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DOI:
10.57938/c14a9329-c606-44a7-948d-12307f992e74

Published: 01/07/2023

Document Version
Publisher's PDF, also known as Version of record

Department of Economics
Working Paper No. 343

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July 2023

WIRTSCHAFTS UNIVERSITÄT WIEN VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS

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June 7, 2021

Abstract We exploit the regulatory environment in the Austrian pharmaceutical market to study the effects of price regulation on market outcomes and consumer welfare. We evaluate all mergers of drug producers in the 2009-2017 period and find that the coexisting regulated and unregulated markets were unequally affected. While M&A have substantially increased prices without regulation, particularly for price-inelastic products, prices did not increase under regulation. Instead, variety increased in regulated markets. Therefore, regulation can successfully mitigate the effects of market power: whereas M&A decrease consumer welfare absent regulation, the additional product variety increases consumer welfare in the regulated market.

Keywords: pharmaceuticals; regulation; market power; consumer welfare; pharma mergers; product variety

JEL Codes: L65; I18; D22; I11; L51; G34

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1 Introduction

The global market for pharmaceuticals reached a volume of $1.2 trillion in 2018 and is expected to robustly grow to $1.5 trillion in 2023 (IQVIA, 2019). Yet it is not only size that makes pharmaceutical markets an interesting object of evaluation for academics and practitioners alike: a large and increasing number of people consume pharmaceutical products daily and the availability and price of drugs have a large impact on their quality of life. Furthermore, in most countries a significant portion of pharmaceutical expenses is paid for through public healthcare systems, potentially impeding the efficiency of price signals in the market. Therefore, well-designed and well-functioning pharmaceutical markets as well as efficient regulation are required in order to i) supply state-of-the-art drugs to consumers requiring them and ii) keep public as well as total expenditures at an acceptable level.

In this paper we analyze the effects of changes in market structure through M&A under regimes of price regulation and no regulation on prices, quantities and product variety as well as consumer welfare. We investigate the pharmaceutical market in Austria, where a strictly regulated drug market coexists with an unregulated segment, permitting us to estimate the effects of regulation in a within-country setting. Specifically, we exploit ownership changes of pharmaceutical products – induced by 56 worldwide mergers of large pharmaceutical producers, which constitute the population of horizontal mergers affecting the Austrian market – to evaluate changes in firms' strategies and how they are affected by regulation.

As pharmaceutical markets often comprise regulated and unregulated segments, they constitute an ideal setting to trace out the impact of regulation on price and non-price outcomes. Yet, since national healthcare and pharmaceutical markets differ substantially, cross-country comparisons of regulatory regimes might be problematic. By observing the same products in regulated and unregulated market segments, we identify the effects of regulation within the same relevant market and within the same country. Further, as the changes in the ownership of drugs in the data are caused by large mergers (with a mean deal value of almost $10 billion) and the Austrian pharmaceutical market is relatively small (approximately €6 billion in 2018 (HVB, 2018), corresponding to 0.5% of global sales), we assume that these mergers are not determined by pharmaceutical regulation in Austria. We therefore regard the observed ownership changes as orthogonal to the regulatory situation. We argue thus that we are able to (1) identify the causal effects of regulation by observing regulated and unregulated segments within the same relevant market, and to (2) observe changes in market structure exogenous to regulation, since pharmaceutical mergers are worldwide in nature and unlikely to be determined by Austrian regulatory conditions. We later relax the second assumption by focusing on drugs, that are simultaneously sold in both market segments.

