on market structure and economic outcomes in their annual report. Motivated by these findings, Chapter 3 provides an illustrative case study of mixed ownership structures in the pharmaceutical industry. Some of the largest asset management companies (as reported by the German Monopolies Commission, see Table 1.2) indeed also hold shares in several pharmaceutical companies, e.g BlackRock, Vanguard Group or Capital Group. This supports the assumptions in the presented theoretical research. In addition to these complex intra-firm structures the need for automation and cost-reduction in the pharmaceutical industry is obvious: due to health reforms they are forced to cut their budgets or reduce costs (see Table 1.1).

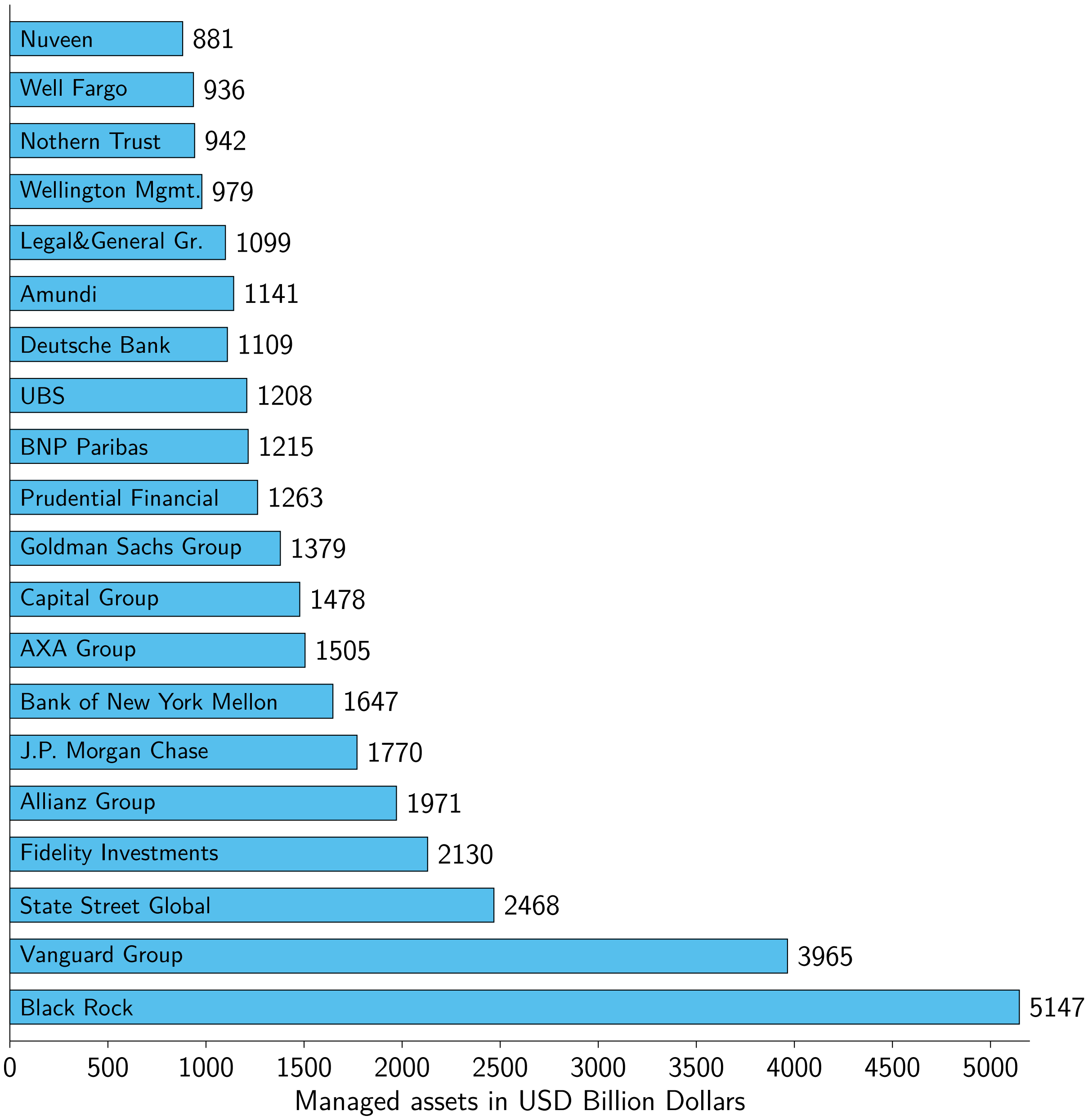
In the first stage of the game, independent and coordinated owners decide on the incentive parameters of the compensation contracts, which consist of a fixed and a variable payment depending on profits and sales. In the second stage, managers decide on the investments in automation, in the third stage on capacities and in the last stage they set prices. The model analyzes the effects of mixed ownership and manager delegation in combination with investments in automation, which to our best knowledge has not been done in the existing literature so far.

The new results aim at closing the gap in the literature a little further. Firms subject to common ownership invest less in automation and achieve lower profits than firms with independent owners which is in accordance with empirical evidence. By conducting a welfare analysis it can be shown that, depending on the technological opportunities, mixed ownership structures in combination with manager delegation lead to the highest social welfare.

After many years of cost-containment policy, the government started to implement competition-enhancing reforms. In 2004 and 2007 reforms on modernization of the statutory health insurance and on strengthening the competition have come in force. Among other targets, the reform in 2004 aimed at enforcing more competition on the market of pharmacies which is analyzed in depth in the fourth chapter.

Chapter 4 *"Entry Regulation and Competition. Evidence from Retail and Labor*

Table 1.2: Largest Asset Management Companies



Notes: Data retrieved from annual report of German Monopolies Commission (2018).

Markets of Pharmacists" is based on joint work with Davud Rostam-Afschar (see Rostam-Afschar and Unsorg, 2021). The chapter assesses the reform effects of the liberalization of the multiple-ownership ban on the pharmacy market with respect to the retail and the labor market of pharmacists. Since 2004 pharmacists are allowed to run chains with up to four stores.

We develop a theoretical model where firms locate on a circular city and decide on their optimal store number given the specific characteristics of the pharmacy market. The model allows to assess the decisive factors for chain entry in local markets. It suggests that the governmental limitation to four stores only is excessively restrictive. Depending on the specific regional market's characteristics it might be competition-enhancing to allow for larger chains. Labor demand per firm increases, while the demand per store is lower in comparison to a pre-reform situation. The findings of the theoretical model are in line with the results of our empirical analysis.

We use the very rich information from administrative panel data matched with survey data from the Federal Statistics Office. Due to mandatory and annual reporting in the administrative panel all German pharmacies can be observed over the time period from 2002 to 2009. The analysis in this chapter is based on two empirical approaches. First, the impact of the policy change is quantified with a potential outcomes framework. We contrast outcomes to several counterfactuals to quantify the impact of the liberalization. Second, we estimate the relationship of market concentration and employment to assess the reform impact on employment.

We find that, as a consequence to chain entry, competition on the product market is intensified. After the reform, entry rates of chains are higher and their market shares are larger. The market concentration is decreasing for markets where chains entered. On the labor market we find that chain entry has positive effects on the employment overall. Additionally, the number of employees per firm is increasing for chains.

The research questions addressed in the chapters of this thesis are all motivated by (recent) developments on the health economic markets and are analyzed by applying and extending different approaches of industrial organization. The aim of this dissertation is to gather a better understanding of theoretical and empirical industrial organization in the pharmaceutical markets.

Finally, Chapter 5 summarizes and discusses the findings of this dissertation and draws conclusions from the research presented in the main chapters. Implications for policy and suggestions for future research and open questions will be addressed.

Chapter 2: Reference Pricing Systems on the Pharmaceutical Market*

Constantly rising expenditures for pharmaceuticals require government intervention in firms' pricing decisions. To this end, reference pricing systems are a frequently employed regulatory mechanism. This chapter considers a duopoly market with vertically differentiated firms highlighting the effects of a reference pricing system on prices, consumer and producer surplus, expenditures and welfare. Reference pricing decreases equilibrium prices and induces a more competitive environment. It promotes generic usage leading to increased market coverage. Especially generic consumers benefit from this regulation. The losses in producer surplus are mainly borne by the brand-name firm. Introducing a reference pricing system unambiguously increases welfare.

Keywords: reference pricing · pharmaceutical market · copayment · price cap · price competition · expenditures · consumer surplus

JEL Classification: I11, I18, L51

*This chapter "Reference Pricing Systems on the Pharmaceutical Market" is published in the German Economic Review (see Unsorg, 2022).

2.1 Introduction

Worldwide, the market for pharmaceuticals is subject to various regulations: from mere copayment systems affecting patients' decisions, to price caps or reference pricing regulating firms' price setting. Rising expenditures of statutory health insurances and increasing fees or copayments for patients due to high drug prices have led to a multitude of regulatory instruments - often applied in combination with each other in order to dampen expenditures on consumer and insurer side.

In addition to high-priced drugs, information asymmetry further increases expenditures. Drugs exhibit characteristics of confidence goods, therefore, a situation with asymmetric information arises as consumers cannot determine the quality of the drugs with certainty. Indeed, patients often do not know about the existence or substitutability (López-Casanovas and Puig-Junoy, 2000) of these cheaper alternatives, like generics, or they believe that they are of inferior quality (due to their lower price). Therefore, patients tend to purchase high-priced brand-name drugs instead of their alternatives. This lack of information leads to unnecessarily high expenses since brand-name drugs are significantly more expensive in comparison with their alternatives.

In order to dampen the increase in expenditures and to overcome the high price difference between the drug types, among other regulatory measures, reference pricing systems have been implemented in several (European) countries, e.g. Germany, France, and Spain (Kaiser et al., 2014). This chapter analyzes the effects of reference pricing on market outcomes such as prices, consumer and producer surplus, expenditures - on the one hand for consumers (patients) and on the other hand for health insurers - and welfare. Government intervention in pharmaceutical pricing is necessary to protect consumers from excessively high prices and to ensure their access to medicines.

I develop a theoretical model with vertically differentiated firms as a basis for the empirical results provided by the literature. The model captures the effects of reference pricing on market outcomes and derives the optimal level of regulation. Furthermore, it contrasts the findings with the market outcomes under an alternative price regulation, i.e. a price cap. The chapter assesses the differences in the two regulatory mechanisms, evaluates the outcomes, and derives the social planner's solution. Depending on a regulator's intention, each of the systems has some advantages.

Reference pricing decreases prices, stimulates generic demand, and significantly decreases expenditures, especially for consumers of the generic drug, and for health insurers. Further, reference pricing increases market coverage and consumer surplus while simultaneously and unambiguously reducing overall expenditures: the increase in demand is compensated for by a sufficiently large decrease in prices. The improved medical supply in combination with lower prices lead to an increase in consumer surplus. Under a reference pricing system, the brand-name firm is subject to even stronger regulation than the generic producer. This is not the case under a price cap regulation. The socially optimal price cap reduces firm profits to zero.

The chapter is organized as follows: Section 2.2 gives a brief insight into the institutional background, Section 2.3 relates the article to the existing literature, Section 2.4 presents the theoretical model including a welfare analysis. Section 2.5 provides the theoretical analysis of a price cap. Section 2.6 concludes.

2.2 Institutional Background in Germany

Although being quite a specific kind of price regulation, reference pricing is applied in many European pharmaceutical markets. This section briefly considers the institutional background in order to clarify the regulatory mechanism and the applied reimbursement scheme. The pharmaceutical market is highly innovative and always subject to change: new drugs are continually introduced to the market, often bringing therapeutic advantages for the patients achieved after a long period of research and development. In order to compensate the firms for their research expenditures for inventing new drugs, these brand-name firms obtain a period of patent protection (Verband forschender Arzneimittelhersteller, 2015) for their invention.

During this period, the firms can set their price freely on the German market if - and only if - the new drugs are "sufficiently innovative" (Bundesgesundheitsministerium, 2016). This criterion is imposed on firms when entering the market.

Hence, if firms cannot prove the therapeutic advantages and novelty of the drug, their product will be clustered with other drugs (therapeutically equivalent, i.e. treating the same diseases or symptoms) right away and, therefore, be subject to price regulation from market entrance onwards.

Besides these original drugs, over time, rival firms come up with cheaper alternatives such as generics, or branded copies. While the former can enter the market after patent expiry only, the latter can directly enter without violating the patent protection of the brand-name drug ("inventing around"). Thus, many slightly different drugs exist on the market, capable of treating the same diseases but categorized into: brand-names, generics or branded copies.

Generic drugs as well as branded copies treat the same diseases as the associated original drug, one also speaks of therapeutic equivalence. Generics are (more or less exact) copies of the original brand-name drug, since they contain the same active substance in combination with varying additive components. Therefore, they are not only characterized by therapeutic but also by pharmacological equivalence.

In comparison, branded copies consist of different active substances and, therefore, these drugs are of therapeutic equivalence only. Consequently, they are not violating the patent protection and can enter the market at the same time. Generic versions, due to their pharmacological equivalence, have to wait for the patent to expire in order to enter the market. Depending on the type of reference pricing, two kinds of clustering can be applied: either generic reference pricing (GRP) or therapeutic reference pricing (TRP).

In Germany, drugs are usually clustered according to their therapeutic equivalence (Danzon and Ketcham, 2004), hence, drugs treating the same diseases will be subject to the same reference price group (Dingermann, 2013). Consequently, the brand-name drug can be clustered with its respective generic versions as well as with branded copies. The resulting reference price then is a (linear) combination of those initially announced drug prices clustered in the respective group of interchangeable (therapeutically equivalent) medicines (Herr and Suppliet, 2011).

Health care systems' expenditures have risen continuously over the last years. Therefore, to dampen the increase in consumer and, especially insurer expenditures, reference pricing systems are applied as cost containing measures. If patients do not actively decide to take out private health insurance, they are required to be insured via a statutory health insurance (Schöffski et al., 2008). When insured in a statutory health insurance, patients have to bear a (percentage) part of the drug price (copayment) only in addition to their (fixed) insurance premium. The remaining amount is funded by their insurance. The German reimbursement scheme patients face when purchasing a prescription drug is differentiated even further and described in Figure 2.1 (Herr and Suppliet, 2011; Bundesgesundheitsministerium, 2019).

Figure 2.1: Reimbursement Scheme Germany

$$\text{copayment} = \begin{cases} \text{p} & \text{if} \quad \text{p} < 5\,€ \\ 5\,€ & \text{if} \quad 5\,€ \leq \text{p} < 50\,€ \\ 0.1 \times \text{p} & \text{if} \quad 50\,€ < \text{p} \leq 100\,€ \\ 10\,€ & \text{if} \quad 100\,€ < \text{p} \end{cases}$$

Consequently, patients tend to overuse drugs, see López-Casanovas and Puig-Junoy (2000), since they do not fully consider the high price difference between the brand-name drug and its therapeutic alternatives. The reference price implies a further payment for the consumers when purchasing the brand-name drug. In addition to their regular copayment, they have to pay the amount by which the brand-name's price is higher than the respective reference price, which could be described as a "financial penalty" (Farfan-Portet et al., 2012).

To keep the theoretical analysis tractable, the model in this article only considers patients covered by statutory health insurance purchasing drugs in the intermediate price range where patients have to bear a percentage of the price themselves. In Germany, patients are required to pay 10%, equivalent to a copayment-rate k equal to 0.1 (see Figure 2.1), of the prescription drug price when it lies in the range of 50 € to 100 €.

The following analysis does not include so called over-the-counter products (OTC). OTC products or drugs are available in pharmacies as well, however, no prescription is necessary and OTC drugs can be subject to free price competition. A physician prescribes a drug, or rather an active substance, to treat the patient's disease. Afterwards, the patient can decide in the pharmacy which drug (brand-name or generic) to consume. Therefore, the price difference between the drug types indeed plays a role - at least to a certain degree via the copayment. Consequently, for the demand determination I consider the consumer indifferent between the two drugs and the consumer indifferent between the generic drug and no consumption at all.

2.3 Literature Review

The presented research contributes to the literature on the effects of price regulation on market outcomes, expenditures, and welfare with regard to health care markets. In general, the literature related to reference pricing often refers to specific markets and their characteristics while the application of reference pricing is quite similar across countries. Therefore, this section also considers theoretical and empirical literature beyond the German pharmaceutical market.

Instead of responding to the entrance of generic substitutes with a price decrease, brand-name firms continue their high-price strategy (Scherer, 1993) or even increase their prices to reach brand-loyal customers (Dalen et al., 2006). Generics, however, due to intense competition among each other, continue with low prices (Grabowski and Vernon, 1992). These findings are in line with the "generic competition paradox" (Frank and Salkever, 1997) and justify the need for price regulation on the pharmaceutical market. Pavenik (2002) finds that reference pricing indeed leads to lower prices for both firms, with the decrease being even stronger for the brand-name firm, and to intensified competition (see also Brekke et al., 2007). Using a Norwegian policy experiment where reference pricing replaced a price cap regulation, Brekke et al. (2009) can confirm that reference pricing indeed reduces prices with a stronger reaction of the brand-name firm. However, the authors do not provide an explicit theoretical solution.

Brekke et al. (2011) and Herr et al. (2014) derive significant cost savings on the insurance side as a consequence of the applied price regulation. In contrast, reference pricing might induce higher demand due to lower prices and consequently cause increasing expenditures (Miraldo, 2007). Based on the data on patients' price sensitivity collected upon a reference price reform in Denmark, Kaiser et al. (2014) show that expenditures decline more strongly under a more restrictive reference price calculation. With respect to these findings, the model presented in this chapter indeed can account for an increase in the demand for generic drugs due to lower prices, and at the same time derives that reference pricing leads to a decrease in expenditures.

Puig-Junoy (2005) analyzes reference pricing on the highly regulated Spanish statin market, finding a decline in prices for off-patent brand-names as well as for generics. The decline was not associated with higher competition but directly with the regulation. Further, it can be confirmed that expenditures decline stronger under a more restrictive reference price. Brekke et al. (2016) focus on the effects of reference pricing on generic entry. The authors find that generic entry can be reduced when implementing a reference pricing system. However, the authors find ambiguous effects on pricing only.

Indeed, on the German market prices of brand-name drugs subject to reference pricing decrease and competition intensity is higher in clusters where GRP is applied instead of TRP (Podnar et al., 2007). However, TRP should be preferred since this regulation minimizes mismatch costs and prices (Königbauer, 2006) and reference pricing should in general not be applied as a stand-alone regulation but rather as a supporting mechanism (Drummond et al., 2010).

To a great extent the literature on reference pricing provides empirical analyses. Explicit theoretical solutions complementing the empirical research rarely exist. Therefore, this chapter focuses on deriving explicit solutions for the firms' pricing under regulation and shows that indeed prices decrease with the decrease being more pronounced for the brand-name firm. Which is in line with the empirical findings from Brekke et al. (2009); Pavenik (2002). Additionally, the model also can account for a decrease in expenditures (compare Kaiser et al., 2014).

2.4 Reference Pricing

This article examines a vertically differentiated duopolistic market with a brand-name firm ($i = 1$) producing an original drug and second firm ($i = 2$) producing a generic version.[1] A constant copayment-rate, $k \in [0, 1]$, which the consumers face when purchasing a drug, is assumed. Thus, the patients bear a proportional part of the drug costs while the remaining amount is covered by the statutory health insurance.

The brand-name drug 1 and the drug of firm 2 differ in their perceived[2] quality, where the quality of firm 1 is assumed to be as high as the current research status allows ("state-of-the-art"), i.e. $\theta_1 = 1$. The quality of firm 2 is denoted by θ, with $0 < \theta < \theta_1 = 1$.

The consumers are uniformly distributed according to their drug valuation $\tau \in [0, 1]$. Consumers with a relatively high valuation prefer the brand-name drug since they are willing to pay a higher price for the higher (perceived) quality. Consumers with a lower drug valuation are not committed to purchasing a specific drug and, therefore, will decide to purchase the alternative drug due to its lower price.

The utility from buying one unit of the drug is given by the direct utility from drug consumption (as the product of the consumer's valuation and the quality) minus the consumer's copayment, i.e. c_i, $i \in \{1, 2\}$. The consumer's utility is defined as

$$U(\tau, \theta_i) = \begin{cases} \tau\theta_i - c_i & \text{if consumer buys one unit of drug } i \\ 0 & \text{otherwise,} \end{cases}$$

with the respective copayment as

$$\mathrm{c}_i = \begin{cases} kp_1 + (p_1 - p_R) & \text{for } \ i = 1 \\ kp_2 & \text{for } \ i = 2. \end{cases}$$

[1] The analysis applies only to drugs which are available on prescription and, therefore, covered by statutory health insurance. OTC products are not included. After receiving a prescription patients are free to choose which drug to consume, i.e. generic or brand-name.

[2] Uninformed consumers might perceive the alternative drug as being of inferior quality.

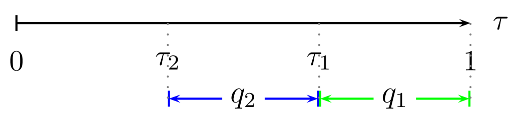
Both firms charge positive prices p_i, $i \in \{1,2\}$. The endogenous reference price is defined as a linear combination of the two drug prices

$$p_R = \alpha p_2 + (1-\alpha)p_1,$$

where $\alpha \in [0,1]$ describes the weight put on the two prices. The limit case of $\alpha = 0$ in the subsequent results depicts the unregulated situation where consumers only pay the amount resulting from the copayment-rate k. The higher the weight α, the more restrictive the regulation and, hence, the lower the implemented reference price.

The consumer indifferent between the brand-name drug and its alternative is located at $\tau_1 = ((k+\alpha)(p_1 - p_2))/(1-\theta)$ and the consumer indifferent between the alternative drug and no purchase is located at $\tau_2 = (kp_2)/\theta$. The demand system[3] follows as depicted in Figure 2.2.

Figure 2.2: Demand System



Hence, the demand functions read $q_1 = 1 - \tau_1$ and $q_2 = \tau_1 - \tau_2$, with the demand for drug 2 responding more sensitively to price changes than the demand for the brand-name drug, i.e. $\frac{\partial q_2}{\partial p_2} < \frac{\partial q_1}{\partial p_1}$.

The firms' profits are given by the sum of the direct revenues obtained from consumers and the revenues obtained from the statutory health insurance. Production costs are assumed to be zero.[4] Firm profits are

$$\pi_i = \underbrace{kp_iq_i}_{\text{consumers}} + \underbrace{(1-k)p_iq_i}_{\text{insurance}} = p_iq_i\,, \qquad i \in \{1,2\}.$$

The firms sequentially decide upon their prices with the brand-name firm moving

[3] It is assumed that $\tau_1 > \tau_2$, the proof can be given by substituting the prices calculated in the following.

[4] Further, the costs for the quality development and R&D expenditures are assumed to be sunk and are neglected here.

first[5]. Firm 1 anticipates the reaction of the follower given by the reaction function of firm 2

$$R_2(p_1) \equiv p_2 = \frac{(k+\alpha)\theta}{2(k+\alpha\theta)}\, p_1. \tag{2.1}$$

Substituting equation 2.1 into the profit function leads to the reduced-form optimization problem for firm 1

$$\pi_1 = p_1 \left[1 - \frac{(k+\alpha)(2k+(\alpha-k)\theta)}{2(1-\theta)(k+\alpha\theta)}\, p_1\right].$$

The resulting equilibrium prices are

$$p_1 = \frac{(1-\theta)(k+\alpha\theta)}{(k+\alpha)(2k+(\alpha-k)\theta)} \qquad \text{and} \qquad p_2 = \frac{\theta(1-\theta)}{2(2k+(\alpha-k)\theta)}. \tag{2.2}$$

The lower the reference price, the more the firms will decrease their prices, i.e. $\frac{\partial p_i}{\partial \alpha} < 0$. The brand-name firm is directly affected via the additional copayment. Firm 2 realizes an indirect effect. Since prices are strategic complements, firm 2's price also decreases under a more restrictive reference price. Nevertheless, the decrease in the price of firm 2 is comparably small, i.e. $\frac{\partial p_1}{\partial \alpha} < \frac{\partial p_2}{\partial \alpha}$. In Figure 2.6 in the appendix the strong price decrease of firm 1 is visible.