A number of studies have evaluated the price effects of mergers, both in the pharmaceutical industry (Björnerstedt and Verboven, 2016) and elsewhere (Dafny, 2009; Ashenfelter and Hosken, 2010). There are also studies on the non-price effects of mergers, for example on product variety (Berry and Waldfogel, 2001; Fan, 2013) or product repositioning (Sweeting, 2010) in the radio industry. Moreover, the effects of regulation on pharmaceutical market outcomes have been studied (Branstetter et al., 2016; Dubois and Lasio, 2018). Thus, while our main research questions (price and non-price effects of mergers, effect of regulation) have been addressed individually, this is to our best knowledge the first study to jointly analyze the price and non-price effects of mergers in the presence or absence of regulation. We achieve this integration by analyzing the impact of global mergers in the 2009-2017 period on the Austrian pharmaceutical market. If product prices are regulated and constraints are binding, mergers will not entail price increases. It would, however, be premature to conclude that mergers have no effects in such a setting. In the presence of binding price regulation, firms may find other ways to optimally respond to changes in market structure brought about by mergers, e.g. through product variety. Not accounting for these aspects is likely to give a misleading picture of the effects of ownership changes. Additionally, while most of the literature focuses on single merger cases, we evaluate the population of horizontal mergers affecting the Austrian market, a total of 56 deals leading to almost 600 ownership changes of drugs.

In standard IO models horizontal mergers raise unilateral market power and therefore the incentives of firms to increase prices. However, in section 3 we show that absent the ability to increase prices (due to binding price regulation), firms may have an incentive to increase product variety instead.[1] In a regulated market, markups are smaller than in an unregulated market. Thus, cannibalization effects due to additional varieties are smaller. Further, in the unregulated market segment, firms can simply increase prices. Thus, incentives to increase product variety are higher under price regulation than without regulation after a horizontal merger.

We empirically test these predictions in a dataset containing monthly sales, prices and characteristics of all drugs sold in the Austrian pharmaceutical market over the 2004-2017 period. In addition to observing the population of drugs at a disaggregated level, the data also allow us to distinguish sales in regulated and unregulated market segments. Importantly, the data allow us to

[1] We measure product variety as the number of different formulations and dosages (strenghts) of a drug.

define product markets (ATC4 groups[2] in regulated and unregulated segments) and geographical markets (national, i.e. Austria) at the relevant antitrust level.[3]

Using a nested logit model, we obtain price elasticities of demand for all drugs. We show that mergers (1) increase prices in the unregulated parts of the market in general and particularly for price-inelastic products, (2) do not increase prices in the regulated market segment, (3) increase product variety in the regulated parts of the market, but (4) do not increase product variety in the unregulated parts. Our results thus show that regulation can successfully mitigate the effects of increased market power due to industry consolidation.

This has important implications for the welfare of consumers in affected markets. In unregulated markets an average price increase of 11% leads to an average decrease in consumer welfare of around 6%. In contrast, the prices of merging firms in regulated markets do not increase after mergers but there is an increase in product variety of 21%. This leads to an increase in the utility of a representative consumer of around 15%.

The literature most closely related to our paper consists of papers structurally analysing the effects of mergers on prices, e.g. Björnerstedt and Verboven (2016), papers analyzing non-price effects of mergers, e.g. Berry and Waldfogel (2001), Sweeting (2010), and Fan (2013), and papers analysing the effects of regulation on market outcomes, such as Dubois and Lasio (2018) and Branstetter et al. (2016).

A recent structural analysis of mergers is provided by Björnerstedt and Verboven (2016). They analyze a large merger in the Swedish market for analgesics (painkillers) and find that the predicted and actual price effects are of similar magnitude (+30-40%). However, while their simulation model predicts larger price increases for the smaller firm (the acquirer), both merging firms raised their prices by a similar percentage. Moreover, while the model predicts only small price increases of outsider firms, two of them substantially increased prices after the merger. The paper does not analyze the effects of regulation or non-price effects of mergers.

A number of studies show that mergers have also led to increased product prices in other industries. For instance, McCabe (2002) conducts a difference-in-difference analysis of journal pricing and Dafny (2009) uses IV estimation in an application to hospital pricing. Their results are largely consistent with the findings of the Weinberg (2007) literature survey on the price effects of horizontal mergers. Accordingly, many studies find increased market power and reductions in consumer

[2]The Anatomical Therapeutic Chemical code (ATC) is a WHO classification scheme comprising 5 levels: the main group (ATC1), the therapeutic group (ATC2), the pharmacological subgroup (ATC3), the chemical subgroup (ATC4) and the subgroup of the active substance (ATC5).