The copayment-rate negatively affects the pricing decision of both firms, i.e. $\frac{\partial p_i}{\partial k} < 0$. The relative price ratio decreases in the weight of the reference price, hence, fiercer price competition can be induced by the regulation

$$\frac{\partial(p_1/p_2)}{\partial \alpha} = \frac{2k^2 - 2k\theta}{(k+\alpha)^2\theta^2} < 0.$$

In contrast, the influence of the copayment-rate on the relative price ratio is positive - a higher copayment decreases the competition intensity between the two firms

$$\frac{\partial(p_1/p_2)}{\partial k} = \frac{2\alpha\theta - 2\alpha\theta^2}{(k+\alpha)^2\theta^2} > 0.$$

[5]The analysis of a simultaneous price decision can be found in Unsorg (2018). The main results differ only slightly between the two timing structures.

The equilibrium generic market share results as

$$\gamma = \frac{q_2}{\sum_{i=1}^{2} q_i} = \frac{k + \alpha\theta}{3k + (2\alpha - k)\theta},$$

with $i \in \{1, 2\}$. The more restrictive the reference price is, the higher the generic market share will be, i.e.

$$\frac{\partial\gamma}{\partial\alpha} = \frac{k\theta - k\theta^2}{(3k + (2\alpha - k)\theta)^2} > 0.$$

Consumers tend to purchase more of the generic drug when a low reference price is implemented. However, the higher demand for generic drugs is not due to a switching behavior of consumers from the brand-name drug to the generic version. The consumption decision can be analyzed when examining the location of the respective indifferent consumer. When substituting for the equilibrium prices, the consumer who is indifferent between the two drug types is not affected by the reference price, i.e. $\tau_1 = 1/2$.

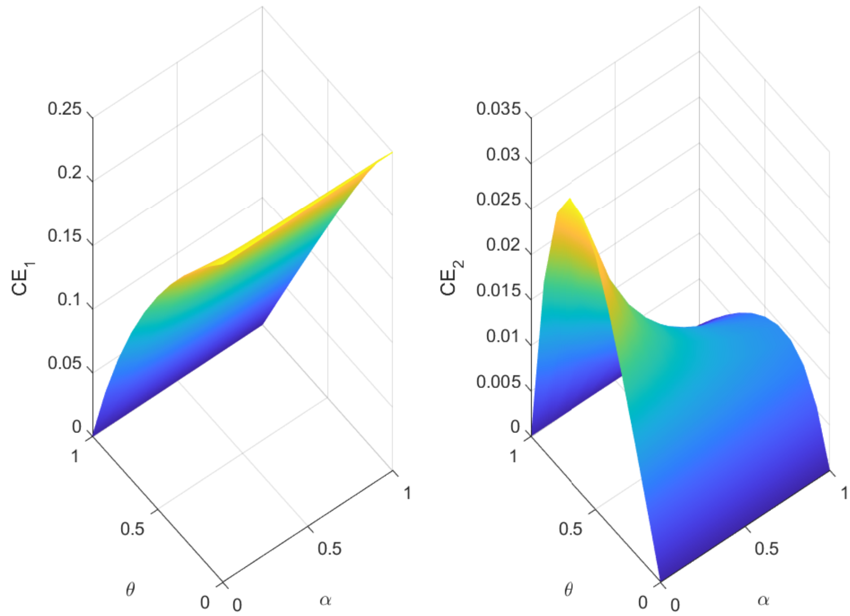
The higher generic usage results from a movement of the location of the second indifferent consumer to the left, i.e. $\frac{\partial\tau_2}{\partial\alpha} < 0$. The fraction of consumers who do not purchase decreases. So, while consumers cannot be incentivized to switch from the brand-name drug to its generic version, higher market coverage can be induced by the reference price

$$Q = \sum_{i=1}^{2} q_i = \frac{3k + (2\alpha - k)\theta}{2(2k + (\alpha - k)\theta)},$$

with $i \in \{1, 2\}$ and $\frac{\partial Q}{\partial\alpha} > 0$, $\frac{\partial Q}{\partial k} < 0$.

So, while prices are lower when firms are regulated, the demand for drugs increases since consumers face lower prices for both drugs. Hence, two contrary effects have an impact on consumer expenditures: lower prices decrease costs per drug, while higher demanded quantities might increase expenditures overall. The expenditures are divided between the proportion consumers bear themselves and those paid for by the health insurance. Consumer expenditures per drug-type can be derived by $CE_i = c_i q_i$ with $i \in \{1, 2\}$ and c_i being the copayment for the respective drug.

Figure 2.3: Consumer Expenditures



Notes: Graphical illustration of equations 2.3 for the consumer expenditures for both drug types. The copayment-rate is set at $k = 0.1$, the generic drug quality varies in the interval $0 \leq \theta \leq 1$ and the weight of the reference price in $0 \leq \alpha \leq 1$.

The expenditures per drug-type follow as

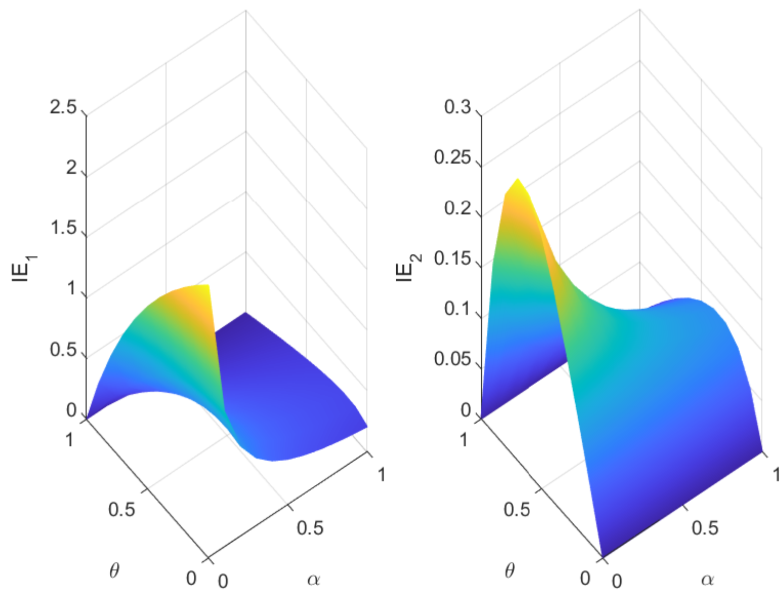
$$CE_1 = \frac{(1-\theta)(2k+\alpha\theta)}{4(2k+(\alpha-k)\theta)} \qquad \text{and} \qquad CE_2 = \frac{k\theta(1-\theta)(k+\alpha\theta)}{4(2k+(\alpha-k)\theta)^2}. \tag{2.3}$$

Consequently, the overall consumer expenditures are

$$CE = \sum_{i=1}^{2} c_i q_i = \frac{(1-\theta)(4k(\alpha\theta+k)+\theta(\alpha^2\theta-k^2))}{4(2k+(\alpha-k)\theta)^2},$$

with $i \in \{1,2\}$. When considering the expenditures of the consumers for the respective drug, a crucial difference becomes visible with regard to the effect of the reference price weight α (see Figure 2.3).

Figure 2.4: Insurance Expenditures



Notes: Graphical illustration of equations 2.4 for the insurance expenditures for both drug types. The copayment-rate is set at $k = 0.1$, the generic drug quality varies in the interval $0 \leq \theta \leq 1$ and the weight of the reference price in $0 \leq \alpha \leq 1$.

While the expenditures of those patients purchasing the generic drug decrease significantly, those of brand-name consuming patients do not undergo a decrease of comparable size. This effect is due to the additional payment in the amount of the price difference between brand-name price and reference price. Overall, the effect of the price decrease just dominates the higher demand for drugs, therefore, consumer expenditures decrease under reference pricing. On the insurer side, the expenditures per drug-type can be calculated by $IE_i = (1-k)p_i q_i$ with $i \in \{1,2\}$ and follow as

$$IE_1 = \frac{(1-k)(1-\theta)(k+\alpha\theta)}{2(\alpha+k)(2k+(\alpha-k)\theta)} \qquad \text{and} \qquad IE_2 = \frac{(1-k)\theta(1-\theta)(k+\alpha\theta)}{4(2k+(\alpha-k)\theta)^2} \tag{2.4}$$

The total expenditures of the insurer follow as

$$IE = \sum_{i=1}^{2}(1-k)p_i q_i = \frac{(1-k)(1-\theta)(k+\alpha\theta)(4k+(3\alpha-k)\theta)}{4(\alpha+k)(2k+(\alpha-k)\theta)^2},$$

with $i \in \{1,2\}$, where, in contrast to the consumers' expenditures, only the copayment-rate k is considered. This is due to the fact that the additional amount brand-name consuming patients have to bear does not apply for the insurance. The additional amount born by brand-name consumers is paid to the health insurance, which will become relevant when considering welfare.

Once again, it is worthwhile to differentiate between the two drug types and look at the expenditures separately (see Figure 2.4). The decrease in expenditures for the generic drug exhibits a similar shape as we have seen for the consumers before. Whereas for the brand-name drug, the expenditures on the insurer side unambiguously decrease with the introduction of a regulation (i.e. with an increasing weight of the reference price α).

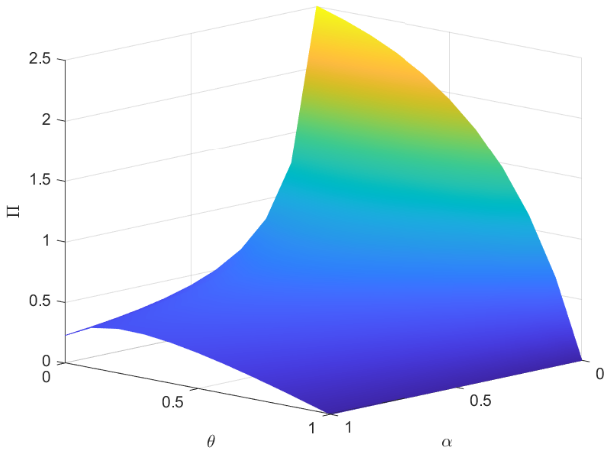
Eventually, when considering the overall expenditures, i.e. $E = CE + IE$, a decrease due to the regulation can be confirmed. When introducing reference pricing, expenditures on the consumer and the insurer side can be reduced. This effect is stronger the more restrictively the reference price is set by the regulator, i.e. a higher α. A larger part of overall savings in expenditures is allocated to health insurers.

As a result of the decrease in consumer expenditures and of the higher market coverage, consumer surplus increases

$$\begin{aligned} CS &= \int_{\tau_1}^{1}(\tau\theta_1 - c_1)\,\mathrm{d}\tau + \int_{\tau_2}^{\tau_1}(\tau\theta_2 - c_2)\,\mathrm{d}\tau \\ &= \frac{3+\theta}{8} + \frac{(1-\theta)(\theta^2(k^2-2\alpha^2)+k\theta(k-8\alpha)-8k^2)}{8(2k+(\alpha-k)\theta)^2}. \end{aligned}$$

A stricter regulation and lower perceived quality difference ($\theta \to 1$) increase consumer surplus. In order to induce a higher consumer surplus, patients should be informed about the non-existence of a significant quality difference. If consumers perceive generics as being of similarly high quality, consumer surplus could be

Figure 2.5: Producer Surplus



Notes: Graphical illustration of equation 2.6 for the overall producer surplus. The copayment-rate is set at $k = 0.1$, the generic drug quality varies in the interval $0 \leq \theta \leq 1$ and the weight of the reference price in $0 \leq \alpha \leq 1$.

increased.

Finally, the two firms' profits remain to be calculated and follow as

$$\pi_1 = \frac{(1-\theta)(k+\alpha\theta)}{2(\alpha+k)(2k+(\alpha-k)\theta)} \qquad \text{and} \qquad \pi_2 = \frac{\theta(1-\theta)(k+\alpha\theta)}{4(2k+(\alpha-k)\theta)^2}. \tag{2.5}$$

In contrast to the consumer surplus, the producer surplus, $\Pi = \pi_1 + \pi_2$, see equation 2.6, decreases if a more restrictive reference price is implemented. The increase in demand cannot compensate for the loss due to lower prices, hence, both firms' profits decrease. In Figure 2.5 the overall producer surplus is depicted.

$$\Pi = \frac{(1-\theta)(k+\alpha\theta)(4k+(3\alpha-k)\theta)}{4(\alpha+k)(2k+(\alpha-k)\theta)^2} \tag{2.6}$$

Producers undergo a huge loss in surplus when reference pricing is introduced. For the brand-name firm, it is preferable that the original drug is perceived as being of high quality in comparison with the generic version. A high level of (perceived) differentiation would support the high-price strategy of firm 1. Firm 1 has to bear a larger part of the loss in producer surplus, see Figure 2.7 in the appendix. The brand-name producer's profits undergo a higher loss due to the stronger price decrease of the original drug. The generic firm's profit loss is comparably small, nevertheless, its profits unambiguously decrease in α.

The effect of an increase in θ works into both directions. For a lower (perceived) quality profits increase and for a quality closer to the upper limit ($\theta \rightarrow \theta_1 = 1$) profits of the generic firm decrease. This is quite intuitive the higher the quality of the firm producing the generic drug, the smaller the differentiation between both firms, and the smaller the differentiation between the two firms, the lower the price difference, see Figure 2.6. While the price of the brand-name drug unambiguously decreases in α as well as in θ, the price of the generic version follows a pattern similar to the one of the generic profits.

For the interval borders of the (perceived) quality of the generic drug, $\theta = 0$ and also when allowing for $\theta = 1$, the price and profit of the generic firm equal zero. Clearly, when providing zero quality the firm cannot set a positive price and for $\theta = 1 = \theta_1$ firms are homogeneous and, therefore, price competition would drive the prices down to zero. Nevertheless, θ is smaller than $\theta_1 = 1$ by assumption, which makes the case of $\theta = 1$ a theoretical benchmark only.

The analysis finally leads to the question whether introducing a reference pricing system leads to an increase in overall welfare or whether the regulation of the firms leads to a decrease. Overall welfare is calculated as the sum of consumer surplus CS, producer surplus Π and the additional proportion patients have to pay to the health insurance when purchasing the brand-name drug $(1 - \tau_1)(p_1 - p_R)$ minus the insurance expenditures. Therefore, welfare in a health care market results as

$$\begin{aligned} W &= CS + \Pi + (1 - \tau_1)(p_1 - p_R) - IE \\ &= \frac{3 + \theta}{8} - \frac{k^2\theta(1 - \theta)^2}{8(2k + (\alpha - k)\theta)^2}. \end{aligned} \tag{2.7}$$

A social planner intending to maximize overall welfare (equation 2.7) decides for a strict regulation in the form of $\alpha^* = 1$ because $\partial W / \partial \alpha > 0$ for all possible α (equation 2.8).

$$\frac{\partial W}{\partial \alpha} = \frac{k^2\theta^2(1-\theta)^2}{4(2k+(\alpha-k)\theta)^3} > 0 \tag{2.8}$$

Further, due to the negative derivation of the welfare with respect to the copayment-rate k, i.e. $\partial W/\partial k < 0$, the social planner aims for the corner solution of a very low copayment-rate as well. While opting for the corner solution of $k^* = 0$ leads to a significant increase in insurance expenditures, it also increases producer surplus since consumers tend to consume more.

2.5 Price Cap

To assess the effects of reference pricing on market outcomes and welfare completely, this section derives the most important outcomes under an exogenously given and binding price cap for the brand-name drug 1, $p_1 = \bar{p}_1$. Substituting this price cap $\bar{p}_1$ into the price reaction function of firm 2 (equation 2.1) yields the generic price $p_2^{PC} = \frac{\theta}{2}\bar{p}_1$.

A first shortcoming of this kind of regulation becomes visible in the price ratio which does not change in comparison to the benchmark case ($\alpha = 0$), i.e. $\bar{p}_1/p_2^{PC} = 2/\theta$. Hence, the price cap cannot induce fiercer competition. Further, it is sufficient to solve for the generic market share

$$\gamma^{PC} = \frac{k\bar{p}_1}{(1-\theta)(2-k\bar{p}_1)}.$$

The generic market share is increasing with the price cap, i.e. $\partial\gamma_{PC}/\partial\bar{p}_1 > 0$. Consequently, decreasing the price cap leads to a lower generic market share, which constitutes a second shortcoming. A regulator would implement the lowest possible price cap to induce low prices, but this does not stimulate generic usage. A change in the price cap of a regulated product leads to a change in the same direction for the non-regulated product since prices are strategic complements. The price cap directly reduces prices but cannot overcome the price difference between the two drugs. However, when comparing the systems, the regulation via a price cap decreases the generic price more strongly.

Overall consumer expenditures follow from $CE^{PC} = \sum_i kp_iq_i$ with $i \in \{1,2\}$ where patients only bear their proportion k of the price regardless of the consumed drug as

$$CE^{PC} = k\bar{p}_1 - \frac{k^2(4-3\theta)}{4(1-\theta)}\bar{p}_1^2.$$

Since consumers of the brand-name drug do not need to bear the additional costs imposed by a reference price, consumer expenditures are lower under a price cap. Insurance expenditures follow as

$$IE^{PC} = (1-k)\left(\bar{p}_1 - \frac{(4-3\theta)k}{4(1-\theta)}\bar{p}_1^2\right),$$

while they are only lower under a price cap regulation when the implemented price cap is extremely low. Consumer and producer surplus are given by equations 2.9 and 2.10.

$$CS^{PC} = \frac{1}{2} - k\bar{p}_1 - \frac{(3\theta-2)(2-\theta)k^2\bar{p}_1^2 - k^2\theta\bar{p}_1^2}{8(1-\theta)^2} \tag{2.9}$$

$$\Pi^{PC} = \bar{p}_1 - \frac{(4-3\theta)k\bar{p}_1^2}{4(1-\theta)} \tag{2.10}$$

Overall welfare under a price cap follows from $W = CS^{PC} + \Pi^{PC} - IE^{PC}$ as

$$W^{PC} = \frac{1}{2} - \frac{3\theta^2 - 7\theta + 4}{8(1-\theta)^2}k^2\bar{p}_1^2. \tag{2.11}$$

The optimal solution for the price cap set by a social planner would be $\bar{p}_1 = 0$ to induce the highest possible welfare, however, leaving the firms with zero profits and the brand-name firm as only supplier in the market. Indeed, when comparing the two systems evaluated at the most restrictive regulation, i.e. $\alpha = 1$ in equation 2.7 and $\bar{p}_1 = 0$ in equation 2.11, welfare under a price cap will be higher.

2.6 Summary and Conclusion

In this chapter, I developed a theoretical model capturing the effects of price regulation in terms of a reference pricing system and compared it to the outcomes under a price cap. The model allows for calculating the optimal level of regulation. Under the socially optimal price cap all surplus is redistributed to consumers, leading to a higher welfare compared to reference pricing. Producer surplus decreases to zero at the same time. However, a price cap exhibits some short comings when the intention of the regulator is to promote generic usage or intensify price competition.

In contrast, the reference price system still allows producers to obtain positive profits, it successfully boosts generic consumption, increases market coverage, intensifies price competition between firms and significantly reduces insurance expenditures, albeit not to the same extend as the socially optimal price cap. Nevertheless, as a cost-containing measure the reference price proves to be quite effective due to the additional costs imposed on brand-name consumers which are paid to health insurers.

The reference pricing system can dampen insurance expenditures further via the additional payment by brand-name consumers, and regulation affects the high-price brand-name firm even more. However, the increase in demand is compensated for by the lower price leading unambiguously to lower expenditures. When the regulator intends to increase generic usage, increase market coverage and with that medical supply, and regulate the high-price strategy of brand-name firms, the implementation of a reference pricing system is favorable.

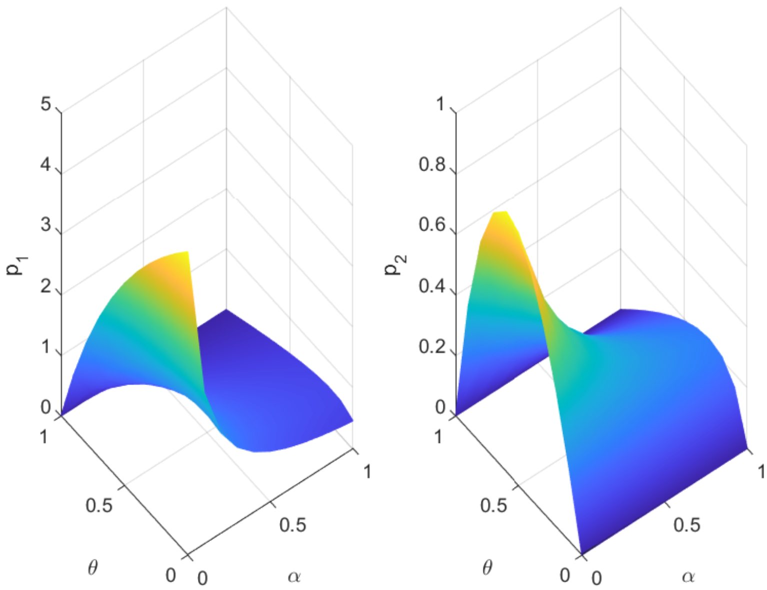
Concluding, both regulatory mechanisms lead to an increase in welfare. In the end, it is down to the intention of the regulator which system to choose. In both situations, the regulator has to decide how restrictive to design the regulation, i.e. which weight parameter to choose for the calculation of the reference price or which price cap to apply.

Of course, introducing reference prices might lead to further changes in the insurance system, like an adjustment of the fixed health care contributions, as well as to effects on the firms' R&D investment decisions. Considering that brand-name firms will experience a significant drop in profits when being subject to a reference price, they need the period of free price setting even more when entering the market in order to compensate for expensive research expenditures.

Consequently, it might be less attractive to enter the German pharmaceutical market when it is not certain that a new brand-name drug is characterized as "being sufficiently innovative" and then obtaining a period of free price setting. In case the firm cannot prove the therapeutic novelty of the drug it will be clustered and the reference price will be applied right away. However, the welfare analysis conducted in this research is rather short-term, therefore, these issues are beyond the scope of this chapter and should be considered in further research.

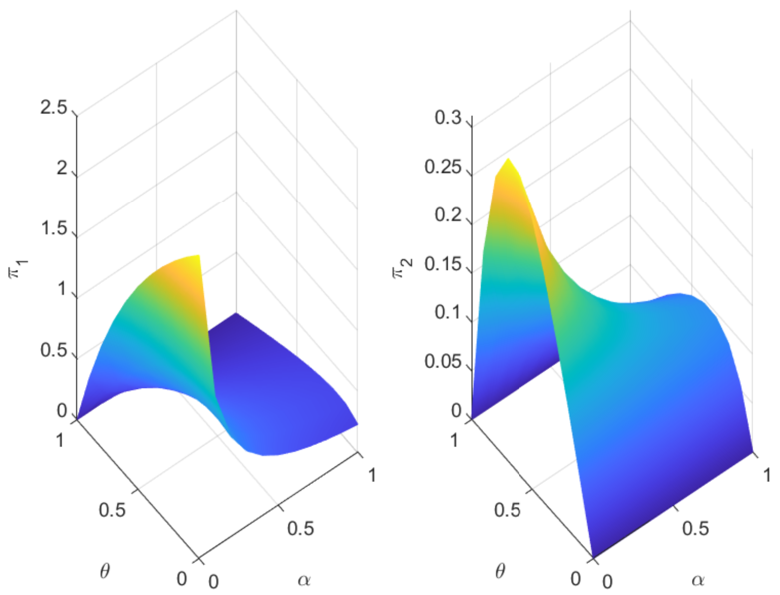
2.A Appendix

Figure 2.6: Prices



Notes: Graphical illustration of equations 2.2 for the prices of both drug types under reference pricing. The copayment-rate is set at $k = 0.1$, the generic drug quality varies in the interval $0 \leq \theta \leq 1$ and the weight of the reference price in $0 \leq \alpha \leq 1$.