[3]The European Commission defines the relevant market for pharmaceuticals at the ATC3 or ATC4 level, see e.g. Ornaghi et al. (2019).

welfare due to mergers. However, as noted by Weinberg (2007), the mergers in these studies are not randomly selected, thus possibly oversampling mergers where anti-competitive effects are significant. The present study circumvents the problem of merger selection by analyzing the population of relevant mergers in the pharmaceutical industry.

Gandhi et al. (2008) analyze the product repositioning effects of mergers. In a price-location model they find a plausible scenario (merging products are close substitutes) in which merging firms have an incentive to separate products and reduce substitutability between them. This mitigates unilateral price increase incentives. Mazzeo et al. (2014) present simulation evidence on the effects of mergers on product choice. While overall effects are ambiguous, they pin down circumstances in which the price effects of mergers may be counterbalanced by endogenous product choice. Mergers could potentially lead to increases in consumer welfare if more products are introduced, counteracting price effects of mergers. Fan (2013) develops a structural model of newspaper markets to analyze the effects of ownership consolidation on price but also non-price adjustment of newspaper characteristics. In simulations of a hypothetical merger in the Minneapolis newspaper market, firms increase their subscription prices with the smaller firm increasing prices by more than the larger firm. Moreover, merging firms decrease content quality, the ratio of local news and variety. Thus, in Fan (2013) (negative) welfare effects of mergers through price increases are reinforced by negative product repositioning effects.[4] Berry and Waldfogel (2001) find that concentration reduces radio station entry, but holding the number of stations constant, increases product variety (number of formats). One consistent interpretation would be that multi-station firms populate product space with stations offering similar but not identical programming. The authors explain this by spatial pre-emption of competitors instead of scale or scope economies. Sweeting (2010), in contrast, finds that common owners differentiate their music radio stations, but also tend to make them more similar to competitors. Thus, mergers may increase competitive pressure and ignoring product repositioning effects of mergers may be misleading. Summarizing, the non-price effects of mergers are ambiguous and depend on the circumstances of the industry or even case. Generally, the welfare reductions due to price increases may be counterbalanced but could also be reinforced by non-price effects. We add to this literature by showing that the non-price effects of mergers (i.e. product variety) depend on the regulatory environment.

The third strand of the literature related to our paper is research on the effects of regulation on market outcomes. In a structural model of the pharmaceutical industry, Dubois and Lasio (2018) investigate the effects of price regulation of drugs in France. Their counterfactual simulations sug-

[4]Similarly, Fan and Yang (2016) find in a merger simulation model that a hypothetical merger in the smartphone market (Samsung and LG) would increase prices and decrease product variety.

gest that price constraints generated modest savings for anti-ulcer drugs in 2003-2013 (2% of total expenses) relative to a free pricing scenario, and shifted consumption from generic to branded drugs. While Dubois and Lasio (2018) rely on a cross-country identification strategy (i.e. the effects of regulation are identified through comparison to the comparatively unregulated German and American markets), we utilize within-country and within-market variation of regulation, since many substances are marketed in both the regulated and unregulated parts of the Austrian pharmaceutical market. While we also find price dampening effects of regulation, we in addition find that price regulation leads to entry of additional varieties.[5]

The paper proceeds by describing the market for pharmaceuticals in Austria (section 2) and presenting the model framework (section 3). In section 4, we discuss the data and the estimation of merger effects, while section 5 presents the findings. Finally, section 6 concludes.

2 The Austrian Pharmaceutical Market

The Austrian pharmaceutical market is strictly regulated, with 99% of Austria's population of 8.7 million covered by one of the 21 social insurance institutions. In 2017, total health expenditures amounted to €41.3 billion corresponding to 11.2% of GDP.

All operating decisions on drug authorization, pharmacovigilance, inspection and clinical testing are the responsibility of the AGES (Austrian Agency for Health and Food Safety). The authorization of a new product is granted if the applicant can demonstrate that the expected benefits of a medicine exceed the expected side effects. This is to be distinguished from increasing variants of existing products, which can be achieved relatively quickly, since no new authorization process needs to be initiated. Human medicine products can be distinguished according to their prescription status as well as whether they are reimbursed or not. In 2015, there were 9,830 prescription medicinal products and 4,711, or 32%, non-prescription medicinal products ("over the counter", OTC). In terms of sales, the OTC market amounted to €821.3 million.