Figure 2.7: Profits



Notes: Graphical illustration of equations 2.5 for the profits of both firms under reference pricing. The copayment-rate is set at $k = 0.1$, the generic drug quality varies in the interval $0 \leq \theta \leq 1$ and the weight of the reference price in $0 \leq \alpha \leq 1$.

Chapter 3: Manager Delegation, Owner Coordination and Firms' Investment in Automation[†]

This chapter studies the combined effects of mixed ownership structures and manager delegation on firms' investment in automation processes in a multi-stage triopoly game. We show that, in accordance with empirical evidence, firms owned by common shareholders invest less in automation and realize lower profits compared to a firm owned by independent shareholders. Direct collusion of owners in terms of joint ventures increases all firm profits, even more for the independent firm than for the coordinated firms. Delegation of operational decisions to managers results in higher investment and lower profits. In markets with favorable technological opportunities for automation, common ownership together with manager delegation leads to the highest social welfare.

Keywords: Manager Compensation, Common Ownership, Cost-Reducing Investment
JEL classification: G32, L22, L24, M52, O31

[†] This chapter is based on Stadler and Unsorg (2022) "Manager Delegation, Owner Coordination and Firms' Automation Investment". The present case study is focused on the health care market rather than the automobile market which is considered in the original paper.

3.1 Introduction

The development of industrial production technologies is characterized by a continuing process of automation. The steam engine, the combustion motor, electrification, the assembly line, electronic control and nowadays digitization of smart factories are milestones of technological improvements. The future path for industrial production is clearly heading in direction of "Industry 4.0". Progress in automation, however, does not fall like manna from heaven, but is the result of costly investment in activities, devoted to reduce the marginal cost of production.

In the theory of industrial organization, usually, the analysis of cost-reducing investment is analyzed using models of multi-stage games where firms invest in cost-reducing activities, then install capacities and finally engage in price competition. As it has been shown by Kreps and Scheinkman (1983) for homogeneous markets and by Maggi (1999) for heterogeneous markets, the last two stages can be reduced to a standard game of quantity competition, if one applies the rule of efficient consumer rationing in the out-of-equilibrium case of excess demand. The resulting first-investment-then-quantity-setting game was first analyzed by Brander and Spencer (1983). Since firms' investment activities are observable and incur sunk cost, investment expenditures are treated as strategic and quantities as tactical decision variables of the game which is solved in terms of a subgame perfect Nash equilibrium. The main result is that firms apply the (top dog) strategy of an aggressive overinvestment in cost-reducing activities, thereby reducing their profits.

This basic model has been extended in several directions. Delbono and Denicolo (1990) complementarily analyzed the mode of price competition without any capacity precommitment and derive the opposite (puppy dog) strategy of an inoffensive underinvestment. However, in many industries the production technology is characterized by a strong precommitment value of capacities supporting the mode of quantity competition.

D'Aspremont and Jacquemin (1988, 1990), Henriques (1990), De Bondt et al. (1992), Kamien et al. (1992), Suzumura (1992), Vonortas (1994), and Amir (2000) built on the same approach but interpreted cost-reducing investment as R&D expenditure devoted to process innovations. This allows for a more extensive analysis of R&D cooperation and research joint ventures, anti-competitive measures which are of particular importance in the presence of input and output spillovers of R&D.

The practical relevance of strategic investment in cost reduction is indisputable. Low marginal cost of production are a key factor for the competitiveness of rival firms, especially in industries where advanced technology plays a crucial role. Pharmaceutical producers dependent on advanced (bio-)technology. Furthermore, they are subject to a strict regulatory framework which increases the urge to invest in cost-reducing processes even more. On the pharmaceutical market a variety of expenditure-reducing regulatory measures dampens the profit margin of firms and, therefore, increases the need for cost-reducing automation processes. High quality- and data-protection-requirements hamper the progress of digitization and automation in the pharmaceutical industry, nevertheless, “Pharma 4.0” is advancing.

The pharmaceutical industry is facing the challenge how manufacturers can deliver new medicines faster and at lower cost to meet the growing needs of an aging population and tighter health care budgets - especially where governmental regulations restrict product launch, quality and reimbursement. Therefore, the pharmaceutical industry is characterized by a growing demand for process improvements (Jämsaä-Jounela, 2007). In order to meet these needs for higher efficiency and cost reduction in production processes the implementation of continuous processing (Palmer et al., 2020) or of manufacturing execution systems (MES) have lead to more efficient production processes in the pharmaceutical industry (Bundesverband der Deutschen Pharmazeutischen Industrie e.V., 2017).

Indeed, according to Franken and Franken (2011) firms report that one of the main aims of implementing more efficient processes are cost reductions especially of corporate costs. The association of researching pharmaceutical companies (Verband Forschender Arzneimittelhersteller, 2020) sees process innovations as a hallmark of the pharmaceutical industry - especially in Germany. The annual innovation report of the Leibniz-Zentrum für Europäische Wirtschaftsforschung supports this assumption: in 2021 25% of firms with process innovations in the pharmaceutical industry engaged in cost-reducing activities, which is above the percentage (12%) of the German industry in total (ZEW - Leibniz-Zentrum für Europäische Wirtschaftsforschung, 2022), and also the average unit cost reduction via more efficient processes in the pharmaceutical industry is higher compared to average unit cost reduction of the German industry. Just to give an illustrative example for successful investment in automation, in 2013 Novartis finalized the development of a fully automated system for antibody formulation screening which speed up sample preparation and turned out to be more cost-effective than former systems (Tecan Journal, 2013).

Clearly, process improvements are important firm strategies, even if being very costly. Especially in the pharmaceutical industry, joint ventures (also together with biotechnology or medical engeneering firms) offer firms the opportunity to share risk, boost their balance sheet, achieve scale economies and last but not least allow for reductions of their marginal production cost. Not surprisingly, joint ventures can often be observed when firm owners find it in their very interest to cooperate in specific development projects. Therefore, we will study the role of joint ventures with respect to cost-reducing activities. However, in contrast to the models in the tradition of Kamien et al. (1992), we assume, that only firms commonly owned by the same shareholders participate in the joint venture.

A complementary contribution to the theory of strategic games was added by Vickers (1985), Sklivas (1987), and Fershtman and Judd (1987, 2006), who studied the role of managers in quantity (capacity) and price competition. Listed firms are run by managers who have their own interests which do not coincide with the objectives of the firm owners. This internal firm structure has an additional impact on the investment activities. Under the assumption of irreversible compensation contracts with fixed and performance-dependent components, the delegation of quantity decisions leads to compensation schemes that induce the managers to behave more aggressively than profit maximizers, i.e. to choose higher production quantities.

Jansen et al. (2009, 2012) compared alternative specifications of the performance-dependent component of the compensation scheme. The first part of the performance-dependent component is the firm's own profit. At least in the basic models cited above, the second part is sales or revenue.[1] As an alternative, Jansen et al. (2007), Ritz (2008), and Kopel and Lambertini (2013) considered market-share evaluation,

[1]Both versions lead to the same market outcome if marginal production costs are scale-invariant.

whereas Salas Fumas (1992), Aggarwal and Samwick (1999), Miller and Pazgal (2001, 2002), and Chirco et al. (2011) studied relative-profits evaluation. Even if the last two types of compensation schemes dominate in leading to higher equilibrium firm profits, problems of observability and verifiability lead in practice to the widespread application of sales as the second component (see, e.g. Murphy, 1985; Jensen and Murphy, 1990; Conyon, 1997; Tröger and Walz, 2019).

To the best of our knowledge, multi-stage games with delegation of investment *and* production decisions to managers have not been considered so far. López and Vives (2019) and Vives (2020) derive predictable hypotheses for the influence of overlapping ownership structures on cost reducing R&D investment in the presence of spillovers. However, they do not take into account strategic delegation of automation decisions to managers. This is obviously a gap in the literature, since in all industries where automation plays an important role, as for example in the pharmaceutical industry, investment decisions are made by managers and not by the firm owners themselves. Therefore, the analysis of the influence of manager delegation on the firms' strategic investment in automation processes is a further contribution of our research. The importance of the indirect cooperation via the contract design of managers in commonly held firms is indeed increasing (see Schwalbe, 2018).

The final and most important contribution of the presented model is to study the role of mixed ownership structures. In many industries, institutional investors[2] such as Vanguard, BlackRock or the Capital Group hold shares of several, but not all firms in a relevant market and are, therefore, common owners of rival producers. Of course, common ownership gives the shareholders an incentive to collude. Even if collusion in price or quantity competition is excluded by antitrust authorities, collusion in terms of joint ventures is often allowed when public interest is presumed. This is typically the case with the current investment activities in automation or digitization especially with regard to cost savings in the production process of drugs or health care products. If joint ventures are not allowed, coordi-

[2]The definition of institutional investors usually refers to specialized financial institutions investing the capital of asset holders on their behalf. Asset managers, investment and pension funds, insurance companies, banks and sovereign wealth funds can be considered as institutional investors.

nated designs of the manager-compensation contracts provide a further and more sophisticated alternative to the direct coordination of firms' investment behavior.

Neus and Stadler (2018) and Neus et al. (2020) studied the influence of common owner structures on the strategic design of manager-compensation contracts. They have shown that, in the mode of quantity competition, owner coordination leads to compensation schemes that induce managers to act less aggressively in the output behavior. The impact of such a coordinated design of compensation schemes on the investment decisions of managers has not been studied so far. This is astonishing since the empirical effects of common ownership on the competitive behavior of firms have proven to be strong (see, e.g. Antón et al., 2021; Schmalz, 2021). Therefore, we aim to identify the influence of common holdings on investment in automation in general and digitization in particular.

The pharmaceutical industry is an appropriate example of an industry, where investment decisions in automation, manager delegation and common ownership are inextricably intertwined. First, the necessity to reduce costs is clearly evident. Second, the percentage of compensation depending on the manager's performance (variable payment) is increasing recently in pharmaceutical companies. Roundabout one quarter to one third of total compensation of a pharmaceutical manager is determined by incentive compensation (see Anbil, 2019). Third, for the majority of international pharmaceutical firms the amount of total ownership shares owned by institutional investors is growing lately. Especially the shares of institutional owners in the largest continental European pharmaceutical companies are growing and thereby catching up to the US or UK pharmaceutical firms in terms of institutional ownership. The increase in the share of institutional investors from 27.05% in 2000 to 56.31% in 2011 in average for the European pharmaceutical firms is remarkable (Montalban and Sakinç, 2021). Due to this increasing share of common ownership in chemical and pharmaceutical firms Newham et al. (2017) argue that more attention of policy and decision makers, as well as regulators and academics, has to be drawn to these industries. Table 3.1 summarizes the shares of investment firms in leading pharmaceutical companies.

Vanguard, BlackRock and the Capital Group hold shares in many of the pharmaceutical firms as it can be seen in Table 3.2. Even if the shares are varying there exists an overlap of firms in their portfolio which cannot be neglected. Some firms, as for example Novartis, have some independent owners and, therefore, can be considered as being controlled by independent owners while others are dominated by common holdings. This evidence justifies our assumption of an asymmetric ownership structure with a mix of common and independent shareholders.

To summarize: As many other industries, the pharmaceutical market is characterized by a complex intra- and inter-firm organization structure where manager delegation and common ownership interact in determining the firms' strategical and tactical decisions. These decisions do not only include capacity installation and price setting, but also investment in cost-reducing activities.

The question of how strategic delegation and common ownership jointly affect the decisions on cost-reducing investment, production capacities and prices has not been studied so far. In order to fill this gap, we present several versions of a multi-stage market game to gain insight into the institutional determinants of the investment in automation. Due to the ongoing discussion on digitization, for the time-being the last step of automation in smart factories, such analyses are not only interesting from a theoretical point of view, but also of direct relevance for antitrust authorities.

We use a stylized framework of a homogeneous triopoly market and find that the two firms, coordinated by common owners via a joint venture, behave less aggressively by investing less in cost-reducing activities and consequently installing lower capacities compared to the independent firm. Without such a coordination, delegation of investment decisions to managers increases these expenditure due to the biased incentives towards higher production. Coordination of common owners via manager delegation induces commonly owned firms to invest less in cost-reducing activities than in all other cases.

In general, social welfare is higher when independent owners delegate operational decisions to managers than without delegation. Whether social welfare is maximized under coordinated or non-coordinated delegation depends on the investment costs. If technological opportunities are favorable, coordinated delegation leads to maximum welfare. For high investment costs, however, non-coordinated delegation yields higher welfare. Scenarios with owner-controlled firms always yield lower

Table 3.1: Shares of Investment Managers

Firm	Share of the 5 biggest Investment Firms	Share of the 10 biggest Investment Firms
Johnson & Johnson	19.26%	24.89%
Roche	17.75%	23.34%
Novartis AG	14.59%	22.28%
Merck & Co	22.35%	28.69%
AbbVie	18.08%	24.00%
Glaxo Smith Kline	11.74%	18.07%
Bristol-Myers Squibb	27.12%	35.12%
Pfizer Inc	23.65%	30.77%
Sanofi	16.89%	21.71%
Takeda Pharmaceuticals	13.93%	21.27%
Astrazeneca	17.03%	23.90%
Bayer AG	11.42%	16.49%
Amgen	32.97%	42.24%
Gilead Sciences	29.73%	40.81%
Eli Lilly and Company	40.44%	55.31%
Novo Nordisk	14.46%	19.57%
Teva Pharmaceutical Industries	22.05%	30.69%
Biogen	34.57%	46.98%
Astellas	20.70%	30.63%

Notes: Data retrieved from `https://de.marketscreener.com/` at March, 23^{rd} 2022, own calculations of aggregate shares. Shares denote the aggregate shares of the biggest five or ten investment firms respectively.

Table 3.2: Shareholders in Pharmaceutical and Bio-tech Firms

Firms	Shareholders
Johnson & Johnson	Vanguard, SSgA Funds, BlackRock, Geode Capital, Northern Trust
Roche Holding AG	Roche Holding AG, Vanguard, Norges Bank, BlackRock, Fidelity
Novartis AG	Novartis AG, Sandoz Family Found., Vanguard, UBS, Norges Bank
Merck & Co	Vanguard, Capital Group, SSgA Funds, BlackRock, Wellington
AbbVie	Vanguard, SSgA Funds, BlackRock, T. Rowe Price, JPMorgan
GlaxoSmithKline	Vanguard, BlackRock, Dodge & Cox, Norges Bank, Schroder
Bristol-Myers Squibb	Capital Group, Vanguard, SSgA Funds, JPMorgan, Wellington
Pfizer	Vanguard, SSgA Funds, Capital Group, Wellington, Capital Group
Sanofi	L'Oréal S.A., Vanguard, Norges Bank, Dodge & Cox, Fidelity
Takeda Pharmaceutical	Nomura, BlackRock, Vanguard, Nippon Life Insurance, Daiwa
Astrazeneca	Wellington, BlackRock, Investor AB, Vanguard, Capital Group
Bayer AG	Temasek Holdings, Vanguard, Norges Bank, Dodge & Cox, Fidelity
Amgen	Capital Group, Vanguard, SSgA Funds, Capital Group, Primecap
Gilead Sciences	Capital Group, Vanguard, Capital Group, SSgA Funds, Capital Gr.
Eli Lilly and Company	Capital Group, Lilly Endowment, Vanguard, PNC Bank, PNC
Novo Nordisk	Novo Holdings, Vanguard, Norges Bank, Novo Nordisk, BlackRock
Teva Pharmaceutical	Capital Gr., Berkshire Hathaway, Abrams Capital, Menora Mivtachim, Capital Gr.
Biogen	Primecap, Capital Group, Vanguard, SSgA Funds, Wellington
Astellas	Nomura, Wellington, Sumitomo Mitsui, Nikko, Nippon Life Insurance

Notes: Data retrieved from `https://de.marketscreener.com/` at March, 23^{rd} 2022, own summary. Five largest shareholders of the pharmaceutical companies with highest profits worldwide in 2022. "Capital Group" refers to all institutional investors belonging to the Capital Group and "BlackRock" refers to all institutional investors belonging to the BlackRock Group. Therefore, both can be mentioned more than once in the top five of some firms.

values of welfare.

The rest of the chapter is organized as follows: Section 3.2 develops the theoretical model, where we distinguish between four scenarios of (i) independent owners making the operational decisions themselves (section 3.2.1), (ii) common owner coordination with respect to the investment expenditure in terms of a joint venture (section 3.2.2), (iii) independent owners setting incentives for their managers by designing their compensation contracts (section 3.2.3) and, finally, (iv) mixed ownership and coordinated manager delegation (section 3.2.4). Section 3.3 compares the different scenarios and presents a welfare analysis. Section 3.4 concludes the chapter.

3.2 The Game-Theoretical Model

Our model aims to capture the combined effect of an asymmetric ownership structure with a mix of common and independent shareholders and the necessity to delegate operational decisions to managers on the investment behavior of firms. Therefore, we have to integrate different approaches provided by the theory of industrial organization. In order to keep the model tractable, we restrict our analysis to a homogeneous triopoly market, characterized by the standardized demand function

$$p = \alpha - Q\,,$$

where $\alpha > 0$ measures market size and $Q = \sum_{i=1}^{3} q_i$ denotes aggregate production of firms $i = 1, 2, 3$. Their marginal capacity-installing and production costs are determined by $c_i = \bar{c} - x_i$, where $\bar{c}$ is the given upper limit of marginal cost (including constant unit cost of capacity installation) without any investment activity of firms. A reduction x_i of the marginal production cost causes investment expenditures $\gamma x_i^2/2$, where the investment-cost parameter will be restricted to $\gamma > (15 + \sqrt{153})/8 \approx 3.42$.[3]

We distinguish four scenarios of multi-stage games: (i) the benchmark, (ii) joint-

[3]This restriction on γ is necessary to guarantee positive equilibrium production levels in all scenarios.

venture, (iii) non-coordinated delegation, and (iv) coordinated delegation. In the first two scenarios, owners decide themselves on the amount of investment in automation. In the last two scenarios, the firms' owners decide on the strategic contract parameters of the compensation schemes for their managers.

In all variations of the model, owners or managers, respectively, decide in the second to last stage on production capacities. In the last stage, according to the Kreps and Scheinkman (1983) approach, they set equilibrium prices $p_i = \alpha - Q$ which satisfy the market-clearing condition. This allows us to solve for a simple quantity-setting model in the next to last stage.

3.2.1 Owner-Controlled Independent Firms

In this benchmark scenario, owners do not coordinate or delegate decisions to managers. We consider a three-stage game where owners themselves decide on cost-reducing investment x_i in the first stage, on capacities q_i in the second stage, and on the market-clearing prices $p = \alpha - q_1 - q_2 - q_3$ in the third stage. Then, the owners reduced-form profit functions in the second stage read

$$\pi_i = (\alpha - (\bar{c} - x_i) - q_1 - q_2 - q_3)q_i - \frac{\gamma}{2}x_i^2\,, \tag{3.1}$$

$i, j, k = 1, 2, 3;\ i \neq j \neq k$. Profit maximization with respect to the capacities leads to the equilibrium outcome

$$q_i = \frac{1}{4}(\alpha - \bar{c} + 3x_i - x_j - x_k)\,. \tag{3.2}$$

Capacities are increasing in the own investment but decreasing in the rivals' investments. Substituting the capacities (3.2) into the profit functions (3.1) yields the reduced-form profit functions in the first stage of the game

$$\pi_i = \frac{1}{16}(\alpha - \bar{c} + 3x_i - x_j - x_k)^2 - \frac{\gamma}{2}x_i^2\,. \tag{3.3}$$

Profit maximization with respect to the investment expenditures gives the symmetric equilibrium values

$$x^0 = \frac{3}{(8\gamma - 3)}(\alpha - \bar{c})\,. \tag{3.4}$$

The investment expenditures are decreasing in the cost parameter γ. The more costly the automation of the production process, the less firms engage in such activities. This investment behavior implies the capacities

$$q^0 = \frac{2\gamma}{(8\gamma - 3)}(\alpha - \bar{c})\,,$$

the market-clearing prices[4]

$$p^0 = \bar{c} + \frac{(2\gamma - 3)}{(8\gamma - 3)}(\alpha - \bar{c})\,,$$

and the firm profits

$$\pi^0 = \frac{\gamma(8\gamma - 9)}{2(8\gamma - 3)^2}(\alpha - \bar{c})^2\,. \tag{3.5}$$

An increase in γ causes higher marginal production costs and, hence, lower capacities, higher prices and higher profits. In the limit case of $\gamma \to \infty$, the market outcome converges to the solution of a standard Cournot triopoly, where firms do not invest in cost-reducing activities at all, i.e. $c = \bar{c}$. However, favorable technological opportunities, measured by lower γ-values, trigger the top-dog effect of an aggressive overinvestment in cost reduction, leading to higher capacities, lower prices and lower net profits (in comparison to the standard Cournot triopoly).

3.2.2 Joint Ventures of Owner-Controlled Firms

When several but not all firms in the market are owned by common shareholders, these owners are often allowed to coordinate their firms' investment behavior via joint ventures. We capture this scenario by assuming that firms 1 and 2 are commonly owned and engage in a joint venture (JV), while firm 3, owned by

[4]The equilibrium conditions in the last stage read $2q_i + q_j + q_k \leq \alpha - \bar{c} + x_i$, $i, j, k = 1, 2, 3$, $i \neq j \neq k$, and are satisfied as inequalities as soon as the capacity installing costs are positive.

independent shareholders, is not involved in this arrangement (NJV). Anti-trust authorities prevent collusion in capacity and price decisions, so that the reduced-form profit functions are still given by (3).

The owners of firms 1 and 2 jointly maximize the sum of their profits, while firm 3 maximizes its individual profit. The equilibrium investment behavior can be calculated as

$$x^{JV} = \frac{(2\gamma - 3)}{(8\gamma^2 - 13\gamma + 3)}(\alpha - \bar{c}) \,, \tag{3.6}$$

$$x^{NJV} = \frac{3(\gamma - 1)}{(8\gamma^2 - 13\gamma + 3)}(\alpha - \bar{c}) \,, \tag{3.7}$$

where the investment of the commonly owned firms, $x_1 = x_2 = x^{JV}$, is lower than the investment of the independent firm, $x_3 = x^{NJV}$. A comparison with the benchmark case shows that $x^{JV} < x^0 < x^{NJV}$ holds for all permitted γ-values. The firms participating in the joint venture reduce their investment activities, whereas the independent firm invests a higher amount. As a consequence, the market is now characterized by an asymmetric cost structure of the firms. Correspondingly, the equilibrium capacities of the firms,

$$q^{JV} = \frac{\gamma(2\gamma - 3)}{(8\gamma^2 - 13\gamma + 3)}(\alpha - \bar{c}) \,,$$

and

$$q^{NJV} = \frac{2\gamma(\gamma - 1)}{(8\gamma^2 - 13\gamma + 3)}(\alpha - \bar{c}) \,,$$

differ, too. It can be shown that $q^{JV} < q^0 < q^{NJV}$ generally holds. Thus, due to high investment in automation, the independent firm is the biggest one. In the last stage of the game, all firms set the market-clearing price

$$p^{JV} = \bar{c} + \frac{(2\gamma^2 - 5\gamma + 3)}{(8\gamma^2 - 13\gamma + 3)}(\alpha - \bar{c}) \,,$$

so that the firm profits amount to

$$\pi^{JV} = \frac{\gamma(2\gamma-1)(2\gamma-3)^2}{2(8\gamma^2-13\gamma+3)^2}(\alpha-\bar{c})^2 \tag{3.8}$$

for the joint-venture firms and

$$\pi^{NJV} = \frac{\gamma(8\gamma-9)(\gamma-1)^2}{2(8\gamma^2-13\gamma+3)^2}(\alpha-\bar{c})^2 \tag{3.9}$$

for the independent firm. Compared to the benchmark case, the joint venture of the common owners reduces the intensity of competition and thus leads to higher profits for all firms in the market. However, corresponding to the well-known effect from the merger literature (see Salant et al., 1983), the independent firm realizes a higher profit gain than the coordinated firms, i.e. $\pi^0 < \pi^{JV} < \pi^{NJV}$.

Finally, the result of a higher prices, $p^0 < p^{JV}$, clearly indicates a loss of consumer surplus due to the joint venture.

3.2.3 Independent Owners and Manager Delegation

Usually, institutional owners cannot run their firms by themselves. Instead, they have to delegate the operational decisions to specialized managers. However, managers have their own interests which do not coincide with the owners' objectives. The focus of this scenario is, therefore, on pure manager delegation, while common ownership is neglected. The game is structured such that owners first design the managers' contracts and managers thereafter undertake the delegated operational decisions.

Following the tradition of Vickers (1985), we assume that the firm owners offer their managers observable and irreversible compensation contracts. The linear compensation schemes specify the managers' payments according to

$$s_i = a_i + b_i\psi_i\,,$$

$i = 1, 2, 3$. a_i denotes the fixed salary for the manager of firm i and $b_i > 0$ denotes a weight parameter which, in combination with a_i, guarantees that the total payment s_i equals an exogenously given market-specific level. The performance-dependent component of payment consists of a weighted sum of the measures profit π_i and sales q_i, i.e.

$$\begin{aligned}\psi_i &= \pi_i + \kappa_i q_i \\ &= (\alpha - \bar{c} + x_i - q_1 - q_2 - q_3 + \kappa_i) q_i - \frac{\gamma}{2} x_i^2 \,, \end{aligned} \tag{3.10}$$

$i, j, k = 1, 2, 3$; $i \neq j \neq k$, where κ_i is the strategic contract parameter set by the owners of firm i. Maximizing the managers' objective functions with respect to the capacities leads to the equilibrium levels

$$q_i = \frac{1}{4}(\alpha - \bar{c} + 3x_i - x_j - x_k + 3\kappa_i - \kappa_j - \kappa_k) \,. \tag{3.11}$$

Substituting (3.11) into (3.10) leads to the reduced-form objective functions of the managers

$$\psi_i = \frac{1}{16}(\alpha - \bar{c} + 3x_i - x_j - x_k + 3\kappa_i - \kappa_j - \kappa_k)^2 - \frac{\gamma}{2} x_i^2 \,.$$

Maximiziation with respect to the cost-reducing activities gives the managers' investment decisions

$$x_i = \frac{3}{(8\gamma - 3)} \left[\alpha - \bar{c} + \frac{3(2\gamma - 1)}{(2\gamma - 3)} \kappa_i - \frac{2\gamma}{(2\gamma - 3)} (\kappa_j + \kappa_k) \right] \,, \tag{3.12}$$

which depend positively on the weight parameter κ_i of the own manager's compensation contract, but negatively on the weight parameters of the rivals' manager compensation contracts. Zero values of the κ-variables would induce the investment levels (3.4) of the benchmark model. However, positive equilibrium weights of the sales components induce higher investment in automation.

Substituting the investment levels (3.12) into (3.11) and both expressions into

(3.1) leads to the owners' reduced-form profit functions

$$\pi_i = \frac{\gamma}{2(8\gamma-3)^2}\left[\alpha - \bar{c} + \frac{3(2\gamma-1)}{(2\gamma-3)}\kappa_i - \frac{2\gamma}{(2\gamma-3)}(\kappa_j+\kappa_k)\right]$$
$$\left[(8\gamma-9)(\alpha-\bar{c}) + \frac{2\gamma(21-8\gamma)-9}{(2\gamma-3)}\kappa_i - \frac{2\gamma(8\gamma-9)}{(2\gamma-3)}(\kappa_j+\kappa_k)\right]. \tag{3.13}$$

In the first stage of the game, the owners strategically decide on the weight parameters κ_i of the compensation contracts. The first-order conditions can be solved in terms of the symmetric subgame perfect weight parameters

$$\kappa^* = \frac{(16\gamma^2-18\gamma+9)}{(80\gamma^2-66\gamma+9)}(\alpha-\bar{c}) > 0\,.$$

The positive sign indicates compensation schemes inducing managers to act aggressively in terms of higher automation investment levels and capacity expansion. The subgame perfect investment activity

$$x^* = \frac{18(2\gamma-1)}{(80\gamma^2-66\gamma+9)}(\alpha-\bar{c})\,, \tag{3.14}$$

is higher in comparison to the benchmark scenario, i.e. $x^0 < x^*$. The subgame perfect capacities are

$$q^* = \frac{12\gamma(2\gamma-1)}{(80\gamma^2-66\gamma+9)}(\alpha-\bar{c})\,,$$

and indicate an expansion, i.e. $q^0 < q^*$, due to the delegation of decisions to managers. The capacity levels lead to the prices[5]

$$p^* = \bar{c} + \frac{(8\gamma^2-30\gamma+9)}{(80\gamma^2-66\gamma+9)}(\alpha-\bar{c})\,,$$

[5] The equilibrium condition in the last stage read $2q_i + q_j + q_k \leq \alpha - \bar{c} + x_i + \kappa_i$, $i, j, k = 1, 2, 3$, $i \neq j \neq k$, and are satisfied as inequalities as soon as the capacity-installation costs are positive.

and firm profits

$$\pi^* = \frac{6\gamma(2\gamma - 1)(16\gamma^2 - 42\gamma + 9)}{(80\gamma^2 - 66\gamma + 9)^2}(\alpha - \bar{c})^2\,. \tag{3.15}$$

The necessity of delegating operational decisions to managers induces more investment in automation leading to a capacity expansion. As a consequence, the resulting prices are lower, i.e. $p^* < p^0$. Therefore, delegation leads to a reduction of firm profits, i.e. $\pi^* < \pi^0$, but to an increase in consumer surplus.

3.2.4 Mixed Ownership and Manager Delegation

So far we derived two channels of how the intra-firm organization affects the firms' investment behavior. Collusion of common owners in terms of joint ventures induces lower investment of the coordinated firms, but higher investment of the non-coordinated firm. Delegation to managers leads to more investment. Since many technology-intensive industries are characterized by common ownership as well as by manager delegation, it is of particular interest to analyze the combined effects on investment.

To study this scenario, we follow Neus and Stadler (2018) and assume that the owners of firms 1 and 2 indirectly coordinate via the design of their manager compensation contracts. In this scenario, common owners maximize the sum of their profits $\pi_1 + \pi_2$, while the owners of the independent firm 3 decide on their compensation contract individually. The equilibrium contract parameters can be derived as

$$\kappa^C = \frac{3(8\gamma^2 - 30\gamma + 9)}{D}(\alpha - \bar{c})$$

for the coordinated firms ($\kappa_1 = \kappa_2 = \kappa^C$) and

$$\kappa^{NC} = \frac{(16\gamma^2 - 18\gamma + 9)(16\gamma^2 - 36\gamma + 9)}{3D}(\alpha - \bar{c})$$

for the non-coordinated firm ($\kappa_3 = \kappa^{NC}$), where $D \equiv 256\gamma^4 - 992\gamma^3 + 984\gamma^2 - 306\gamma + 27 > 0$. It can be shown for all permitted γ-values that $0 < \kappa^C < \kappa^{NC}$.

Hence, the strictly higher incentive parameter set by the owners of the independent firm induces its manager to act more aggressively than the managers of the commonly owned firms. The common owners of firms 1 and 2 reduce the incentives towards sales in order to soften competition due to their common interests, i.e. they induce their managers to behave less aggressively.

As a novel feature of our model, we can now determine the cost-reducing investment levels

$$x^C = \frac{2(4\gamma-3)(8\gamma^2-30\gamma+9)}{D}(\alpha-\bar{c})\,, \tag{3.16}$$

$$x^{NC} = \frac{6(2\gamma-1)(16\gamma^2-36\gamma+9)}{D}(\alpha-\bar{c})\,. \tag{3.17}$$

The non-coordinated firm increases its investment in cost-reduction while the expenditures of the coordinated firms are reduced in comparison to the scenario with independent owners. The investment decisions of the firms in the joint venture scenario lie in between, i.e. $x^C < x^{JV} < x^0 < x^{NJV} < x^* < x^{NC}$. Indeed, the coordinated firms set the lowest investment levels of all scenarios. Their capacity decisions are

$$q^C = \frac{4\gamma(4\gamma-3)(8\gamma^2-30\gamma+9)}{3D}(\alpha-\bar{c})\,,$$

$$q^{NC} = \frac{4\gamma(2\gamma-1)(16\gamma^2-36\gamma+9)}{D}(\alpha-\bar{c})\,.$$

We identify an expansion of capacities of the non-coordinated firm, while the coordinated firms behave less competitive. The capacity decisions exhibit a similar pattern as the decisions on automation investments, i.e. $q^C < q^{JV} < q^0 < q^{NJV} < q^* < q^{NC}$. Again, common ownership induces the coordinated firms to soften competition. The capacities of the coordinated firms are the lowest. The equilibrium prices are

$$p^C = \bar{c} + \frac{(128\gamma^4 - 768\gamma^3 + 1296\gamma^2 - 594\gamma + 81)}{3D}(\alpha-\bar{c})\,.$$

Hence, the resulting prices are lower in comparison to owner decision but higher compared to delegation without owner coordination, i.e. $p^* < p^C < p^0 < p^{JV}$.

Finally this leads to the firms profits

$$\pi^C = \frac{2\gamma(4\gamma-3)(8\gamma^2-30\gamma+9)^2(32\gamma^2-60\gamma+9)}{9D^2}(\alpha-\bar{c})^2 \tag{3.18}$$

for the coordinated firms and

$$\pi^{NC} = \frac{2\gamma(2\gamma-1)(16\gamma^2-36\gamma+9)^2(16\gamma^2-42\gamma+9)}{3D^2}(\alpha-\bar{c})^2 \tag{3.19}$$

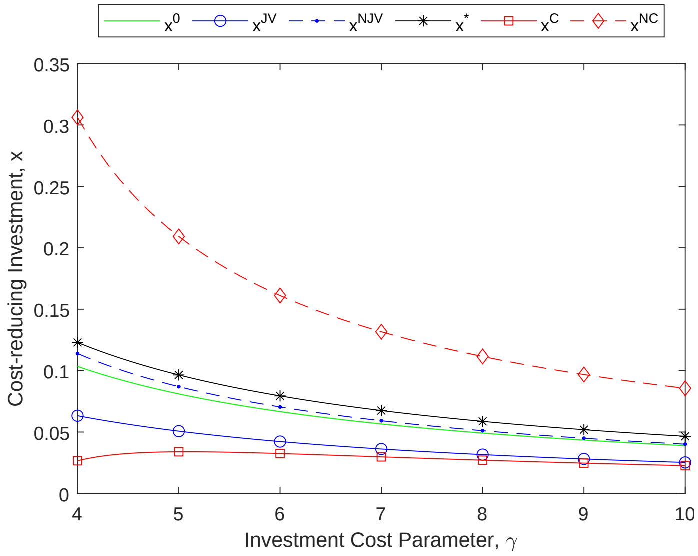
for the non-coordinated firm. The non-coordinated firm realizes a higher profit due to a higher investment in automation in comparison to the commonly owned firms. Indeed, profits of the commonly owned firms are reduced even below the level of profits under delegation without owner coordination. In comparison to joint ventures, we find that profits for the coordinated firms fall even below those as a joint venture. The profit of the independent firm, however, exceeds the profits of independently deciding owners, i.e. $\pi^C < \pi^* < \pi^0 < \pi^{JV} < \pi^{NJV} < \pi^{NC}$.

3.3 Strategic Behavior and Welfare Implications

In this section we compare the derived results and complete our study by conducting a welfare analysis. Without owner coordination, the managers' incentives are such that they invest more in automation and install larger capacities than pure profit maximizers (owner-controlled firms) would do. Due to $\kappa^* > 0$, we observe incentives biased towards a more aggressive behavior of managers. Mixed ownership structures with independent owners of one firm and common owners of the the other two firms, alter the incentive structure. While the common owners decrease the weight put on sales, the owners of the independent firm increase it. Consequently, the managers of the commonly owned firms behave less aggressive in contrast to the manager of the independent firm, i.e. $\kappa^C < \kappa^{NC}$. The contract parameter in case of delegation without common owners lies in between, i.e. $\kappa^C < \kappa^* < \kappa^{NC}$. This indicates a competition-softening behavior of the commonly owned firms.

Operational decisions are decisively influenced depending on whether firms are owner- or manager-controlled. The novel set-up of our model allows us to draw

Figure 3.1: Cost-Reducing Investment ($\alpha - \bar{c} = 1$)



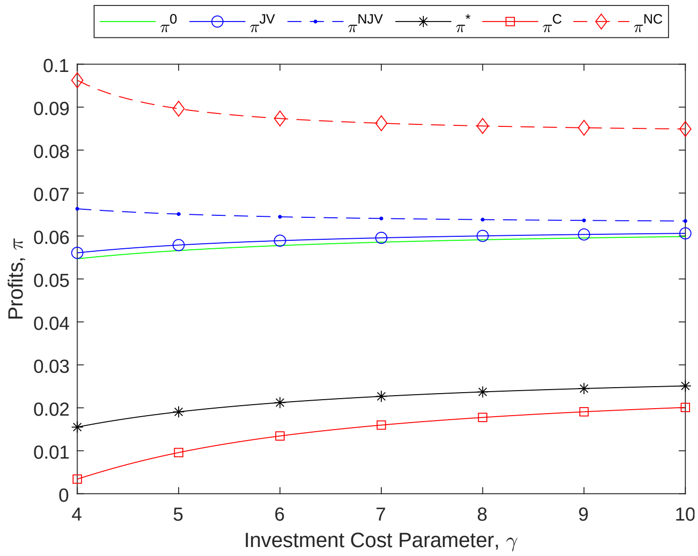
consequences from delegation of operational decisions (including investments in automation) to managers as well as from mixed ownership structures. Indeed, we find that commonly owned firms behave less efficient, in terms of investing lower levels in automation, than the firm controlled by independent owners. This remarkable result is in line with empirical findings e.g. by Schmalz (2021).

A quite similar pattern results for the scenario of coordination in joint ventures, where we find lower investment levels of the coordinated firms and a higher investment of the independent firm. Again there exists a competition-softening effect of owner coordination resulting in low investments by coordinated firms. However, delegating operational decisions to managers without coordination leads, due to the biased incentives towards sales, to higher investment decisions in comparison to owner-controlled firms. Figure 3.1 depicts the investments in cost-reducing activities in our four scenarios.

The level of investment in automation directly influences the subsequent decisions on capacities and prices. Delegation of operational decisions to managers leads to an aggressive capacity expansion. However, if managers run a firm under common ownership, opposing effects are at work, since the incentives to reduce competition lead to lower capacities despite of delegation. The independent firm installs higher capacities and, therefore, becomes the largest player in the market due to its aggressive behavior in its investment and capacity decisions.

The resulting prices especially depend on the intra-firm structure, i.e. whether firms are owner- or manager-controlled. The equilibrium prices are lower if all operational decisions are delegated to managers. As soon as owners exert the operational decisions by themselves, the resulting equilibrium prices are higher. Coordination of owners leads for both intra-firm structures (owner- vs. manager-controlled) to higher prices in comparison to non-coordinated owners.

Figure 3.2: Profits ($\alpha - \bar{c} = 1$)



An intra-firm organization with delegation of operational decisions to managers reduces profits for all firms in the mixed ownership structure and for the firms under common ownership in the mixed ownership structure. The independent firm always benefits from the coordination of the rival firms' owners. Figure 3.2 illustrates the profits depending on the investment cost parameter. Finally, we evaluate the four scenarios on the basis of the resulting social welfare. First, we calculate the consumer surplus $CS = (\alpha - p)^2/2$ as

$$CS^0 = \frac{18\gamma^2}{(8\gamma - 3)^2}(\alpha - \bar{c})^2$$

for the basic scenario,

$$CS^{JV} = \frac{4\gamma^2(3\gamma-4)^2}{2(8\gamma^2-13\gamma+3)^2}(\alpha-\bar{c})^2$$

for the joint-venture scenario,

$$CS^{*} = \frac{648\gamma^2(2\gamma-1)^2}{(80\gamma^2-66\gamma+9)^2}(\alpha-\bar{c})^2$$

for the pure-delegation scenario, and

$$CS^{C} = \frac{8\gamma^2(160\gamma^3-552\gamma^2+414\gamma-81)^2}{9D^2}(\alpha-\bar{c})^2$$

for the final scenario with common holdings and manager delegation.

Figure 3.3: Consumer Surplus ($\alpha - \bar{c} = 1$)

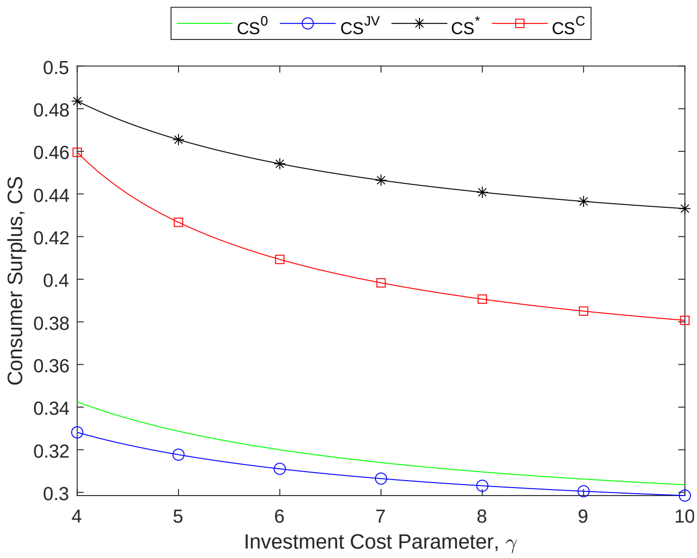


Figure 3.3 illustrates the consumer surplus which is decreasing in the investment cost parameter. Infra-firm owner-manager structures lead to lower prices and, therefore, to higher consumer surpluses in comparison to the scenarios with owner-controlled firms. Mixed ownership structures, either due to joint-ventures

or to common shares, increase prices and, thereby, reduce the consumer surplus in comparison to the respective symmetric ownership structure, i.e. $CS^{JV} < CS^0 < CS^C < CS^*$.

Finally, we calculate the social welfare $W = CS + \sum_{i=1}^{3} \pi_i$ for each scenario as

$$W^0 = \frac{3\gamma(20\gamma - 9)}{2(8\gamma - 3)^2}(\alpha - \bar{c})^2$$

for the benchmark scenario,

$$W^{JV} = \frac{3\gamma(20\gamma^3 - 59\gamma^2 + 50\gamma - 9)}{2(8\gamma^2 - 13\gamma + 3)^2}(\alpha - \bar{c})^2$$

for the joint-venture scenario,

$$W^* = \frac{18\gamma(2\gamma - 1)(88\gamma^2 - 78\gamma + 9)}{(80\gamma^2 - 66\gamma + 9)^2}(\alpha - \bar{c})^2$$

for an intra-firm structure with delegation of operational decisions to managers and,

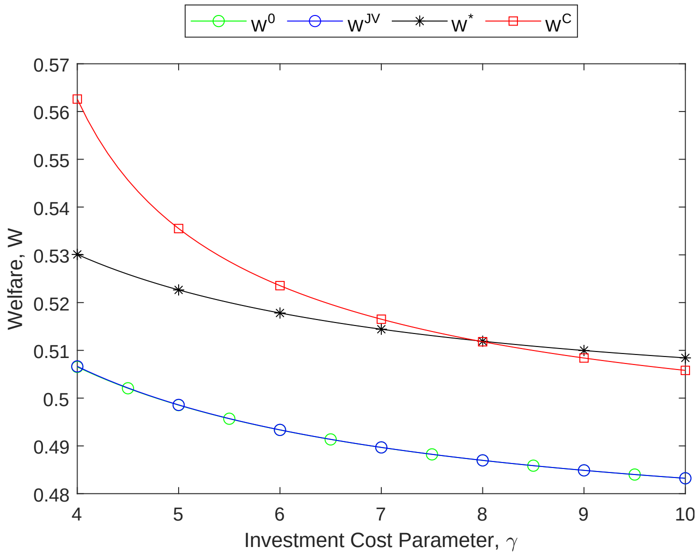
$$W^C = \frac{2\gamma A}{9D^2}(\alpha - \bar{c})^2$$

with $A \equiv 143360\gamma^7 - 1059840\gamma^6 + 2909952\gamma^5 - 3734208\gamma^4 + 2422224\gamma^3 - 796068\gamma^2 + 122472\gamma - 6561$, for a market structure with mixed ownership and manager delegation.

Delegation exhibits a strong influence on the social welfare. Indeed, welfare is lower for those scenarios with owner-controlled firms. However, due to the comparably high firm profits in the joint-venture scenario, the welfare is slightly higher compared to a symmetric owner structure. Nevertheless, the extremely low consumer surplus under owner-controlled firms reduces social welfare.

Interestingly, the findings with respect to intra-firm structures where owners

Figure 3.4: Social Welfare ($\alpha - \bar{c} = 1$)



delegate the operational decisions to managers are ambiguous. For both scenarios, the welfare is higher in comparison to the owner-controlled scenarios. The remarkable findings concern the comparison between symmetric and mixed ownership structures under delegation. We find that for lower values of the investment cost parameter, i.e. favorable technological opportunities, welfare is higher under common ownership, while for higher values of γ welfare is higher under delegation without owner coordination. Figure 3.4 depicts the welfare ranking $W^0 < W^{JV} < W^* < W^C$ for low values of γ and $W^0 < W^{JV} < W^C < W^*$ for high values.

Therefore, from a welfare-theoretic point of view, the frequently observed manager-controlled intra-firm structure dominates owner-controlled firm structures. In markets with favorable technological opportunities (characterized by lower investment costs) common ownership structures lead to the highest welfare. However for markets where investing in automation is more costly one should refrain from this.

3.4 Summary and Conclusion

Industries where firms intensively invest in automation and digitization, such as the pharmaceutical market, are often characterized by a special structure of intraand inter-firm organization. First, there exists a mixed ownership structure with several but not all firms being commonly held by the same (institutional) investors. Second, investors cannot run the firms by themselves. Instead, the operational decisions must be delegated to specialized managers. These managers have their own interests and decide according to the incentives given by their compensation schemes. Third, operational decisions delegated to managers do not only consist of capacity-installing and price-setting decisions but also on investment decisions in automation processes.

This research integrated different approaches of industrial organization in order to capture the combined effects of owner coordination and manager delegation on the firms' investment in cost-reducing automation processes. While the strategic effects of cost-reducing investment on quantity and price competition have been studied in detail, the links to manager delegation on the one hand and to common ownership on the other hand have been neglected so far. The present research aimed to fill these gaps.