[5]Danzon and Chao (2000) show that price competition between generic competitors is significant in unregulated or lightly regulated markets (United States, United Kingdom, Canada, and Germany) but that regulation undermines generic competition in strict regulatory systems (France, Italy, and Japan). Regulation thus undermines the potential for significant savings on off-patent drugs. Moreover, from a dynamic perspective, strict price controls, such as reference pricing, may discourage or delay drug introduction, see e.g. Danzon et al. (2005), Kyle (2007), or Cockburn et al. (2016), and prevent firms from recouping fixed R&D costs, see e.g. Dubois et al. (2015) for required revenue estimates for the invention of a new chemical entity. For the (positive) welfare effects of generic entry induced by Paragraph IV certification (entry upon invalidity or noninfringement claim of the branded product's patent), see Branstetter et al. (2016), and for generic entry in attention deficit hyperactivity disorder (ADHD), see Bokhari and Fournier (2013). In this paper, we do not analyze generic nor dynamic competition.

Since 2005 a Code of Reimbursement (Erstattungskodex, EKO) governs the process and requirements for a medicinal product to be reimbursable. If a medicinal product is in the EKO, it can also be subjected to price regulation. Around 63% of all available medicinal products are included in the EKO and therefore reimbursable. 80% of these are freely dispensable, while the remainder needs to be approved by a chief physician. In the year 2015, the Austrian social security system paid €2,929 million for medicinal products, thus the bulk of medicinal expenses is reimbursed.

Maximum prices for EKO products are calculated using the EU average prices ("reference pricing"). [6] This contrasts sharply with unregulated sales, the prices of which can be freely set.[7] Thus, it is possible for a firm to strategically leave medicines out of the EKO in order to set prices freely. This has led to some publicly sensitive price increases in recent years,[8] where manufacturers moved products out of the EKO in order to charge unregulated prices. This strategy is all the more profitable, the more essential the drug is, i.e. the fewer substitutes exist, and the more likely the drug is therefore dispensed and reimbursed without being in the EKO. As laid out above, unregulated products might also be reimbursed by social insurance if approved by a chief physician. The expenses for reimbursing unregulated products amounted to €380 million or 13% of total social insurance expenses for drugs in 2015, rising from 6% in 2005.[9]

The co-payment prescription fee increased from €4.45 per pack to €5.85 per pack, essentially reflecting inflation. Health insurance institutions collected approximately €403 million in prescription fees in 2016, which is around 14.7% of total expenses for medicinal products. Besides specific exemptions for social reasons, there is also an annual ceiling on prescription fees of 2% of personal net income. Thus, insured persons are likely to be price insensitive for reimbursed drugs. Price elasticities for reimbursed drugs stem predominantly from physicians and pharmacists, who are

[6] Generics are also subject to stringent regulation. The first generic to enter a market has to lower prices by 48% relative to the original product in order to be acquitted to the EKO. The second generic entry needs to reduce prices by a further 15%, and the third by another 10%. In the course of the reform in 2017 ("ASVG-Novelle 2017), from 1 April, 2017 onwards, the second generic has to lower its price by a further 18%, and the third by a further 15%. Biosimilars are also covered. Moreover, a price band was introduced, such that the price of the most expensive product (i.e. the original product) in a group must lie within 30% of the least expensive product. After patent expiration, the original product has to cut its price by at least 30% in order to remain in the EKO.

[7] From 1.1.2018 onwards, certain unregulated products are also subject to price regulation. More specifically, products with annual sales of more than €750,000 must not charge more than the EU average price. This regulatory change is out of the sample period.

[8] As an example, see https://www.derstandard.at/story/2000073528899, where the Austrian competition authority criticises the 58-fold price increase of an antidepressant.

[9] This increase was one of the main reasons for also regulating non-EKO products from 1.1.2018 onwards. In general, expenses for high price medicine (more than €700 per pack) rose over-proportionally, from 16% in 2010 to 33% in 2015 (Lichtenecker, 2016).

incentivized by health insurance institutions to prescribe and dispense cheaper alternatives, such as generics. Yet, there is no mandatory requirement to do so.