We analyzed different scenarios to capture the effects of delegation of operational decisions to managers as well as the effects of mixed ownership structures in isolation and in a combined setting. We find that firms being directly coordinated by common owners via joint ventures, behave less aggressively in terms of a lower investment in cost-reducing activities and smaller capacities in comparison to the non-coordinated firm. In contrast, without coordination, manager delegation leads to higher investment in cost reduction as a consequence of compensation contracts, providing manager incentives for installing higher capacities.

As an alternative to direct coordination via joint ventures, delegation allows the common owners to indirectly coordinate via the design of the managers' compensation schemes. Direct as well as indirect coordination leads to lower investment in cost-reducing activities and a decrease of production capacities. Therefore common holdings are a decisive factor of explanation why some industries are characterized by a low automation activity. Due to coordination, the intensity of inter-firm competition is reduced. There are less incentives to produce at lower costs. With regard to the pharmaceutical market, we indeed see that the frequency of automation activities, especially of those with "stand-alone features" as once the assembly line in the automobile industry, is reduced. This is certainly due to a higher degree of difficulty with high-technology processes, immense data protection requirements and qualitative standards, but common ownership structures do exert an influence in terms of reduced competition as well.

Direct coordination of firms via joint ventures increase the firms' profits, the profit of the independent firm more than the profits of the joint venture firms. Without owner coordination, delegation per se reduces the firm profits. Indirect coordination of common owners via the compensation contracts further reduces the profits of the coordinated firms. However, the profit of the non-coordinated firm drastically increases.

Social welfare is influenced crucially by the intra-firm structure. In general, markets with owner-controlled firms are characterized by a lower social welfare compared to intra-firm structures where owners delegate operational decisions to managers. Whether social welfare is the highest under common ownership or pure-delegation depends on how costly the investments in automation are. For markets with favorable technological opportunities we find that social welfare is highest under mixed ownership structures with some firms being commonly held by the same institutional owners. However, for markets with higher costs of investment in automation an ownership structure without common owners should be preferred in terms of social welfare.

Our results suggest that firms organized by an internal structure of owners delegating operational decisions to managers is most conducive to social welfare. A mixed ownership structure is only in favor of the independent firm which can realize high profits by high investment in automation.

Due to its simplified structure, the presented model can be modified or extended in several directions. In industries not characterized by a precommitment value of capacities, i.e. IT industries, quantity (capacity) competition should be replaced by unrestricted price competition. Different degrees of product differentiation could be taken into account. Some automation activities, such as process innovations, require costly investment in research and development. Then, additionally, effects of technological input and output spillovers as well as research joint ventures should be addressed. More complex ownership structures where m out of n firms are commonly held by investors are of more realistic relevance. Finally, alternative specifications of the compensation contracts could be (re-) considered. All these relevant topics are left to future research.

Chapter 4: Entry Regulation and Competition: Theory and Evidence from Retail and Labor Markets of Pharmacists[‡]

We examine a deregulation of German pharmacists to assess its effects on retail and labor markets. Our theoretical model suggests that firms with high managerial efficiency open more stores per firm and have higher labor demand due to the reform. We find a sharp persistent increase in entry rates for expanding firms. These firms can double revenues but not profits after three years. We show that the increase of the number of employees by 50% after five years and the higher overall employment in the local markets, which increased by 40%, can be attributed to the deregulation.

Keywords: regulation, acquisitions, entry, market concentration, wages, employment, pharmacists
JEL classification: M1, J44, L4, L5, L2, J23

[‡]This chapter is based on Rostam-Afschar and Unsorg (2021) "Entry Regulation and Competition: Theory and Evidence from Retail and Labor Markets of Pharmacists".

4.1 Introduction

Whether entry regulations serve public or private interest is a controversial issue for competition policy with consequences for product and labor markets. Such restrictions, which are very common in different countries and industries, potentially affect entries, exits, economies of scope and scale, prices, and efficiency.[1] A highly prevalent entry regulation restricts markets at the occupational level by imposing costs even before specific occupations may be legally exercised. These restrictions, particularly frequent among the socalled liberal professions (pharmacists, lawyers, physicians, tax advisors, etc.) and other service providers are mainly justified with reducing quality uncertainty and have been shown to limit labor market competition (Kleiner, 2006). The same line of argument, that is, to prevent undesired effects of competition on quality, is applied to a range of regulations that restrict firm entry in these occupations. However, there is very little evidence on the relationship between occupational regulations and the competitive structure of local markets (Pagliero, 2019).

In this study, we contribute such an analysis by exploiting a deregulation of pharmacists in Germany to understand its effects on retail and labor markets. We aim to contribute to the literature on entries, exits, and market structure in industrial organization, labor demand and occupational licensing in labor economics, and on the economics of health care markets. The reform substantially reduced the cost of firm expansion by allowing a pharmacy to open or acquire up to three additional stores from 2004 onward. We focus on the easing of the multiple-ownership ban in Germany to assess the effects of deregulating entry restrictions. We evaluate the consequences of this reform for entry, exit, survival, and market concentration. Moreover, we show its effects on revenues, costs, and profits as well as labor demand and the occupational choice between self-employment and working as an employee. Our analysis uses very rich information from administrative panel data on the universe of pharmacies from 2002 to 2009 and their affiliated stores matched with survey data, which provide information on the characteristics of expanding

[1] There is a growing set of extensive studies commissioned by the OECD, the European Commission, and national governments devoted to this topic. For instance, see von Rueden and Bambalaite (2020); Koumenta et al. (2019); Paterson et al. (2007); German Monopolies Commission (2005).

firms before and after the reform.

German pharmacists provide an ideal setting to study these effects because access to the profession, and conduct, remain strictly regulated.[2] In this laboratory-like controlled situation, the multiple-ownership ban was eased in 2004. Opponents of a cap on the number of stores like the German Council of Economic Experts and the German Monopolies Commission argue that multiple-ownership ban (and third-party ownership ban) prevent the entry of new stores and restrict pharmacies to have a sub-optimal number of stores (German Monopolies Commission, 2008, 2005; German Council of Economic Experts, 2003).

The European Court of Justice, in contrast, cites the notion of a "pharmacy operated by a pharmacist" as a concept to prevent risks to public health (verdicts C-171, 172/07) and views these regulations as being in line with the EU law. It advocates them as extensions to standard occupational licensing practices. Licensing verifies personal experience and diligence by imposing time and cost-intensive educational requirements. Multiple-ownership (and third-party ownership) ban aim to tie personal investments and the professional existence of pharmacists directly to the operation of the business to make professional misconduct or profit maximization at the cost of consumers prohibitively costly. Evidence that the multiple-ownership ban can achieve these goals is hardly available. On the contrary, Janssen and Zhang (2020) show for the US that independent pharmacies illegally divert drugs and after being acquired by a chain, a previously independent pharmacy reduces dispensing of opioids.

There exists further literature in favor of loosening entry restricitions. Using town-level data, Schaumans and Verboven (2008) find no support for entry regulation on grounds of public interest with entry restrictions reducing the number of pharmacies by more than 50%. Kleiner and Kurdle (2000) show that tougher licensing of practitioners in dentistry does not improve economic outcomes and leads to slower growth in the number of dentists. The findings of Pagliero (2011)'s study on American lawyers support the capture theory, licensing increases professional

[2]For instance, product quality, prices, fees, mark-ups, the internal organization of firms (legal form) and store fixed costs (through ordinances on quality, size, number, and arrangement of rooms, etc.) and wages (through collective bargaining). Moreover, non-pharmacist investors are not allowed to own a pharmacy.

salary via a supply reduction, rather than the public interest theory, licensing as the solution to the lemons problem of information asymmetry. Findings which are clearly in favor with entry regulations rather serving private interests. Timmons (2017) finds support for broadening the scope of practice in medicare for certain assistant professions as a low-cost alternative as it can decrease the costs of outpatient care.

Focusing on firm and job creation, Branstetter et al. (2013) analyze the effects of reducing entry costs on the reform in Portugal and find that firm entry and job creation increased in the short-term.[3] However, similar to the deregulation of 53 crafts professions in Germany studied in Rostam-Afschar (2014), the increased number of new businesses was mainly due to smaller firms. For a further reform in Mexico, Kaplan et al. (2011) and Bruhn (2011) find that business start-ups profit from the deregulation of entry costs and processes, even if the effect is only temporary. Bertrand and Kramarz (2002), similar to our study of both product and labor market effects, find that a stronger entry deterrence increases industry concentration in the French retail industry with commercial zoning regulation and reduces the employment growth. Using similar methodology, Sadun (2015) analyzed whether planning regulations affect independent retailers. She finds that the regulation harms independent retailers as large retail chains adjust store sizes and locations such that competition for small local retailers increases.

Dunne et al. (2013) investigate different types of entry costs and the resulting competitive effects on entry as well as on profits for so-called Health Professional Shortage Areas (HPSA). They find that short-run price competition, the magnitude of entry costs (either sunk for potential entrants or fixed for incumbents) are important components for long-run firm values and the market structure. The results of Maican and Orth (2018) are in line with these findings. Long-run profits are affected by entry regulations, as well as market structure and welfare. In their counterfactual policy experiment, they found that in markets for differentiated products competition intensity among firms is affected and, therefore, profits. Further, as a result of increased competition, welfare increases. Implementing licensing fees as entry regulation to protect small stores is counterproductive, how-

[3]Via a reform that introduced so-called one-stop-shops, which significantly reduced the costs and the time needed to register a new business.

ever, markets with liberal regulation perform better.

Indeed, liberalization can increase market performance. The dismantling of the license Raj[4] in India results in industry growth, especially in those states with more pro-employer laws as shown by Aghion et al. (2008). Yakovlev and Zhuravskaya (2013) show that three consecutive liberalization reforms in Russia had a substantial positive effect on the performance of firms and reduced the informal sector in regions with stronger governance institutions.

The partial lift of these entry restrictions studied in this article allows us to provide unconfounded and precise evidence on key questions of firm dynamics. We aim to assess how entries, exits, and firm survival evolve towards the competitive equilibrium and how quickly it is reached. The reform capped the number of stores per chain at four, however, this partial liberalization might still be excessively restrictive. Further, we analyze the effects of the reform on overall employment and answer the question whether overall employment has increased. The reform of the German pharmacy market provides a propitious set-up to assess the effects of entry regulations on product and labor market.

We apply two empirical approaches to answer these questions: first, we quantify the impact of the policy change with the widely used potential outcomes framework. We contrast outcomes to several counterfactuals to quantify the impact of the liberalization. Our main base for comparison are pharmacies that remained independent after the reform. We provide evidence that the presence of chains in the market did not affect independent pharmacies, perhaps through more intense competition. Moreover, we show, using difference-in-difference regressions with general practitioners as a control group and pharmacists as a treated group, that the main results are supported.

Second, we estimate the relationship of market concentration and employment following an approach inspired by Bertrand and Kramarz (2002). The basic idea is to describe the association between the number of chains in a local market and concentration measures on the product market as well as, in turn, the effect of market concentration on the labor market. The underlying theoretical mechanism

[4] A system that centrally controls entry and output expansion by requiring a license for establishing new factories, expanding capacities, changing locations, or even starting a new product line.

has been described in Blanchard and Giavazzi (2003), where tougher product market regulation, which they model as a higher cost of entry for new firms, increases market power for incumbent firms and lowers equilibrium sales and employment. Therefore, one can expect the liberalization of the pharmacy market to facilitate store foundation and lead to employment growth.

We find that strong immediate increases in entry rates remain more than fivefold after five years for expanding firms. The overall survival of pharmacies and the market concentration decrease significantly. Expanding firms double revenues (but not profits after three years), and increase the number of employees by 50% after five years and overall employment by more than 40% per local market.

We develop a theoretical model with market share competition, which also allows to draw inference about interlacing and cannibalization effects consistent with these findings. Without additional welfare gains though banning chains, the optimal store number per firm size suggests that the maximum number of four stores is excessively restrictive. Perhaps surprisingly, firms do not increase personnel after the deregulation proportionally. This is predicted by our model in which firms with higher (relative) managerial and organizational efficiency decide to open more stores per firm and have under-proportionally higher labor demand. The implications of our results are that both labor and product market consequences have to be considered when designing entry regulation.

The article is organized as follows. Section 4.2 provides an overview of the institutional background, based on this Section 4.3 presents the theoretical model. Section 4.4 describes the markets of pharmacies (and physicians). Section 4.5 specifies the econometric entry model, Section 4.6 discusses the empirical results and the implications for policy reform. In Section 4.7 we provide a robustness check for our results. Section 4.8 concludes.

4.2 Institutional Background

4.2.1 German Regulatory Framework

German Pharmacies are widely regulated with the justification to prevent threats to consumers' health and to guarantee that pharmaceutical products are accessible and affordable for all consumers. To achieve these objectives in Germany a set of regulations including restrictions of the supply of pharmacists, pricing guidelines, and further requirements including product quality controls are installed. The market of pharmacies is characterized by restricted supply of pharmacists through occupational licensing either since medieval times in the form of the so called pharmacist's privilege or at least since 1810 with concessions. In line with the person-specific concessions, multiple ownership has been restricted, except for a short period under US occupation.

In a groundbreaking verdict for the interpretation of the German constitution, demographic and geographic restrictions were abolished, after a pharmacist was denied to start a new pharmacy because of lack of public interest and potential detrimental effects of competition. This allowed pharmacies to enter at any location independently from population counts. At the same time supply restrictions were (re)implemented in 1960 in the form of occupational licensing requirements and the multiple-ownership ban.

The institutions shaping the market of pharmacists changed drastically in the 2004 reform, which is under investigation in this study, when the multiple ownership requirement was loosened. However, first attempts to stimulate competition in the market of pharmacists have started in 1992 already, when the German government debated to implement reforms to increase the incentives for pharmacies to engage in competition. In the upper part of Table 4.1 we summarize the timeline of German reforms and in the second part of Table 4.1 we provide the most important regulatory changes and announcements which took place during our observation period. OECD (2004) provides a detailed overview over all existing regulations in the German pharmacy market.

Multiple ownership, in terms of owning a chain of pharmacies, however, was legally allowed from 2004 on only. Pharmacists could hardly adjust their behavior in anticipation of the reform. Just two years before the liberalization came into force the German government stated no intentions to relax the "tried and tested" multiple-ownership ban. However, in the beginning of 2003, the liberalization was announced allowing for three dependent stores per head store.[5]

Table 4.1: Timeline of German Reforms

Time	Event
before 1949	Occupational license (concession, privilege) required, multiple-ownership ban
1949-1958	No license and multiple-ownership allowed (under US occupation)
1958	German Federal Constitutional Court: "Pharmacy verdict" abolishes all demographic or geographic restrictions
1960	Pharmacy law (Apothekengesetz): occupational license and multiple-ownership ban
April 2, 2002	Federal Government announces to keep multiple-ownership ban (Bundestag, 2002)
February 8, 2003	Social Democratic Party of Germany announces a maximum of four dependent stores
September 8, 2003	Draft of GKV-Modernisierungsgesetz published
Jan 1, 2004	GKV-Modernisierungsgesetz in effect
May 19, 2009	European Court of Justice verdicts C-171, 172/07

Notes: The most important reforms of policies which affected pharmacies are reported. The upper part of the table provides an overview of the historical development of the regulatory measures. The lower part provides the most important regulatory changes and announcements within our observation period.
Sources: Own description.

Pharmacies play a central role in the distribution of drugs and other medical products in Germany. Drugs, especially those requiring a prescription, are available in pharmacies only. Even mild painkillers cannot be purchased in drugstores, resulting in pharmacies being the crucial link between physicians, pharmaceutical industry and patients. This restriction on the dispensing of medicines in pharmacies only is justified on the grounds that patients are particularly vulnerable and require specialist advice.

Prices of prescription (and pharmacy-only) drugs are fixed[6] with the justification to prevent consumers from a costly search for the cheapest pharmacy and in order to separate drug dispersion and profit gains of pharmacists. In contrast to prescription or pharmacy only drugs the so-called over-the-counter (OTC) drugs

[5]The relevant reforms became effective in 2004 ("GKV-Modernisierungsgesetz").
[6]See Arzneimittelpreisverordnung (AMPreisV). The selling prices of prescription drugs are derived with a fixed percentage surcharge.

and some non-medical cosmetic products, are subject to price competition and additionally are admitted for advertisement. Prescription and pharmacy-only drugs account with roughly 90% for the major proportion of revenues (ABDA, 2021).

Further regulations concerning the quality of drugs, the requirements for premises, the legal form, and the opening hours (including emergency services after hours) are placed on pharmacies. This set of regulations in combination with the fact that the largest part of revenues results from fixed price sales, pharmacies compete mainly for consumers in their respective local markets (counties). The complex regulatory framework makes the market of pharmacists a laboratory-like controlled set-up to study, where the only change is due to the 2004 reform.

The multiple-ownership ban, however, is one of two central pillars of all regulatory instruments. In combination with the third-party-ownership ban it prevents formation of (large) pharmacy chains. Both regulatory measures are driven by the notion of "the pharmacist in his pharmacy" to ensure qualitative standards and security (OECD, 2004). In 2004, after repeated requests from pharmacists, competition experts, and some politicians (German Council of Economic Experts, 2002; Bundestag, 2003), a partial liberalization of the multiple-ownership ban took place. Since then pharmacists are allowed to open up to three dependent stores in addition to their head store (German Council of Economic Experts, 2003). In general, freedom of establishment applies to pharmacists, i.e. they can open a pharmacy independently from any geographic or demographic restrictions. However, for the location of the dependent stores a geographic restriction exists. The dependent stores have to be located closely to the head pharmacy, i.e., in the same (or neighboring) county. This restriction is justified by the necessity that the owner of the chain has to reach each store within a reasonable period of time.

The third-party ownership ban aims to prevent conflicts of interests that could lead to impaired quality in the provision of medical supplies and services. Two key dimensions of quality are the level of pharmaceutical expertise and the availability of a pharmacist for medical or pharmaceutical advice. The regulation prevents third parties (e.g. corporations, financial investors), which do not necessarily have pharmaceutical expertise, from owning independent pharmacies or even chains. This expertise is guaranteed by the requirement that the owner of a pharmacy has obtained the occupational license for pharmacists. However, it also prevents producers of pharmaceutical products, i.e. pharmacists in the pharmaceutical industry, to be also dispensers of their products by owning pharmacy chains. For instance, the pharmaceutical industry could restrict supply of products to specific regions, like less lucrative rural areas, to maximize profits instead of meeting demand. The third-party ownership avoids such conflict of interest, even more so as a set of regulatory measures together with the multiple-ownership ban and occupational licensing.

Hence, the question is why the government reevaluated the regulation and decided to allow multiple ownership, at least insofar that it is allowed to have up to three dependent stores. According to the government, the pharmacy market indeed seemed to lack competition due to the combination of many restrictions imposed by the occupational and ownership regulations, and on top of those price and quality controls. Therefore, the policy change was aimed to intensify competition via cost reductions through the expansion of pharmacies in form of a retail chain structure.

Cost-cutting measures can be attained by larger operational units (head and dependent stores as chains) realizing scale effects, that is, the expansion of the pharmacies might lead to higher flexibility in the procurement of drugs and personnel deployment. Indeed, dependent stores are also required to provide an own laboratory (see Apothekenbetriebsordnung, ApoBetrO, §4 S.2) and the pharmacy law actually prohibits pharmacies from purchasing medications from each other (see ApoBetrO §17 S.6c, 1). However, this regulation is not valid for purchases or redistribution within a chain. As a consequence to current case law (see Deutsche Apotheker Zeitung, 2017) dependent stores are allowed to purchase drugs and medical products from their head store.

Besides from changes in the market structure, the liberalization additionally led to the emergence of a new occupational title: the pharmacy store manager. Before the reform a self-employed pharmacists per pharmacy was required. Since the liberalization took place one self-employed pharmacist can own to up to four pharmacies in total. However, for each dependent store a pharmacist has to be designated as manager. Those pharmacists, in contrast to the owner, are not longer self-employed, but rather employed as store managers. Wages for personnel in pharmacies are in general determined by collective bargaining. In addition to a basic salary store managers often are compensated performance dependent, e.g., proportionally to the store's revenues or sales.

4.2.2 International comparison

Overall, entry regulations for pharmacists in terms of occupational licensing are quite similar across European countries including Germany. Virtually everywhere prospective pharmacists need to complete a pharmaceutical training program at a university, complete a compulsory vocational internship, and pass an admission process including an exam. The characteristics of the pharmacy degrees, with which practicing as a pharmacists may be applied for, do not differ a lot across countries. Pharmacy degrees obtained in other European countries are automatically recognized according to the professional recognition directive (Directive 2005/36/EC). In Germany the approval to practice as self-employed pharmacists called "Approbation" is granted by the Federal States.

Table 4.2: Regulation of Pharmacies in Europe

Type of Regulation	Country
Occupational Licensing	all EU28
Multiple-Ownership Ban	AT, BG, CY, DE, DK, ES, FI, FR, GR, HU, IT, LU, LV, PT, SI
Third-Party-Ownership Ban	AT, CY, DE, DK, ES, FI, FR, GR, HU, IT, LU, LV, SI
Demographic/Geographic Restrictions	AT, BE, DK, ES, FI, FR, GB, GR, HR, HU, IT, LU, LV, MT, PT, RO, SI

Notes: Occupational licensing requires a certificate attesting the completion of a secondary course or a diploma of post-secondary level (3-4 years). Multiple-ownership summarizes countries where no or only limited multiple-ownership is allowed. Third-party ownership refers to ownership of pharmacies by non-pharmacists like corporations or financial investors. Freedom of occupational choice refers to the constitutional right to choose occupation and exercise of this occupation, choice of workplace, and educational institution.
Sources: Own description based on the regulated professions database of the European Commission (2021) and Metiäinen (2015).

A summary of the regulations in force in the European countries is given in

Table 4.2. Among the most liberal countries are UK, Ireland, and the Netherlands. All allow either for vertical integration, for chains or even for both. The liberalizations in Norway in 2001 or in Sweden in 2009 respectively led to an ownership structure characterized by large chains. In Norway three pharmacy groups held 97% of the market in 2004 (Anell, 2005). A development which should be prevented in Germany by the multiple-ownership and third-party ban. Italy has liberalized the multiple-ownership ban and allowed up to four dependent stores in 2006, while completely abolishing the ban in 2012 and even allowing for third-party ownership as long as the ownership share is below 20% of all pharmacies in a province.

Chain formation or highly concentrated markets as in other European countries (evolution of oligopolies, see OECD, 2004) was expected to lead to a deterioration of the medical supply in Germany if a single pharmacy chain could gain too much market power. Therefore, the government and regulators decided to only partially liberalize the multiple-ownership ban.

Spain, France, Finland, and Austria apply similarly strict regulations on their pharmacies as Germany. In all these countries, multiple ownership is allowed in a restricted form only or not at all. In Spain no dependent stores are allowed, while Austria allows for one dependent store per head store it has strict demographic and geographic restrictions for pharmacy entry. Since 2016, however, the demographic criteria are not binding in rural areas to secure the local medical supply. Finland allows for three dependent stores (Vogler et al., 2012). Indeed, several EU countries limit the number of dependent stores per head store to a maximum of four, e.g., Poland (2017) or Estonia (2015). Denmark increased its maximum number from four to seven in 2015.

4.3 A Model of Chain Entry

We develop a simple model of chain entry in local markets based on the circular city developed by Salop (1979) to explore the effects of a reform that allows pharmacies to enter as chains. To keep the model tractable we derive the results for market structure and optimal store number (head and dependent stores), in a symmetric equilibrium. We aim at determining the key factors influencing the optimal number of stores per chain.

To derive the competitive effects of chain entry on regional markets, location models provide a straightforward setting. The location choice on the circle (see among others Salop, 1979; Pal and Sarkar, 2006; Janssen et al., 2005) allows us to study the features of competition in geographically restricted markets. Pharmacies compete for market shares in the first place, which is captured best by localized rivalry. Further, due to the geographic restriction of the affiliated stores to the same (or neighboring) county, the set-up of the following model reflects the characteristics of the market.

We explore how the entry of chains affects the competitive situation in a local market with the equilibrium number of chains M, the number of stores m_i per pharmacy i, the total number of all pharmacies N per local market, and the respective market shares of the chains. We assume that consumers (patients) of mass α live uniformly distributed on a circle with length 1, where α accounts for different market sizes to capture local markets with differing demand for drugs, i.e. due to demographic differences.

Consumers incur quadratic transportation costs increasing in the distance to the next store. A representative consumer j's utility when purchasing at a firm i is

$$U_j = \bar{v} - p - (x_j - x_i)^2, \tag{4.1}$$

where $\bar{v}$ denotes the gross utility from consumption and x_j, x_i the locations of the consumer j and a firm i. The shorter the distance to the next store, the lower the transportation cost of a consumer and, consequently, the higher the consumer's utility. Procurement/purchase costs are equal for all firms and are captured in the fixed price level $\bar{p}$ which reflects the price regulation in the market.[7] Pharmacies incur fixed cost C (per store), entry cost F per chain and wage cost wL_i, with wage rate w and labor demand L_i. The wage rate, which is determined by collective bargaining for pharmaceutical personnel, in the same local market is assumed to be identical.

[7] Since prescription and pharmacy-only drugs account for the larger proportion of revenues the assumption of a fixed price level is justifiable.

Assuming a linear relation for the production function with labor as the single input gives $q_i = \mu L_i$, where μ represents a factor for managerial and organizational efficiency. The more efficient a chain is (the higher μ) the lower the level of labor demand L_i of firm i necessary to satisfy a certain demand, i.e. $L_i = q_i/\mu$, such that we can define $p = \bar{p} - w/\mu$.

To determine the market structure and the equilibrium number of stores per firm, we derive a symmetric equilibrium of chain entry. With uniformly distributed consumers and a fixed price level, stores locate equidistantly at a distance of $1/N$ to the next rival store. The firm's demand is determined by the market share and the market size as $q_i = (\alpha m_i)/N$. Each firm i obtains a share m_i/N of the market, where the total number of stores equals the sum of stores per firm $N = \sum_{i=1}^{M} m_i$. The profit of a firm i is

$$\pi_i = \bar{p} q_i - w L_i - m_i C - F\,. \tag{4.2}$$

We start by considering the prohibition of chain entry still to be in force, i.e. only single-store firms may enter the market. This depicts the pre-reform market situation with independent pharmacies only. Consequently, the total number of stores equals the number of firms, i.e. N^S, and the number of stores per firm is equal to one.

To determine the number of firms profitably entering the market, we use the zero profit condition $\pi^S = \frac{p\alpha}{N} - C - F \geq 0$. The number of independent firms is

$$N^S = \frac{p\alpha}{C + F}.$$

The market share of an independent pharmacy is the inverse of the firm/store number N^S. Substituting the market share in the production function yields the labor demand in a single-store equilibrium per firm as $L^S = (C + F)/(\mu\bar{p} - w)$.

After the reform, market entry of chains is possible. We allow firms to enter with more than one store, i.e. $m_i \geq 1$. All firms simultaneously decide on their optimal number of stores. Profits of a firm i in equation (4.2) can be rearranged as

$$\begin{aligned}\pi_i &= \left(\bar{p} - \frac{w}{\mu}\right) q_i - m_i C - F \\ &= p\frac{\alpha m_i}{N} - m_i C - F\,, \end{aligned} \tag{4.3}$$

Differentiating each firm's profit (4.3) with respect to the number of stores yields the first order conditions. Assuming all firms to be symmetric in equilibrium, that is, $m_i = m_{-i}$ and consequently $N = Mm_i$, the number of stores per firm, yet depending on the number of firms M, follows as

$$m^0 = \frac{p\alpha(M-1)}{CM^2}\,. \tag{4.4}$$

The number of firms entering the market is determined by the zero profit condition, that is, firm entry takes place as long as the firms obtain non-negative profits $\pi(M) \geq 0$. Substituting m^0 from (4.4) into the profit function (4.3) and applying the zero profit condition gives the equilibrium number of firms

$$M^* = \sqrt{\frac{p\alpha}{F}}\,. \tag{4.5}$$

The equilibrium number of stores per firm i is

$$m^* = \frac{1}{C}\left(\sqrt{p\alpha F} - F\right). \tag{4.6}$$

The total number of stores is

$$N^* = M^* m^* = \frac{1}{C}\left(p\alpha - \sqrt{p\alpha F}\right).$$

From $N^* = M^* m^*$ the symmetric market share is $\frac{1}{M}$. Substituting the number of stores per firm (4.6) and the equilibrium firm number (4.5) into the production function $q_i = \mu L_i$ and rearranging yields equilibrium labor demand

$$L^* = \frac{q^*}{\mu} = \frac{\alpha}{\mu M^*} = \sqrt{\frac{\alpha F}{\mu(\mu \bar{p} - w)}}.$$

If firms are characterized by a higher the managerial efficiency, they decide to open more stores per firm m^* in equilibrium, i.e. $\partial m^* / \partial \mu > 0$. Consequently, the number of independent firms M^*, i.e. $\partial M^* / \partial \mu > 0$, increases in the managerial efficiency as well. We expect efficient firms which open more stores to be characterized by a higher, though less than proportionally higher, labor demand, i.e. $\partial L^* / \partial \mu > 0$. Labor demand increases in the size of the local market and the fixed entry cost, i.e. $\partial L^* / \partial \alpha > 0$ and $\partial L^* / \partial F > 0$.

In the simultaneous game, firms decide to open stores to increase their market share. If the costs per store C are rather low, the number of stores per firm m^* increases, i.e. $\partial m^* / \partial C < 0$, leaving the number of firms M unaffected. Higher entry costs F lead to fewer firms in the market, and therefore, higher market shares per firm. Consequently, when allowing for a retail structure with multiple stores, the entry costs can be divided between the stores, leading to a higher number of firms.

The optimal number of stores per firm depends on the demand in the local market, that is, in a market with high demand, α, firms would prefer to install more stores due to $\partial m^* / \partial \alpha > 0$. Therefore, regulating the number of stores per firm to a fixed amount independently of the characteristics of the local market is not desirable - neither for firms nor for consumers, given that quality is exogenously fixed.

Comparing the single- to a multi-store entry game, for the threshold $C < \sqrt{p\alpha F} - F$ the number of independent stores in a multi-store set-up is lower, $M^* < N^S$. However, the overall number of stores is higher, $N^* > N^S$, as firms can divide entry costs over all stores. Only for markets with very low demand, α, or very high costs per store C, the labor demand per firm can be higher in the single-store equilibrium. However, the labor demand per store in chains is lower in comparison to an independent pharmacy. Firms can deploy personnel more efficiently over the stores of a chain.

The model does not allow for an explicit analysis of a dynamic transition from the single- to the multi-store equilibrium. However, we can draw inferences from both static equilibria. Since the total number of stores is higher in the multi-store equilibrium consumers will prefer a multi-store market structure which includes lower (travel-)distance to the next store and lower transportation costs which can be seen from the consumer's utility (4.1).

Considering an initial situation with N independent firms in the market and allowing for firm expansion to a chain the next period, firms have incentives to open additional stores. These incentives result from additional market shares which is obtained from the new stores, since consumers purchase at the closest store. Indeed, in the model set-up firms would prefer an interlacing structure instead of market segmentation in order to avoid cannibalization (Janssen et al., 2005). Opening a new store next to the own stores is only possible at the expense of market share of the existing store. However, market entry and the optimal number of stores depends on the size of the market α, the cost per store C and whether entry is profitable at all. This explains the empirical finding that the number of stores reaches the equilibrium gradually.

The model does not account for the labor choice of a pharmacist and the wage of a pharmacy manager since all stores are symmetric, which means it does not allow for different costs of the head pharmacy and the dependent stores. However, each pharmacist has to decide whether to be the owner of a pharmacy(-chain) or to be employed as a store manager. The pharmacist will decide to run a pharmacy(-chain) instead of being employed as long as the expected profits are higher as the (negotiated) salary of being a pharmacy store-manager.

The presented theoretical model allows to draw predictions about the entry reform[8], i.e. the liberalization of the multiple-ownership ban, which can be summarized as follows:

(i) lower entry costs, that is, allowing firms to spread entry costs over more

[8]When assuming a duopoly market, where two pharmacies $i = 1, 2$ (number of firms $M = 2$) with different levels of managerial efficiency, i.e. $\mu_1 < \mu_2$, decide on their optimal store number an asymmetric store equilibrium where $m_1^* > m_2^*$ (with $N^* = m_1^* + m_2^*$) can be explained. Additionally, it can be shown that the more efficient firm obtains the larger market share, i.e. $q_1^* > q_2^*$, and that the labor demand per store decreases in the more efficient firm, i.e. $L_1^*/m_1^* < L_2^*/m_2^*$. These theoretical predictions further support the empirical findings.

stores leads to intensified competition between firms due to a higher overall number of stores and, therefore, decreasing market concentration

(ii) chains can realize reduced costs per store, that is, experience efficiency gains or are characterized by higher managerial efficiency

(iii) by allowing for a multi-store structure labor demand per firm can increase

To summarize, the firms obtain (in a symmetric equilibrium) higher market shares compared to the single-store equilibrium (extensive margin). However, when the number of stores per firm increases, each firm obtains smaller market shares (intensive margin) reflecting intensified competition. These findings are in line with our empirical results.

4.4 Data and Descriptive Statistics

Our dataset is based on two unique sources that we match to a register and survey panel on firm, store, and local market characteristics. The first one is an administrative data panel, the German business register (AFiD-Panel URS).[9] It is a decentralized register that is maintained by the German Federal Statistical Offices. The register combines data from the German Federal Employment Agency and fiscal authorities. Reporting the data is mandatory for all firms in Germany. Due to the regular annual updating of the register, it is a very detailed data source offering us the possibility to observe the universe of pharmacists and general practitioners in Germany not only on firm but also, further disaggregated, at a store-level. We use the AFiD-Panel URS from the very first year available in 2002. The data include 579,203 observations over the observation period of the years 2002 to 2009.[10]

[9] AFiD-Panel URS is short for Amtlichen Firmendaten für Deutschland Panel, Unternehmensregister.

[10] All observations until 2007 are covered by the industry classifications of the German Federal Statistical Office (Klassifikation der Wirtschaftszweige, Ausgabe 2003, WZ2003), and (Klassifikation der Wirtschaftszweige, Ausgabe 2008, WZ2008). We distinguish between pharmacists and general practitioners via the industry branch classifications. Industry codes for Pharmacies are WZ2003: 52310, WZ2008: 47730, and for general practitioners WZ3003: 85121, WZ2008: 86210.

We extend this rich information by our second data source, which is a survey of firms in the retail trade sector (AFiD-Panel Retail) compatible with the AFiD-Panel register data, despite its high quality, not officially on the program of the German Federal Statistical Offices. It includes 11,990 observations of pharmacists from 2002 to 2006. The trade survey panel draws its sample from the firms included in the URS. The survey is an unbalanced panel. In each federal state, the industry branches are clustered by their revenues and within these clusters, a random sample is drawn. About 8% of all firms are surveyed and supplemented with sampling weights, which we use in our analysis. In the survey data, we observe pharmacies at the firm level only. Nevertheless, it provides additional information to the administrative data like costs, i.e. information about wages, rents or commodity-input.

We use these rich data with information on firm- and store-level to analyze the short- and medium-run effects of the deregulation of the multiple-ownership ban on the entry of new firms and stores, acquisition of stores, exit, and survival rates. We also analyze the effects of this professional regulation on product-market characteristics such as revenues, costs, and profits, as well as on labor market outcomes like hiring or firing decisions and wages costs. Furthermore, we assess the effects of market concentration on the employment.

Some observations need to be excluded, all sample restrictions are summarized in Table 4.7 in the appendix. We do not consider observations which are expired already or inactive. While they do not undergo the updating process anymore, they are still listed in the register. In order to avoid double counting we need to exclude head-stores. These units are listed twice, once as a dependent store and once as the head-store itself. Additionally, we exclude firms that were chains before 2004 already. This was possible before the reform due to a special permit only and, therefore, is not a result of the deregulation. This special chain operating permit was granted to some pharmacists as a temporary permit in order to prevent a serious undersupply with pharmaceuticals in a specific region. Also, we drop pharmacies with more than the upper limit of four stores.

For our analysis, we distinguish between pharmacies that stayed independent over the whole observation period and pharmacies that expanded to a chain, either via acquisition or foundation of new stores after the deregulation. With this definition, we can observe those pharmacies that turn into chains even before they could decide to acquire or open new dependent stores. Therefore, we can determine whether certain characteristics are influencing the expansion decision. In the following subsections we provide some descriptive statistics and developments of the pharmacy market.

4.4.1 Market Developments

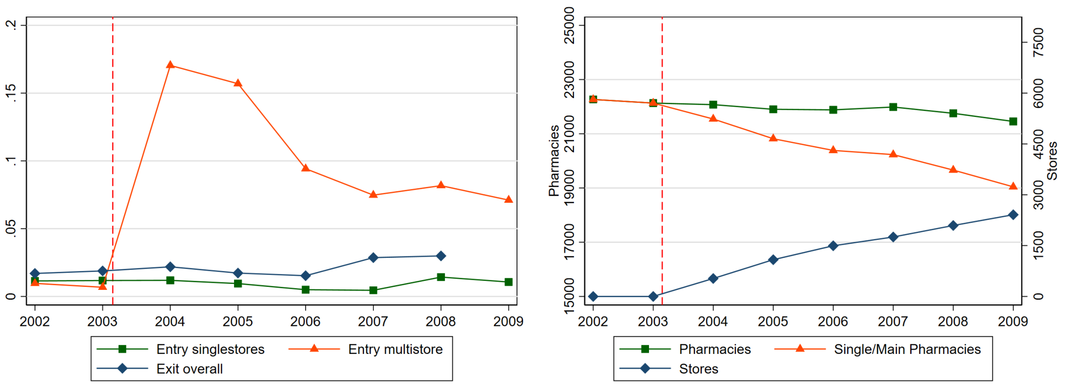
Dependent stores can either be newly founded or acquired by taking over existing pharmacies, which are designated then as dependent stores to a head store. Consequently, when considering chains we distinguish between the head pharmacy and its dependent stores. Before 2004, chains could not be formed and the number of independent pharmacies evolved in year t according to $M_t = entries_t^M - exits_t^M - takeovers_t^M + M_{t-1}$, where M_t is the number of independent pharmacies in year t that increases due to new pharmacies entering the market $entries_t^M$, decreases with pharmacies exiting the market $exits_t^M$ to retirement or take up of a different job and $takeovers_t^M$ in the sense of acquiring a dependent store were restricted to zero.

After the reform, acquisitions, i.e. $takeovers_t^M > 0$, could reduce the number of independent firms. The steady decline in the number of independent firms suggests that chains were primarily formed through acquisitions instead of new entries. This is consistent with statistics of the Apobank that reports more than 80% of changes in the owner of a pharmacy are due to acquisitions and instead of new entries, a trend growing especially in the last years (Apobank, 2021).

Indeed, the total number of stores decreases recently and in 2017 the numbers fell below the 20,000 mark for the first time since 1990. Breaking the numbers down into independent stores, head stores and dependent stores, respectively, makes apparent that the former is declining whereas the number of dependent stores is increasing (ABDA, 2018) representing the structural change. It seems that the closures outweigh the openings of new pharmacies each year, which explains the shrinking number of pharmacies in total.

Figure 4.1a presents the entry and exit rates of pharmacies. An entry (at store

Figure 4.1: Pharmacy Market in Germany



(a) Market Entry and Exit Rates (b) Number of Stores in Germany

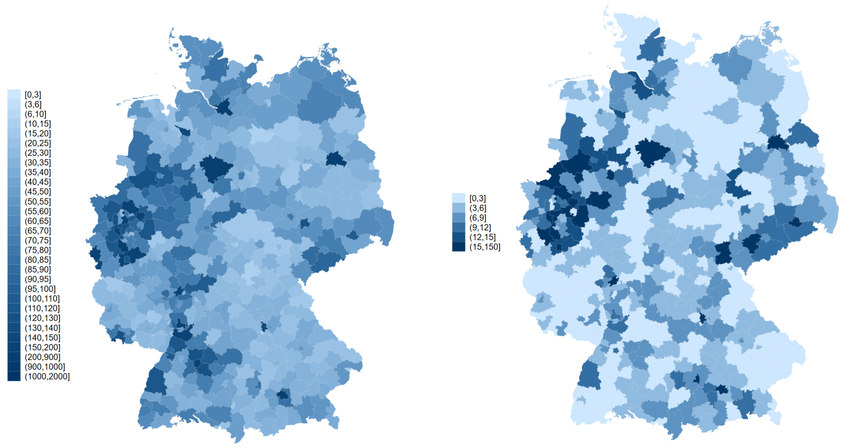
Notes: In panel (a) we report entry rates for pharmacies becoming chains over the observation period and those staying independent. Exit rates are calculated over all pharmacies independent of store type. Panel (b) provides the numbers of pharmacies counted at store level.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS).

level) is recorded whenever a new admission in the register is observed. From this, we calculate the entry rates for independent pharmacies and chains. We define an exit whenever we observe a pharmacy store, which is expired. The exit rate (overall) and the entry rate of independent pharmacies seem unaffected by the reform. Consistent with Figure 4.1b, however, entry rates increase after the 2004 lift of the multiple-ownership ban. The entry rate for chains increased to over 15%, which reflects either newly opened stores or acquisitions of existing pharmacies.

Considering that the total number of pharmacies decreases although we can observe more stores belonging to one pharmacist, we can conclude that competition has intensified due to deregulation. These findings are in accordance with our theoretical model. As the group of independent pharmacies is significantly larger than the group of chains, the overall entry rate is closer to one of the independent pharmacies. Thus, the overall entry rate lies below the overall exit rate of pharmacists. This fact explains the continuous (in our observation window still rather slow) decrease in overall pharmacy numbers.

The spatial distribution of pharmacies across German counties is characterized by a higher density of pharmacies in the cities, that is, Berlin, Hamburg, or Mu-

Figure 4.2: Distribution of Pharmacies across German Counties



(a) Pharmacies (2002-2009)

(b) Main pharmacies & stores (2009)

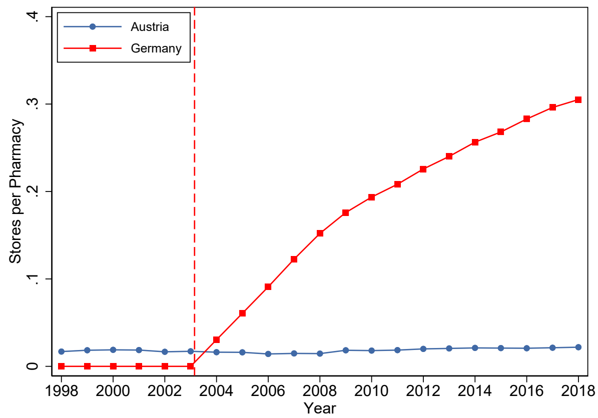
Notes: Data on store and county level.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS).

nich, and urban areas, which are characterized by a higher population density, therefore by a higher demand. Some federal states appear to have a lower density of pharmacies, like Bavaria, Thuringia, Brandenburg, and Rhineland Palatine. Figure 4.2 provides an overview of the mean number of pharmacies in Germany by counties over the observation years.

A similar pattern is visible when considering the distribution of chains. Figure 4.2b depicts the location of the main pharmacies and their dependent stores over Germany in each county after the reform in 2004. Especially in Northrhine-Westphalia, we observe a high number of chains. Figure 4.2 shows that the prevalence of pharmacies is comparatively low in Bavaria and much of Eastern Germany, where many chains seem to enter markets. In contrast, for example, in Baden-Wuerttemberg, chains rather emerge in already densely served regions. This supports our findings from the theoretical model, where with increasing demand the number of stores is increasing as well.

A brief comparison to Austria, where a pharmacist is allowed to run one dependent store in addition to the head store, the number of dependent stores per

Figure 4.3: Stores per Pharmacy in Germany and Austria



Notes: We plot the dependent stores per pharmacy for Germany and Austria. In Austria one dependent store per head store is allowed. In Germany from 2004 on up to four dependent stores per head store are allowed.
Source: Own calculations based on data from the German business register (AFiD-Panel URS), ABDA and Österreichische Apothekerkammer.

pharmacy remains virtually constant over time (see Figure 4.3). In contrast, the number of dependent stores per pharmacy in Germany increased steadily from 2004. Although, both countries are quite similar with respect to their regulatory framework, a chain formation did not take place in Austria to the same extent. Hence, on the German pharmacy market incentives for chain formation exist.

4.4.2 Firm and Market Characteristics

Table 4.3 provides summary statistics for (prospective) chains and independent pharmacies before and after the reform. We first discuss firm dynamic outcomes (entries, exits, survival), competition outcomes (market share, revenues, input costs, profits), and finally, labor demand in a difference-in-differences style comparison supplemented with a before-after comparison for concentration measures on the local market level. Comparing the differences before and after 2004 for (ex-post) chains, we see substantial increases in entries and exits in columns I through III. Such effects are virtually absent for independent pharmacies (columns IV through VI).

The impact on competition outcomes seems similarly concentrated almost exclusively among chains. They could further increase their already larger market shares from 2.8% to 3.5%, while independent pharmacies remained almost unchanged below 2.0%. There is also a stronger revenue increase among chains, by more than 50%, whereas they only increase by 20% for independent pharmacies. Input costs rise only by 30% for chains and at the same time for independent pharmacies by 20%.

However, profits grow at the same rate for both types of pharmacies. This might be due to higher personnel costs due to increased labor demand. Each dependent pharmacy requires a pharmacy manager who is in charge of the respective pharmacy. The number of employees increases by almost five for chains but remains at the pre-reform level of six for independent pharmacies. In terms of revenues and employees, pharmacies that expanded to chains after the reform were already bigger before the reform. However, the reform has not been conditioned on any of the pre-existing differences in outcomes between pharmacies.

Finally, we observe that concentration outcomes measured (CR[10] and Herfindahl-index) on the local market level increased. Concentration measures CR[1] through CR[5] (not reported) also indicate higher concentration after the reform. We calculate the Herfindahl-index as well as the concentration measures with the market shares per firm and aggregate those on county level. In Table 4.8 in the Appendix we provide how we construct this measure in greater detail.