Summarizing, the Austrian pharmaceutical market is heavily regulated and subject to reference pricing (EU average price) for reimbursable medicines. However, during the sample period, the prices of non-reimbursable medicines as well as the OTC market (non-prescription medicinal products) were not (price) regulated. To increase variants of existing products is relatively easy, since no new application is necessary. As price sensitivities by insured persons are likely to be low, observed price sensitivities may stem from physicians' and pharmacists' incentives.

3 A Framework for Merger Effects

We expect two broad categories of merger effects, price effects and non-price effects. Moreover, for each category of effects, we expect that the presence or absence of price regulation are intermediating factors for the effects of mergers.

3.1 Price Effects of Mergers

The classical horizontal effects of mergers consist of unilateral market power effects. To illustrate, consider the following simple oligopoly model of Bertrand competition with differentiated products, where we abstract from price regulation to begin with. The exposition follows Björnerstedt and Verboven (2016). Each firm f offers a set of drugs F_f, so that its total variable profits are given by the sum of profits for each product $k \in F_f$, which are maximized

$$max\, \Pi_f(\mathbf{p}) = \sum_{k \in F_f} (p_k - c_k) q_k(\mathbf{p}, \mathbf{v}), \tag{1}$$

where c_k denotes marginal cost for product k, and demand $q_k(\mathbf{p}, \mathbf{v})$ depends on prices $\mathbf{p}$ and variety $\mathbf{v}$. The profit maximizing price of each product $j = 1, \ldots, J$ satisfies the following first order conditions:

$$q_j + \sum_{k \in F_f} (p_k - c_k) \frac{\partial q_k(\mathbf{p}, \mathbf{v})}{\partial p_j} = 0 \quad \forall j \in F_f, \forall f. \tag{2}$$

A price increase affects profits through three channels. First, it raises variable profits proportional to current demand; second it lowers the products' own demand proportional to the price elasticity of demand; and third, it affects the variable profits of other products the firm produces proportional to their cross-price elasticity with the focal product. As we will see below, this latter effect is particularly important for analyzing unilateral price effects of mergers.

It is useful to define the $J \times J$ matrix θ^F as the firms' ownership matrix of products, which is a block-diagonal matrix with a typical element $\theta^F(j,k)$ equal to one if drugs j and k are marketed

by the same firm, and zero otherwise. Denoting by $\mathbf{q}(\mathbf{p}, \mathbf{v})$ the $J \times 1$ demand vector, by $\Delta\mathbf{p} \equiv \partial\mathbf{q}(\mathbf{p}, \mathbf{v})/\partial\mathbf{p}$ the corresponding $J \times J$ Jacobian matrix of first derivatives, and by $\mathbf{c}$ the $J \times 1$ marginal cost vector, we arrive at the following first order conditions

$$\mathbf{p} = \mathbf{c} - \left(\theta^F \odot \Delta\mathbf{p}\right)^{-1} \times \mathbf{q}(\mathbf{p}, \mathbf{v}), \tag{3}$$

where $\odot$ denotes the element-by-element multiplication of two matrices of the same dimension.

The price can thus be decomposed into a marginal cost and a markup term. Markups depend negatively on the own-price elasticity of demand and positively on cross-price elasticities of demand with other own products. A merger increases the number of products in the ownership matrix θ^F with - in case of substitutes - positive cross-price elasticities of demand and therefore it increases the optimal price for the drug under analysis. Since a larger part of demand lost is captured by the newly-owned (i.e. acquired) products, firms have an incentive to increase prices until equation (3) is satisfied (again). This analysis abstracts from other merger effects such as merger efficiencies, reactions of rivals or non-price effects (e.g. product repositioning).

Next, we evaluate how firm strategies change in the presence of price regulation. Following Dubois and Lasio (2018), the firms' constrained optimization problem for regulated drugs is

$$max\, \Pi_f(\mathbf{p}) = \sum_{k \in F_f} (p_k - c_k) q_k(\mathbf{p}, \mathbf{v}) \text{ subject to } p_k \in \Omega_k, \tag{4}$$

where $\Omega_k = [0, \bar{p}_k]$ denotes the set of admissible prices for product k. In Austria, this would involve the EU average prices for regulated drugs. The resulting first order conditions in matrix form and solved for the resulting prices are given by

$$\mathbf{p} = \mathbf{c} - \left(\theta^F \odot \Delta\mathbf{p}\right)^{-1} \times \left(\mathbf{q}(\mathbf{p}, \mathbf{v}) - \lambda\right), \tag{5}$$

where λ denotes the Lagrange-multiplier of the drugs' price constraints. If an element of λ, say λ_k is positive, the price constraint for drug k is binding. This implies that markups are lower in the regulated markets than they would be absent regulation and firms are prevented from increasing prices through regulation. The more binding the price constraint is (the larger λ_k), the larger the wedge between desired and allowed prices. Of course, a firm can market the same drugs in the regulated market, where incentives are given by equation (5), and in the unregulated market, setting prices according to equation (3).

What are the effects of mergers on prices in the regulated market? First, if the price constraint due to regulation is binding, prices cannot increase after a merger. However, the wedge between the prices firms can set (equation 5) and the prices the firm would like to set (equation 3) is likely to increase due to increased market power (a larger part of demand lost after a price increase would

be captured by own products). Thus, the price effect of mergers in regulated markets is that price constraints become more binding by increasing λ.

3.2 Non-price Effects of Mergers

We now explore the question which non-price effects to expect after a merger. One obvious non-price effect is that the change in market structure affects the firms' incentives to offer product variety.

When analyzing the variety effects of mergers one has to differentiate the change to the set of products F_f from changes in v, the variants of existing products. We will stress changing variants of existing products, since this can be achieved in a relatively short period of time after a merger with no initiation of an authorization process, while introducing new products triggers a new authorization process (see section 2). Of course, retiring products (or variants of products) can also be achieved in the short run.[10]

We follow Crawford et al. (2019) and Remmy (2020) and write the first order condition with respect to variety as

$$\begin{aligned}\frac{\partial \Pi}{\partial v_k} &= -\frac{\partial c_k}{\partial v_k} q_k + \sum_{j \in F_f} (p_j - c_j) \frac{\partial q_j}{\partial v_k} \\ &= \underbrace{-\frac{\partial c_k}{\partial v_k} q_k}_{\text{marginal cost effect}} + \underbrace{(p_k - c_k) \frac{q_k}{v_k}}_{\text{demand effect}} + \underbrace{\sum_{j \neq k, j \in F_f} (p_j - c_j) \frac{\partial q_j}{\partial v_k}}_{\text{cannibalization effects}} = 0 \end{aligned} \tag{6}$$

where F_f now also includes the target products. When choosing variety, firms trade off higher demand due to increased variety against potentially increased marginal costs as well as cannibalization effects on other products of the firm.

[10] While we analyze the consumer surplus effects of variety later, one may also look at the welfare effects of new products. Whether new products are socially desirable or not depends on two factors. First, it matters whether products are homogeneous or differentiated. Second, it matters whether entry is free. If products are homogeneous, the business stealing effect and the duplication of fixed entry costs result in excessive entry. If products are differentiated and consumers prefer variety, a marginal entrant, by increasing variety, increases surplus but does not capture the whole gain in profits (see Mankiw and Whinston (1986)). Entry therefore stops before rents are fully dissipated. Thus, if consumers have a strong preference for variety and if fixed entry costs are not too large, total welfare increases with entry. On the other hand, if prices are regulated and entry costs are not too high, it is likely that entry dissipates rents and reduces total welfare. For example, Hsieh and Moretti (2003) show that the entry of real estate agents in cities with high housing prices (implying larger income per sold house) is socially inefficient. For every 10 percent rise in average housing prices, the number of real estate agents increases by 9 percent and their productivity (houses sold per hour worked) declines by 7 percent. Thus, free entry of real estate agents in the presence of quasi-fixed commission rates is not socially efficient, since it dissipates the rents of rising house prices.