Table 4.3: Descriptive Statistics

	Chain			Independent		
	After	Before	Difference	After	Before	Difference
Firm Dynamics						
Entry rate	0.102	0.008	0.093***	0.009	0.012	-0.002***
	(0.003)	(0.002)	(0.003)	(0.000)	(0.001)	(0.001)
			14,962			160,501
Exit rate	0.016	0.001	0.015***	0.019	0.019	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
			14,962			160,501
1-Year survival rate	0.996	0.997	-0.001	0.979	0.979	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
			12,342			14,962
Competition Outcomes						
Market share	0.035	0.028	0.007***	0.019	0.018	0.001***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
			11,099			154,577
Log revenues	7.991	7.466	0.525***	7.288	7.093	0.195***
	(0.008)	(0.013)	(0.015)	(0.002)	(0.003)	(0.004)
			9,785			142,535
Log input costs	7.684	7.373	0.311**	6.869	6.679	0.190***
	(0.042)	(0.09)	(0.100)	(0.011)	(0.014)	(0.017)
			623			11,129
Log profits	5.088	5.032	0.055	4.474	4.403	0.072***
	(0.072)	(0.113)	(0.134)	(0.017)	(0.019)	(0.025)
			471			9,300
Labor Market Outcomes						
Number of employees	13.353	8.668	4.685***	6.035	5.952	0.082***
	(0.132)	(0.138)	(0.191)	(0.014)	(0.020)	(0.025)
			10,103			152,186
Concentration Outcomes	*(Market Level)*					
CR(10)	0.516	0.468	0.048***			
	(0.004)	(0.006)	(0.007)			
			3,208			
Herfindahl-index	0.048	0.041	0.008***			
	(0.001)	(0.001)	(0.001)			
			3,208			

Notes: The table evaluates several firm-specific characteristics (firm dynamics, competition outcomes, and labor market outcomes) for chains and independent pharmacies and concentration outcomes on the market level in the years before (2002-2003) and after (2004-2009) the deregulation. We distinguish pharmacies that remained single-store over the whole observation period and pharmacies that expanded to a chain at some point. Firm characteristics are reported at firm level. The market share is calculated at firm level per county. Monetary variables measured in Euro are deflated using the drug price index API (Arzneimittelpreisindex). For the detailed description of variables see Table 4.8 in the appendix. Robust standard errors are in parentheses and the number of observations (observed over 8 years) is presented below. ***Statistical significance at 0.1%, **significance at 1%, *significance at 5%.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS) 2002-2009 and AFiD Retail Panel 2002-2006.

4.5 Empirical Strategies

The empirical analysis has two objectives. First, we quantify the impact of the policy change using the potential outcomes framework in the style of Branstetter et al. (2013). Second, we estimate the relationship of market concentration and employment following an approach inspired by Bertrand and Kramarz (2002).

Our basic empirical approach is to compare outcomes in comparison to several counterfactuals to quantify the impact of the liberalization. Our main basis for comparison are pharmacies that remained independent after the reform. To quantify the impact of the liberalization on pharmacies, we use an event-study style approach on the pharmacy data to account for pharmacies becoming chains at different points in time or not expanding at all. For this, we define an indicator variable CHAIN, which is equal to one at the year of expansion to a chain and all subsequent years (and zero otherwise). This specification is similar to the approach used in Branstetter et al. (2013) and identifies the reform impact from the comparison of outcomes within a particular county in years immediately before the introduction of the chain to those in the years immediately after because we include county-year fixed effects. Standard errors for this and all subsequent regressions are clustered at the county level.

$$y_{fitc} = \sum_{k=-2}^{6} \tau_k \, \textsc{Chain}_{it} + \beta X_{fitc} + \theta_t + \theta_c + \theta_{tc} + \theta_i + \epsilon_{fitc}, \tag{4.7}$$

y is an outcome variable varying over store i and year t in firm f and county c. τ_k is the treatment effect on chains, X_{fitc} is a vector of further characteristics. We include store fixed effects θ_i in addition to year, county, and county-year fixed effects, which are defined with indicator function ϑ as follows:

$$\theta_t = \sum_{t=2002}^{2009} \vartheta_t, \qquad \theta_c = \sum_{c=1}^{403} \vartheta_c, \qquad \theta_{tc} = \sum_{t=2002}^{2009} \sum_{c=1}^{403} \vartheta_{tc}.$$

We have data of all local markets, i.e. counties, in Germany where pharmacies are located. We can distinguish between individual pharmacies and chains (head pharmacy with up to three dependent stores) on firm and store level. In all markets before 2004 entry was possible as an individual store only. From 2004 on pharmacists could enter the market as chains or expand their existing pharmacy. Entry (or acquisition) with (of) dependent stores is restricted to the county (or neighboring county) where the head store is located. The situation creates a natural experiment allowing us to estimate the impact of chain entry. We compare those pharmacies expanding to chains (units accepting treatment) any time after the reform and those staying independent (control). To apply this approach, we rely on the assumption that treatment and control have similar counterfactual trends. Arguments why our choice of treatment and control is valid are listed below:

(1) Random assignment: All pharmacies have the same probability to be a treatment or control unit. The decision to expand depends on the potential gain in market shares. Before the reform, all pharmacies were independent with the same requirements with respect to prices, quality, locations, premises, equipment opening hours and advertisement.

(2) Stable unit treatment value assumption: Availability of retail space drives entry decision with respect to the locations, since pharmacies have a geographic restriction with respect to the location(s) of their dependent store(s). When deciding to expand, the dependent stores are typically in the same county as the head store such that the owner is able to reach all stores within a short time span. In some rare cases, chains may span two neighboring counties.

(3) Balance of observable and unobservable variables in treatment and control: Counties are not identical, while some are more rural others are more urban. To control for such time-invariant differences between counties when comparing treated and control units we include county fixed effects. Restriction of possible locations to the county of the head store reduces threat to validity due to unobserved socio-economic heterogeneity, since markets within a county tend to be homogeneous. For instance, preferences or average travel distance to a pharmacy are more homogeneous within counties which are either more rural counties or counties of large cities in comparison to larger units. To control for time varying unobserved influences of population density (demand) we include the number of general practitioners as a proxy

for demand in the county. The number of general practitioners is tied to population counts.

(4) Anticipation (forecasting): Those effects can be neglected since in 2002 the government still communicated to stick with the multiple-ownership ban ("tried and tested"). In the beginning of 2003, the regulators announced for the first time the abolishment of the ban, which came into force on January 2004.

(5) Error in variables bias: It can be excluded due to the fact that we have high quality data. Administrative data with mandatory reporting which means that we have (almost) no missing data. Furthermore, we cleaned the data as presented in the sample restriction (see Table 4.7). Problems occurring from small samples can be excluded, the administrative data includes all pharmacies in Germany during the observation period.

However, even though the descriptive statistics suggest that their situation did not change at all, the presence of chains in the market could have affected independent pharmacies, perhaps through more intense competition. This could potentially violate the assumption that the observation on one unit should be unaffected by the particular assignment of treatments to the other units. Therefore, in Section 4.7 we provide additional difference-in-difference regressions at the store level with general practitioners as a control group and pharmacists as treated group as a robustness check. Since general practitioners never have been restricted with respect to the number of stores and were not subject to the 2004 reform they can serve as a control group.

For our second analysis we estimate the following two panel data regressions, inspired by Bertrand and Kramarz (2002) to measure i) the relationship of the prevalence of chains on local market concentration measures (4.8) and ii) to estimate the relationship of concentration measures and the prevalence of chains on the number of employees (4.9). We use two measures of prevalence of chains. First, the number of chains. Second, the share of chains among all firms in the local market. We estimate the following specification:

$$\textsc{Concentration}_{ct} = \alpha\,\textsc{Chain}_{ct} + \beta\,\textsc{Entries}_{ct} + \gamma\,X_{ct} + \theta_t + \theta_c + \epsilon_{ct}, \qquad (4.8)$$

where Concentration is a concentration measure at the local market level (Herfindahl-index or the concentration ratios), Chain and $\textsc{Entries}_{ct}$ denote either the number or the share of chains and entries varying over county c and year t. α is the estimate of interest, X_{ct} includes the number of general practitioners to proxy for demand, θ_t denotes the year, and θ_c country fixed effects, and ϵ is a residual. The second equation links product market competition to employment in the local market.

$$\begin{aligned}\textsc{Employees}_{ct} = {} & \delta_1\,\textsc{Chain}_{ct-1} + \delta_2\,\textsc{Entries}_{ct-1} + \delta_3\,\textsc{Concentration}_{ct-1} \\ & + \beta\,X_{ct} + \theta_t + \theta_c + \varepsilon_{ct}, \qquad (4.9)\end{aligned}$$

where Employees is the number of employees in a local market, δ_1, δ_2 and δ_3 are the estimates of interest.

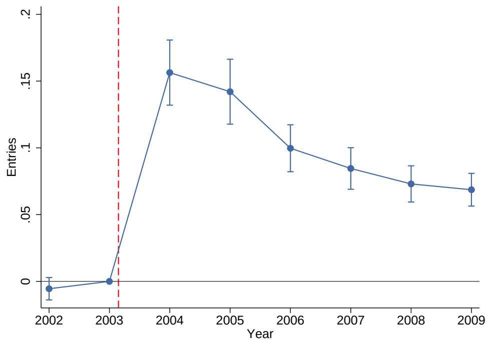
4.6 Results

4.6.1 Market Dynamics

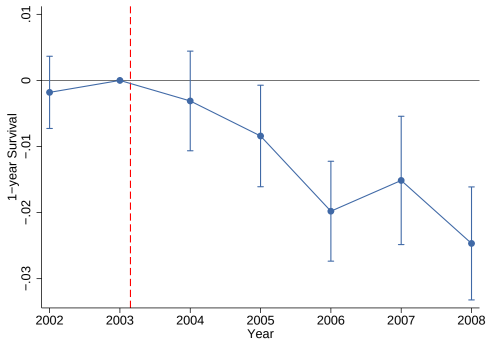
Applying an event-study approach provides the advantage of accounting for the pharmacies expanding at different points in time. To assess the effects of expansion on the market outcomes, we show the comparisons of differential trends around the year pharmacists expanded to chains. We compare expanding pharmacies, that is, those becoming a chain, to those staying independent.

In Figure 4.4a we plot the time trend of entry over the observation period. These results suggest clearly that chains drive entries. Although we can observe an increase in the entry rate for chains after the liberalization, accounting for the full set of fixed effects, we cannot find higher entry rates in the period before the deregulation. Apparently, expanding pharmacies were not characterized by

Figure 4.4: Impact on Firm Dynamics



(a) Entries



(b) 1-Year Survivals

Notes: Differential time trends for entries around the year of the reform, data on store-level. Estimation results from equation (4.7) are reported in Table 4.9 in the Appendix in Section 4.A.2.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS) 2002-2009.

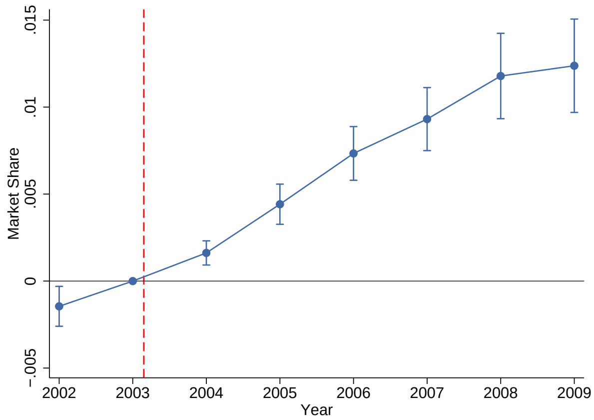
higher entry rates before the reform. Further, we find one-year survival rates to be decreasing for the pharmacies forming chains (see Figure 4.4b). Stores belonging to a chain are characterized by a slightly lower survival rate. Two years after the liberalization, the one-year survival rate starts to decrease significantly.

The above findings regarding the entries are in line with the predictions of our theoretical model concerning the higher number of entering stores when allowing for expansion to chains. When lifting the multiple-ownership ban, entry costs can be divided over multiple stores, and therefore, entry is simplified for chains in comparison to independent pharmacies. The increased number of stores intensifies the competition for market shares, and hence, decreases the survival probability of each store.

4.6.2 Competition Effects

The higher entry rates we found for chains raise the question of whether they perform differently compared to independent pharmacies on the product market—in other words, whether we can identify any competitive effects. We find that the market share of chains increases over time in comparison to independent pharma-

Figure 4.5: Impact on Market Competition



Notes: Notes: Differential time trends for market shares around the year of the reform, data on firm-level. Estimation results from equation (4.7) are reported in Table 4.10 in the Appendix in Section 4.A.2.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS) and AFiD Retail Panel 2002-2009.

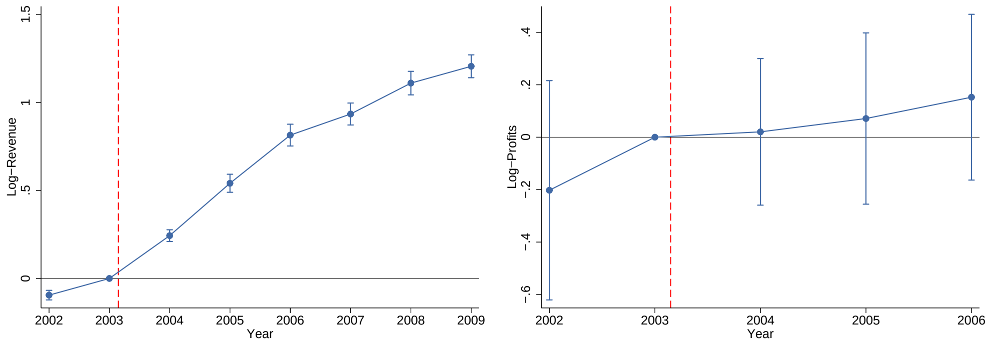
cies, see Figure 4.5.

We statistically reject that the point estimate for 2002 is equal to zero, however, one has to carefully consider the size of the effects shown on the vertical axis, because the difference between those chains and the independent pharmacies is economically minuscule and result from inflation. We apply a rather strict assumption regarding the price index and then calculated real revenues by using the German prescription drug price index API (Arzneimittelpreisindex).[11] We used the API instead of the consumer price index (CPI) as the main part of revenues (about 80%) are generated in the prescription drug market.[12]

After the deregulation, the market shares increased continuously for chains. The increase in market share is reflected in a similar increase in revenues, see Figure 4.6a. Regarding profits, we cannot find increases as we do for revenues. Figure 4.6b shows that profits rather grow—if at all—much more slowly and to a substantially smaller extent, perhaps due to (proportionally) rising costs (wages,

[11]The API is calculated based on prescription drugs that are authorized on the German market and approved by the German central organization of the statutory health insurance (GKV, Spitzenverband der Gesetzlichen Krankenversicherung).
[12]This is why we decided not to present the results based on a deflation factor weighted from both the API and the CPI.

Figure 4.6: Impact on Competition Outcomes



(a) Log-Revenue (b) Log-Profits

Notes: Differential time trends for log-revenue around the year of the reform, data on firm-level. Estimation results from equation (4.7) are reported in Table 4.10 in the Appendix in Section 4.A.2.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS) and AFiD Retail Panel 2002-2009 and 2002-2006 respectively.

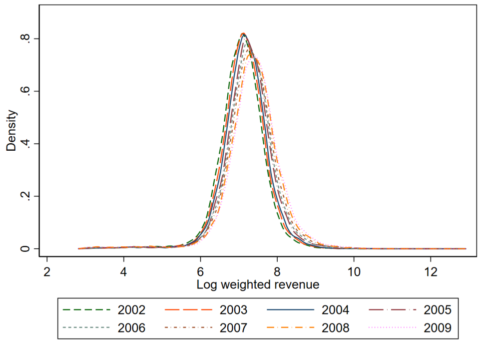
rents, and input costs). Note that the rather large, insignificant point estimate for 2002 is due to substantial revisions in the survey methodology by the Federal Statistical Office between 2002 and 2003 and should, therefore, be interpreted with caution.

To assess the heterogeneity of the treatment effects and the pre-reform differences in greater detail, we compare the revenue distributions between independent pharmacies and chains over the years. These product market effects are described by kernel density plots for each year in Figures 4.7a and 4.7b. The figures show, that chains have had already before the reform, higher revenues on average, mainly due to higher probability mass on the right tail.

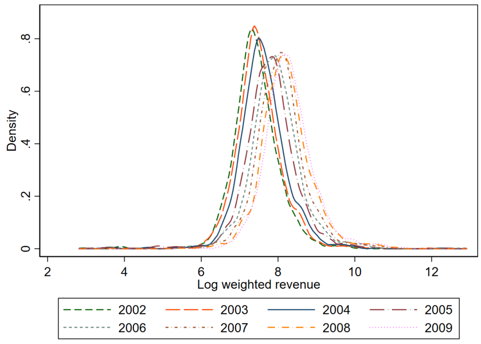
Strikingly, Figure 4.7b shows an instantaneous shift of the revenue distribution, which can be observed in the years from 2004 to 2005 for chains but not for independent pharmacies. The reform not only affected the right tail but also shifted the left tail because all chains expanded to new locations.

Still, it is remarkable that the dispersion of log-revenues has not changed much. Note that we observe small shifts over the years presumably due to inflation. These result from over-the-counter sales for which the CPI applies. In summary, the evidence suggests that i) the reform immediately affected revenues and ii) led

Figure 4.7: Impact across the Distribution of Revenues



(a) Density Revenues Independent Pharmacies



(b) Density Revenues Chains

Notes: Number of employees and revenues counted on firm level. For the kernel density estimation we used the Epanechnikov kernel.
Datasource: Own calculations based on the Business Register (AFiD-Panel URS) 2002-2009.

to doubling after three years, whereas iii) profits have at best only slightly been affected.

4.6.3 Concentration Effects

In this section, we assess one of the key objectives of the liberalization of the multiple-ownership ban, namely to introduce more competition in local pharmacy markets. In order to investigate this, we consider the effects of chains and entries on concentration indicators as the Herfindahl-index or the concentration ratios, accounting for the market concentration and the market power of the leading pharmacies, respectively.

If the liberalization led to higher competition between the pharmacies we should be able to see the impact reflected in decreasing market concentration. Further, we investigate the effect of product market liberalization on employment decisions. In Table 4.4 we report the effects of the liberalization of multiple ownership on the concentration of pharmacies in the local markets, that is, counties.

All regressions of equation (4.8) presented in Table 4.4 include year fixed effects and control for the number of general practitioners as a proxy for demand. We explore the effect on markets with chains alone, hence, excluding markets where no pharmacies expanded during the observation window to assess the intensive margin of higher numbers of chains.

In Table 4.4, we correlate the concentration measures either with the number of chains (column 1) and the number of entries (column 2) or with the shares of chains (column 3) and entries (column 4) in the respective county for all outcome values of concentration measures.

Table 4.4: Impact of Entry Regulation on Concentration

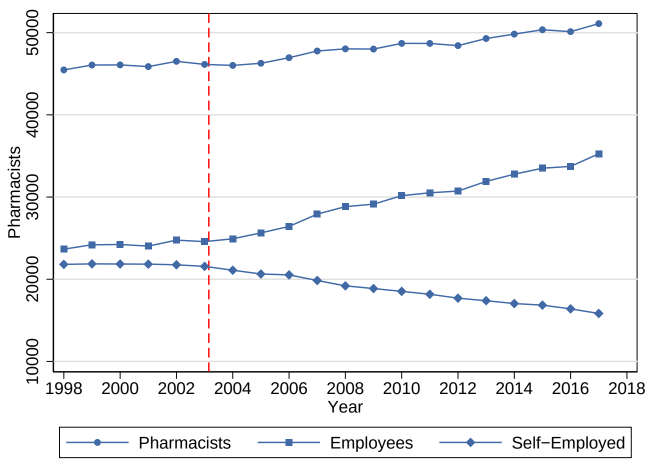
	H	CR[1]	CR[2]	CR[3]	CR[5]	CR[10]
Numbers of firms						
Chains	-0.045**	-0.088**	-0.103***	-0.111***	-0.101***	-0.069**
	(0.022)	(0.035)	(0.037)	(0.038)	(0.037)	(0.031)
Entries	0.034	0.091	0.082	0.076	0.050	0.011
	(0.041)	(0.075)	(0.079)	(0.083)	(0.082)	(0.074)
Shares of firms						
Chain-Share	-0.033**	-0.096***	-0.089***	-0.097**	-0.066*	-0.073**
	(0.016)	(0.032)	(0.032)	(0.035)	(0.036)	(0.035)
Entry-Share	0.010	0.050	0.042	0.032	0.016	0.016
	(0.019)	(0.038)	(0.045)	(0.046)	(0.044)	(0.036)
No. GP's	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	1,865	1,865	1,865	1,865	1,865	1,865

Notes: Chains and Entries correspond to the numbers of chains and entries in the market. Chain-Share and Entry-Share correspond to the chain or entry shares in the market. The dependent variables are the Herfindahl-index (H) as the sum of the squares of the market shares in each county or the concentration ratios cr[n] with n as the corresponding leading market share(s) per county, where [1] is the largest. All regressions include year fixed effects and control for the number of general practitioners as a proxy for demand. Standard errors clustered at county-level are in parentheses.
***Statistical significance at 1%, **significance at 5%, *significance at 10%.
Source: Own calculations based on the Business Register (AFiD-Panel URS) from 2002 to 2009.

We find that all measures of concentration are negatively related to the liberalization: Deregulating the multiple ownership, that is, allowing the number of stores per pharmacy to increase up to four in total, decreases the market concentration. We find this negative effect on the concentration measures to be significant for the number of chains in a county as well as for the share of chains per county. Entry of new pharmacies and a higher entry-share only slightly increase the market concentration, however, these effects are not significant.

How do these findings correspond with our findings from the descriptive statistics, where we stated that concentration increased? In general, concentration in the market seems to have increased. However, disentangling the effects showed: in markets with chains a further increase of the number of stores per firm decreases the market concentration and, therefore, fulfills the intention of the deregulation by introducing a higher competition intensity. This meets the predictions of our theoretical model.

Figure 4.8: Employment Structure of Pharmacists Pre- and Post-Reform



Notes: Own calculations. Overall number of pharmacists, employees and self-employed.
Datasource: ABDA 1998-2017.

We find that the reform had significant effects on the labor market concerning the employment structure. The number of self-employed pharmacists decreased over the years from 1998 till 2017 while the number of employed pharmacists (including those who are employed as a manager of a dependent pharmacy) increased (see Figure 4.8). Expanding a pharmacy still requires a pharmacist in each affiliated store, hence, the “pharmacist in the pharmacy” can be an employed (instead of a self-employed) pharmacist, explaining the increase in the numbers of employed pharmacists after 2004.

Assessing Figure 4.8 more closely reveals several key aspects on the link between product market regulation and labor market outcomes. Before the deregulation in 2004, we observe that the number of self-employed pharmacists equals the aggregate number of stores as shown in Figure 4.1b. Both groups, self-employed and employed pharmacists follow parallel trends prior to the policy change. When the reform became effective, the number of self-employed pharmacists started to decline steadily by about 3,000 - matching precisely the number of new affiliated stores as shown in Figure 4.1b. This can be seen as a potential mechanical impact of the reform on the labor market, suggesting that those independent pharmacies have been closed perhaps because former self-employed pharmacists retired or because new chains hired them as pharmacy managers. Therefore, to assess the aggregate employment effects of the reform, it is important to take this substitution effect into account.

In a brief back-of-the-envelope calculation, we assume that all those 3,000 (on average) former self-employed pharmacists appear as employed pharmacists. With this lower bound, the increase in employment from about 22,000 before the reform to roughly 31,000 after the reform implies about 6,000 new jobs or an increase in employment of 18% on average.

To explore the general impact of market concentration on employment, we report the results obtained from estimating specification (4.9) in Table 4.5. The dependent variable is the number of employees in pharmacies per county.[13]

In all regressions, we control for the number of chains and entries in the year $t-1$. Employment decisions are likely to be made based on the market situation in the year before, markets with many entries or with a high number of chains might be in higher need of personnel. As we will see later on, expanding pharmacies increased their number of employees rather step-wise than instantaneously (see Figure 4.9b). This suggests that it is important to control for the number of

[13]Including all employees subject to mandatory social insurance contribution, hence, including besides employed pharmacists also personnel like pharmaceutical-technical assistants.

expanding pharmacies and entries in the previous year.