If price regulation is binding, drug prices will be lower in the regulated market segments, i.e. $\bar{p}_k < p_k$ and $\bar{p}_j < p_j$. Thus, the second term on the right of equation 6 (demand effect) is smaller under regulation. Ceteris paribus, increasing the number of varieties of existing products is less profitable post-merger under regulation, since the markup on additional demand due to more variety is smaller. However, the third term on the right of equation 6 (cannibalization effects) is less negative under regulation. Since the markups of other drugs (including the newly acquired drugs) are smaller, cannibalization effects are lower in the regulated market segments.

The net effect of a horizontal merger on variety in the regulated market segment compared to a merger in the unregulated market segment is therefore ambiguous, with the profit incease due to higher demand being traded off against the cannibalization effects (and any potential increases in marginal cost). After a merger, it is therefore an empirical question whether the firm chooses to market more or less variants of the drug.[11]

4 Data and Estimation

4.1 Pharmaceutical Sales in Austria

The data, provided by IMS Health, show a disaggregated and detailed picture of the Austrian pharmaceutical market: for the 2004-2017 period, we observe monthly data on the total sales and prices of every pharmaceutical product sold in all pharmacies and hospitals. The drugs in the data are further differentiated by package size, consumption form, dosage and the name of the vendor, but we aggregate the data such that an observation corresponds to the sales of a product (i.e. all sizes, forms and dosages), sold by a company in a month in either the regulated or unregulated market. We record the number of available forms and dosages (but not package sizes) as our measure of product variety.[12]

In addition to prices and quantities, we observe a products' medical area (up to the ATC5, i.e. molecular/active substance level), the companies manufacturing, distributing and selling the product, the products' age, composition and branding, as well as information relating to a products' launch (first or subsequent) and protection (protected, never protected, no longer protected) status and an indicator for generics.

[11] See e.g. Berry and Waldfogel (2001) for an analysis of product variety effects of mergers. See Gandhi et al. (2008) for a theoretical analysis of product repositioning effects of mergers. See Mazzeo et al. (2014) for simulation evidence on the effects of mergers on product choice.

[12] We find this the most reasonable definition of product variety. Including different package sizes in the count would, we believe, exaggerate product variety, while not accounting for different dosages would appear to underestimate product variety. In any case, our main results are robust to alternative definitions of product variety.

We also see a products' reimbursement status, indicating whether the cost of the product (minus a prescription fee / deductible) is reimbursable by public health insurance or not. This permits us to distinguish sales in regulated and unregulated markets. Frequently, we observe identical products being sold in both market segments, because certain package sizes, consumption forms or dosages are reimbursed, while others are not. A total of 1,439 products (24%) are sold in parallel in both (price) regulated and unregulated markets.

We further complement these data by merging them with SiSiX, a database on all medical compounds sold in Austria, maintained by the Austrian pharmacy publishing company, "Apothekerverlag". This provides us with information on the active components contained in a product, whether it requires cold storage, whether there is potential for substance abuse, whether the product needs to be prescribed by a doctor (and whether the prescription needs to be periodically renewed) and the products' shelf life.

As is common in the literature (Dubois and Lasio, 2018), we transform quantities to 'standardized units' in order to make prices comparable across different package sizes and dosages. Hence, we calculate the price of a drug per standardized unit, corresponding to one dose of the drug. We drop products whose total sales (across all 14 years) do not exceed 1,000€ and product-months in which no sales occurred.

The resulting panel contains 8,129 time-series of the sales of 6,006 products, as some products are sold by more than one company and about a quarter is sold both in and out of regulation. Products are observed for up to 168 months (from January 2014 to December 2017), but the panel is unbalanced. 31% of products are sold over the whole sample period, while the majority either enters the panel later than 2004 or is being phased-out after the market introduction of a successor product. On average, drugs are in the market for 103 months. Table 1 reports yearly summary statistics on the data.