Table 4.5: Impact of Concentration on Employment

	(I)	(II)	(III)	(IV)	(V)	(VI)
Chains$_{t-1}$	2.940***	2.935***	2.935***	2.929***	2.916***	2.887***
	(0.485)	(0.486)	(0.488)	(0.491)	(0.496)	(0.504)
Entries$_{t-1}$	-0.607*	-0.578*	-0.593*	-0.591*	-0.570*	-0.531*
	(0.318)	(0.318)	(0.318)	(0.318)	(0.318)	(0.320)
H$_{t-1}$	1.251					
	(0.777)					
CR[1]$_{t-1}$		0.641*				
		(0.341)				
CR[2]$_{t-1}$			0.563*			
			(0.294)			
CR[3]$_{t-1}$				0.545**		
				(0.275)		
CR[5]$_{t-1}$					0.571**	
					(0.281)	
CR[10]$_{t-1}$						0.659**
						(0.319)
Year FE	✓	✓	✓	✓	✓	✓
Observations	2,807	2,807	2,807	2,807	2,807	2,807

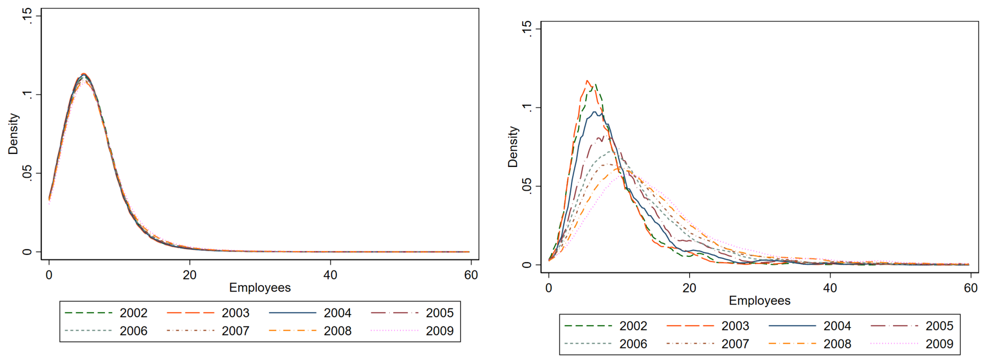
Notes: The dependent variable is the numbers of personnel employed as reported in the URS. We control for Herfindahl-index, chains, entries and concentration ratios in year $t-1$. Standard errors clustered at county level are in parentheses.

***Statistical significance at 1%, **significance at 5%, *significance at 10%.

Source: Own calculations based on the Business Register (AFiD-Panel URS) from 2002 to 2009.

We find that the effect of chains on employment is positive. At the same time, higher market concentration is associated with more employment. These effects are economically relevant. Increasing the market share of the largest pharmacy by ten percentage points leads to six additional employees. The effect of chains is significant for all regressions. A higher number of chains leads to about three employees more.

Figure 4.9: Impact across the Distribution of the Number of Employees



(a) Density Employees in Independent Pharmacies

(b) Density Employees in Chains

Notes: Own calculations. Number of employees and revenues counted on firm level. For the kernel density estimation we used the Epanechnikov kernel.
Datasource: Business Register (AFiD-Panel URS) 2002-2009.

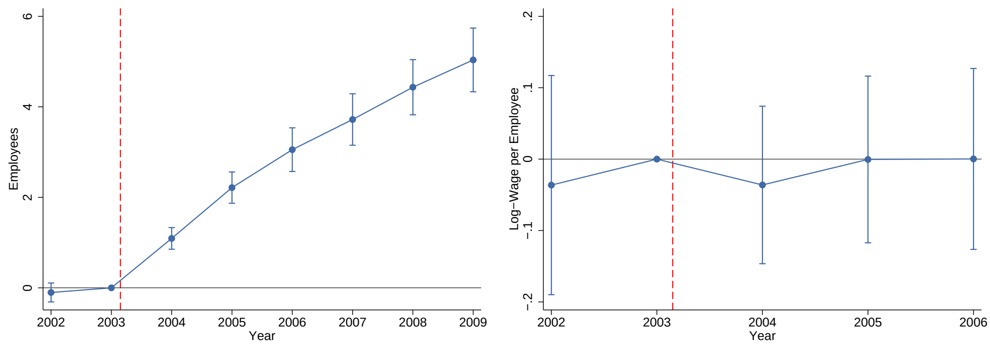
4.6.4 Labor Market Effects

Disentangling the reform effects on the labor market yields key insights into the dynamics of the hiring behavior of pharmacies. After the reform, we find a significant increase in the number of employees for chains, which is not surprising because more stores require more personnel. However, in contrast to revenues, the number of employees gradually increases. Quantitatively, the event-study results shown in Figure 4.10a imply that pharmacists hire about one employee per year on average. The pre-reform estimate is not statistically different from zero.

Presumably, chains successively increase the number of employees over the years due to increased personnel requirements of two or more stores. However, surprisingly we do not observe a doubling of personnel at the firm level after the deregulation. A reason for this under-proportional increase of personnel might be either some efficiency effects in organizing the staff or the fact that firms enter the market with smaller stores, which perhaps grow in the long term.

From the survey data, we see that over time pharmacies hire more full-time than part-time employees (not reported), although this evidence is not as clear. Do wage costs increase for pharmacies with more stores? This could be the case perhaps due to local shortage of supply or overtime pay. In principle, most of

Figure 4.10: Impact on Labor Market Outcomes



(a) Number of Employees (b) Log-Wages per Employee

Notes: Own calculations. Differential time trends for employees around the year of the reform, data on firm-level. Estimation results from equation (4.7) are reported in Table 4.10 in the Appendix in Section 4.A.2.
Datasource: Business Register (AFiD-Panel URS) and AFiD Retail Panel 2002-2009 and 2002-2006 respectively.

the remuneration is based on collective bargaining agreements and the aggregate supply of pharmacists was rather large in our time frame. Therefore, we expect to see no changes in an event-study regression on log-wages. In fact, Figure 4.10b shows that wage costs growth remained virtually at zero.[14]

As with revenues, we find significant effect heterogeneity for the group of independent pharmacies and the group of chains regarding their number of employees after the deregulation. Figures 4.9a and 4.9b depict the density of employees at firm level in independent pharmacies and chains, respectively. Chains have had, except for perhaps some representative pharmacies, on average a similar number of employees before the reform with similar dispersion.

Although the number of employees in independent pharmacies did not change, we observe a dynamic and step-wise shift of the mean number of employees for chains. The largest shift can be observed from 2003 to 2004 and from 2004 to 2005. In contrast to the impact on revenues, this shift only affected the right tail of the distribution, increasing the dispersion of pharmacy size.

In summary, the evidence suggests that regarding the labor market i) the effect

[14]Note that the estimate for 2002 in Figure 4.10b has to be interpreted with caution due to changes in the survey methodology between 2002 and 2003.

of the reform is rather dynamic and step-wise in contrast to the instantaneous effect in revenues, ii) although employment increases at the firm level, we find no doubling of personnel, and iii) wage-cost were not affected. This leads to the conclusion that employment growth is hindered by entry regulations, which is in line with the findings of Bertrand and Kramarz (2002).

4.7 Robustness

The liberalization of the multiple-ownership ban constitutes a large reform for pharmacists, having a major impact on both the labor and product markets of pharmacists. To understand the effects of the entry reform on market dynamics - entry, acquisition, exit, and one-year survival - we apply a difference-in-differences approach. To rule out the possibility that the presence of chains in a local market might have affected independent pharmacies, we apply the difference-in-differences approach to compare the outcomes for pharmacists to those of general practitioners before and after the reform.

General practitioners have been jointly analyzed with pharmacists in studies such as Schaumans and Verboven (2008) and are a natural comparison group for several reasons. First, trends affecting pharmacists translate directly to general practitioners, as the demand for pharmaceuticals is closely tied to the number of prescriptions dispensed. Second, the stable unit treatment value assumption is likely to hold, because the reform could not affect general practitioners as prices were exogenously fixed and physicians do not have freedom of establishment.[15] Third, the absence of anticipation effects seems also plausible, because the decision whether to become a pharmacist or a general practitioner cannot be adjusted as a reaction to the reform, because the average time of more than four years to be admitted as pharmacists or physician exceeds the time span between announce-

[15] If supply of medical services exceeds 110%, the Association of Statutory Health Insurance blocks the planning region for new general practitioners, regardless of whether they would like to work as self-employed or employee.

ment and implementation of the reform.

Table 4.6: Effects on Market Dynamics: Store-Level

	(I)	(II)	(III)	(IV)	(V)
ATE entries	0.024***	0.025***	0.027***	0.034***	0.024***
	(0.003)	(0.003)	(0.007)	(0.001)	(0.001)
ATE acquisitions	0.008***	0.008***	0.009***	0.007***	0.004***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
ATE exits	-0.006**	-0.006**	-0.016**	0.010***	0.007***
	(0.002)	(0.002)	(0.005)	(0.001)	(0.001)
ATE 1-year survivals	0.005**	0.005***	0.002	0.034***	0.026***
	(0.002)	(0.002)	(0.005)	(0.001)	(0.002)
Year FE	✓	✓	✓	✓	✓
County FE		✓	✓	✓	✓
Store FE				✓	✓
First Differences					✓
No. GP/county			✓		
Observations	412,224	412,224	53,605	412,224	336,058

Notes: We run all specifications for the different dependent variables: entry, acquisitions, exit and one-year survival. All regressions include year fixed effects. In specifications (V) and (VI) we control for the number of general practitioners as a proxy for demand. Standard errors clustered at county level are in parentheses. The number of observations varies with the dependent variable. We report the lowest number of observations. Data on store-level.
***Statistical significance at 0.1%, **significance at 1%, *significance at 5%.
Source: Own calculations based on the Business Register (AFiD-Panel URS) from 2002 to 2009.

More precisely, we specify

$$y_{fitc} = \tau \text{ P}\textsc{harmacists}_{it} + \beta X_{fitc} + \theta_t + \theta_c + \theta_{tc} + \theta_i + \epsilon_{fitc},$$

where y is an outcome variable varying over store i and year t in firm f and county c. τ is the average treatment effect (ATE), Pharmacists is a binary indicator equal to one when observing a pharmacist and zero for general practitioners. Year, county and county-year fixed effects are defined as before in Section 4.5.

Table 4.6 reports estimated ATE in five specifications for each market outcome. More precisely, we run regressions in which the respective outcome variable is estimated as a function of year effects (all specifications) and county effects (specifications II-V) to control for unobserved local heterogeneity. Specifications (IV) and (V) additionally include store fixed effects to control for differences in specific stores.

We find that entry increases for pharmacists after the liberalization, and also find a positive and somewhat smaller trend for acquisitions. In our preferred specifications (IV and V), the exit rate increases for pharmacists. The one-year survival rate of a store increases as well, however, the survival in the pharmacy market is generally very high. In specification V, we control for first differences instead of fixed effects to address the problem of time-invariant unobserved variables. The results remain virtually unchanged. Overall, they are in line with our main findings of positive effects on entries and small changes in exits.

4.8 Summary and Conclusion

In this study, we use micro-level data on the universe of pharmacies in Germany to investigate the impact of a reform that liberalized market entry for chains. The deregulation of the multiple-ownership ban on the German pharmacy market provides a case in point to assess the effects of deregulating entry. Our results suggest that the reform has increased the acquisition of stores and entry of new stores substantially in the short and long term. We find that competition increased, resulting in higher exit and lower survival rates, albeit to an economically small extent.

We provide evidence on the characteristics of expanding firms, which have had higher revenues and more employees already prior to the reform, and show that both revenues and labor demand increased, whereas we cannot find evidence that profits increased. We document that expanding firms double revenues after three years but do not observe a doubling of personnel. This under-proportional increase might reflect efficiency effects in organizing the staff. Finally, we show that competition intensifies in markets where chains exist, but concentration decreases with more chains.

We view the results as consistent with the theoretical considerations set out in our study. With a market share competition model inspired by the local rivalry on the unit circle by Salop (1979), we show that artificially suppressing the number of stores may forgo efficiency gains and reduce consumer welfare. The model predicts that the reduction of entry costs affects competition in a way consistent with our findings in the data. Restricting the maximum number of stores to a fixed number independent of the characteristics of a local market seems excessively restrictive. We further can account for the increased labor demand of chains and show that a (relative) higher managerial and organizational efficiency leads to an increased number of stores per firm.

On top of this, we show that employment is strongly positively correlated with each concentration measure. This shows that product market competition and labor market outcomes are intimately linked. In fact, although the reform has directly affected the market structure, we demonstrate clear evidence that it had important and sizable effects on the labor market as well. The policy change increased the number of employees per local market by 40% and led to aggregate job growth for pharmacists of more than 18%.

Our results can be seen as in line with the effects of occupational licensing, which emphasizes the inefficiencies associated with entry regulation in labor markets. More generally, we cannot exclude that entry regulations such as the multiple ownership prohibition serve the private interests of incumbents. However, these results are from our investigation of competition variables. There was no attempt to assess the quality of services, which may be an ambitious but important avenue for future research.

Evaluating the success of the reform shows that it worked as the intended careful partial liberalization. Nevertheless, even if the maximum number of stores remained restricted to four, the gains were likely quantitatively disproportionally high. This is evident from the characteristics of new firms induced into the market by the reform, which strengthened already comparatively efficient firms. Even though employment at the local market level increased only slightly in absolute terms, the (unintended) impact on the labor market has been sizable. These results may suggest further liberalization of the multiple ownership, perhaps also including the admission of third-party ownership (German Council of Economic Experts, 2003). However, the higher market concentration would need to be monitored carefully to prevent monopolization, which could lead to undersupply, particularly in rural regions. Moreover, in terms of job creation, the impact of future reforms could be modest - at least initially, as since the 2004 reform, new stores start rather small.

4.A Appendix

4.A.1 Definition of Key Variables and Sample Restrictions

Table 4.7: Sample restrictions

	AFiD-Panel URS		AFiD Retail	
Full Sample:		579,203		11,990
	Eliminated	Remaining	Eliminated	Remaining
Unit is expired	62,851	516,352	-	-
Unit is head-store	6,034	510,318	-	-
Unit is inactve	34,413	475,905	-	-
Chain before 2004	2,829	473,076	114	11,876
More than four stores	181	472,895	57	11,819

Notes: The observations in the AFiD (URS) panel include the industry sectors of pharmacists (WZ2003: 52310, WZ2008: 47730) and general practitioners (WZ3003: 85121, WZ2008: 86210) over the years 2002 until 2009. The AFiD Retail panel is an unbalanced panel of pharmacists (WZ2003: 52310) over the years from 2002 until 2006. If we would observe each pharmacy over all 5 years, we have 23,190 potential observations.
Sources: Own calculations.

Table 4.8: Definition of key variables

Variable	Definition
Entry	Indicator for being newly registered on the market.
Acquisitions	Indicator for stores of firm i in t and of firm $j \neq i$ in $t+1$.
Exit	Indicator variable having been deregistered form the market.
1-Year Survival	Indicator variable for operating on the market next year.
Market Share	We sum up all revenues r realized in county c and year t by all pharmacies n located in the respective county and divided it by the drug price index (API) we obtain the sales per county Q_{tc}: $$Q_{tc} = \frac{\sum_i^n r_{itc}}{API_t}$$ Then, we calculated the individual market share s_{itc} of each pharmacy (on firm level) in year t and county c by dividing the revenues of pharmacy i by the API and the sales per county: $$s_{itc} = \frac{r_{itc}/API_t}{Q_{tc}} = \frac{r_{itc}}{\sum_i^n r_{itc}}$$
Revenue	Taxable revenue from goods and services in 1,000 Euro deflated with the drug price index (API).
Profits	Profits calculated from revenues and costs in 1,000 Euro deflated with the drug price index (API).
Concentration ratios	$cr(m)$ are calculated using the market share as follows: $$cr(m)_c = \sum_1^m s_i$$ With s_i being the market shares of each of the n pharmacies in the market and m the rank of the leading pharmacies considered in the calculation of the concentration ratios.
Herfindahl-index	$H_c = \sum_1^n s_i^2$.
Employees	Number of employees subject to social insurance contributions.
Wages	(Gross) wages and salaries in Euro deflated with the drug price index (API) reported by the firm.

4.A.2 Regression Tables Event Studies

Table 4.9: Event Study Market Dynamics

	Entry	1-y Survival
2002×Chain	-0.006	-0.002
	(0.004)	(0.003)
2003×Chain	0.000	0.000
	.	.
2004×Chain	0.156***	-0.003
	(0.012)	(0.004)
2005×Chain	0.142***	-0.008*
	(0.012)	(0.004)
2006×Chain	0.100***	-0.020***
	(0.009)	(0.004)
2007×Chain	0.085***	-0.015**
	(0.008)	(0.005)
2008×Chain	0.073***	-0.025***
	(0.007)	(0.004)
2009×Chain	0.069***	
	(0.006)	
Observations	472895	412224
Sample AVGs	0.102***	0.996***
	(0.003)	(0.001)
observations	14962	12342
Year FE	✓	✓
County FE	✓	✓
County-Year	✓	✓
Multistore	✓	✓

Notes: Estimation results from equation (4.7). Data on Store-level.
Source: Own calculations based on the Business Register (AFiD-Panel URS) from 2002 to 2009.

Table 4.10: Event Study Competition Effects

	Market-share	Log-Revenue	Log-Profits	Employees	Log-Wage
2002×Chain	-0.001*	-0.095***	-0.202	-0.103	-0.036
	(0.001)	(0.014)	(0.213)	(0.106)	(0.078)
2004×Chain	0.002***	0.243***	0.020	1.092***	-0.036
	(0.000)	(0.017)	(0.142)	(0.122)	(0.056)
2005×Chain	0.004***	0.541***	0.071	2.214***	-0.000
	(0.001)	(0.026)	(0.166)	(0.176)	(0.059)
2006×Chain	0.007***	0.814***	0.153	3.053***	0.000
	(0.001)	(0.031)	(0.161)	(0.245)	(0.064)
2007×Chain	0.009***	0.934***		3.720***	
	(0.001)	(0.032)		(0.290)	
2008×Chain	0.012***	1.109***		4.433***	
	(0.001)	(0.034)		(0.310)	
2009×Chain	0.012***	1.205***		5.036***	
	(0.001)	(0.033)		(0.358)	
Constant	0.031***	6.596***	4.460***	3.807***	10.376***
Observations	166,600	195,510	9,184	468,007	10,999
Year FE	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓
County×Year FE	✓	✓	✓	✓	✓

Notes: Estimation results from equation (4.7). Dependent variables are presented in the columns. Data on firm level.

Source: Own calculations based on the Business Register (AFiD-Panel URS) and the AFiD Retail Panel from 2002 to 2009 and from 2002 to 2006 respectively.

Chapter 5: Discussion and Outlook

The aim of this dissertation was to gain a deeper understanding of health care markets by using different theoretical and empirical approaches of industrial organization. Chapters 2 and 4 theoretically and empirically analyzed the effects of health reforms on market outcomes and evaluate their effectiveness. Chapter 3 developed a model which can be applied to the pharmaceutical market as it was shown in a case study.

Chapter 2 developed a model in a vertically differentiated duopoly market to assess the effects of the introduction of a reference pricing system on expenditures and welfare and to derive the optimal level of regulation. In terms of a cost-containment measure the regulation proves to be very effective while still allowing brand-name producers to obtain positive profits. Indeed, the findings suggest that regulators should decide in favor of a reference pricing system instead of direct price regulation if a significant reduction in insurance expenditures is intended and generic usage should be promoted. The derived theoretical results in this chapter are in line with empirical findings as reference pricing reduces prices of brand-names more than of generics (see Brekke et al., 2009), which leads to a larger decrease of profits of the brand-name firms (see Pavenik, 2002) and insurance expenditures can be reduced significantly (see Brekke et al., 2011; Herr et al., 2014).

Rising costs in health care markets increase the need for insurers to reduce their expenditures on the one hand while keeping innovation and production of new drugs profitable for firms on the other hand. The optimal set of regulatory measures needs to balance the interests of all parties. Future research should evaluate especially the German law on reorganization of the pharmaceutical market (AMNOG, see Table 1.1) introduced in 2011 with respect to its effects on the market entry of pharmaceutical producers with new innovations. With the introduction of AMNOG pharmaceutical firms are required to prove the therapeutic novelty of their drugs in order to obtain a period of free price setting before being clustered to a reference price group. In case a therapeutic advantage can not be proven during the price negotiations the new drug will be subject to reference pricing from market entry on which dampens the profit margin of the firms on the German market. The effects of these price negotiations need to be assessed especially with respect to the number of newly launched drugs on the German pharmaceutical market.

In Chapter 3, a theoretical model which allowed for the analysis of the combined effects of mixed ownership structures and manager delegation on firms' automation investments was developed. The novelty of the model was to combine mixed ownership structures with strategic delegation of capacity and cost-reducing investment decisions to specialized managers. The stylized set-up allowed to explain the firms' strategies for example in the pharmaceutical industry with its complex inter- and intra-firm structures. Due to the increasing share of common ownership, not only on the pharmaceutical market (see Montalban and Sakinç, 2021), but also in several other industries the importance of the presented research becomes evident. Not only lately (academic) researchers and policy makers wish to gain deeper insights in the effects of common ownership, with the growing influence of large institutional owners as Vanguard, BlackRock or the Capital Group, however, the need to provide more profound research about this topic is increasing.

The presented research shows that direct collusion as well as indirect coordination of common owners via the design of the managers' compensation schemes lead to lower investments in cost-reducing activities indicating that common holdings might be an explanatory factor for low automation activities. With respect to the intra-firm structure, social welfare is lower in markets with owner-controlled firms in comparison to firms where owners delegate operational decisions to managers. The decisive factor whether social welfare is higher under common ownership or pure delegation depends on how costly investments in automation in the respective industry are. Markets with favorable technological opportunities mixed ownership structures indeed lead to the highest social welfare, however, for markets where investment in automation is costly a structure without commonly held firms should be preferred. For future research the effects of spillovers on market outcomes should be addressed in the light of common ownership especially on markets with high investments in research and development as it is the case in the pharmaceutical industry. With the ever-increasing need for pharmaceuticals and new treatments and the thereof resulting high expenditures, such developments in the ownership structures need to be monitored carefully and understood deeply.

Chapter 4 examined the liberalization of the multiple-ownership ban on the pharmacy market and evaluated the reform effects with respect to the outcomes on the retail and labor markets. We showed theoretically that pharmacies as well as consumers profit from chain entry. Depending on the regional market's characteristics pharmacies wish to install additional stores. The new market structure leads to higher labor demand per firm on the one hand and lower labor demand per store on the other in comparison to the pre-reform situation. These findings indicate efficiency gains.

The empirical analysis carried out in this chapter is based on a broad (administrative) data-set which provided deep insights in German pharmacies and allowed to derive the reform effects. The results suggest that the liberalization led to a more competitive environment on the highly regulated pharmacy market. The reform not only affected the market structure by allowing for chain entry but also exerted sizable effects on the labor market. Our findings show that retail and labor market are intimately interlinked.

The theoretical model suggested that a restriction to a chain size of four stores might be overly restrictive. Depending on the local market's size pharmacies might wish to install more stores to realize higher efficiency gains. Future research should aim to evaluate whether the German pharmacy market should be further liberalized in terms of fully abolishing the multiple-ownership ban or even the third-party ban to overcome the lack of competition.

Concluding, on the health care market the usual supply and demand market mechanisms do not (always) work. Prices are not a valid instrument to send the correct signals for an optimal allocation of resources due to the existence of insurance. Firms need to be able to cover their expenses for costly research while pharmaceuticals still need to be affordable. The local supply of health care needs to be secured as well as the consumers (patients) need to be protected from an exhaustive search for treatment or drugs. The implementation of policies on the health care market is a balancing act between the interests of all market participants and will remain an important challenge for policy makers, regulators and (academic) researchers in the future.

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