The total quantity of annual consumption of pharmaceuticals in Austria has increased from 7.4 bn standardized units in 2004 to 9.5 bn units in 2017, or by 28%. In the same time, sales revenues have increased from €1.6 bn to €2.5 bn, or by 54%. The share of sales in regulated markets is about 80% and roughly constant over the sample period. The number of firms active in the pharmaceutical market increases at first and has remained roughly constant at around 350 since the early 2010s. The number of products available has increased more strongly in the regulated segment (+36%) than in the unregulated market (+11%). The market shares of individual firms (at the ATC4 level) average around 20% in the regulated market segment and range between 26 and 29% in the unregulated segment. Thus, in these narrow antitrust markets there are on average around 5 drugs competing in the regulated segments and around 4 drugs in unregulated segments. The largest

Table 1: Summary statistics across years

				Market Share				Variety			
		Products		Overall		Treated		Overall		Treated	
Year	Firms	Reg	UnReg	Reg	UnReg	Reg	UnReg	Reg	UnReg	Reg	UnReg
2004	310	1791	1926	0.21	0.26	.	.	2.51	1.91	.	.
2005	321	1875	1930	0.21	0.27	.	.	2.53	1.91	.	.
2006	322	1947	1912	0.21	0.27	.	.	2.53	1.92	.	.
2007	333	1959	1907	0.21	0.28	.	.	2.54	1.92	.	.
2008	336	1977	1934	0.20	0.28	.	.	2.57	1.91	.	.
2009	341	2004	1956	0.20	0.28	0.35	0.39	2.61	1.88	2.50	1.89
2010	342	2042	1957	0.20	0.28	0.13	0.23	2.59	1.89	2.63	1.87
2011	345	2107	1966	0.20	0.28	0.21	0.27	2.58	1.89	2.60	2.00
2012	352	2184	1961	0.19	0.29	0.02	0.21	2.61	1.90	2.70	2.01
2013	347	2215	1967	0.19	0.29	0.26	0.40	2.61	1.91	2.72	2.02
2014	344	2263	1952	0.19	0.29	0.40	0.29	2.60	1.90	2.66	1.84
2015	354	2327	2019	0.18	0.28	0.07	0.12	2.57	1.92	2.55	1.78
2016	354	2393	2031	0.18	0.27	0.16	0.24	2.63	1.95	2.72	1.86
2017	353	2437	2147	0.18	0.26	0.03	0.00	2.61	1.97	2.65	1.86

Notes: Column (1) contains the number of firms active in the market. Columns (2) and (3) report the number of products available in regulated and unregulated markets. Columns (4) and (5) report average market shares of drugs across ATC4 markets, columns (6) and (7) report average market shares of treated products. Columns (8) and (9) display the average number of varieties per product, while columns (10) and (11) report average varieties of treated products. As ownership changes are observed only in the 2009-2017 period, information on treated products is only available after 2008 (see footnote 13).

player in the Austrian pharmaceutical market is Novartis, with an average share of 12% of total, aggregated pharmaceutical sales, followed by Pfizer and AstraZeneca with shares of 6% and 5% respectively. Although there is variation across time, market shares of treated drugs (the sum of acquirer and target products) are substantial and average around 19.3% (regulated segments) and 24.7% (unregulated segments) in the year of acquisition. The available varieties of products are higher in regulated than in unregulated markets (average of 2.9 versus 1.9), and increase slightly over time. Similar trends apply to the variety of treated drugs.

In summary, the data provide us with a comprehensive overview of every drug sold in Austria over a 14-year period, while at the same time containing detailed, monthly information on sales, prices, variety as well as on product characteristics. These data allow us to define markets at the relevant antitrust level. Moreover, and importantly for the identification of the effects of regulation, around a quarter of drugs are sold in the regulated as well as in the unregulated parts of the market.

4.2 Mergers affecting Market Structure

In the 2004 - 2017 period, the worldwide pharmaceutical sector was substantially reshaped through M&A, with total deal values exceeding $100 bn annually. In 2018, almost $200 bn worth of pharmaceutical assets were bought and sold (EY, 2018).

We observe ownership changes of drugs directly in the IMS data:[13] occasionally, the name of the corporation associated with the sales of a product changes from one period to the next, such that drug sales associated with firm A in period t change to firm B in $t+1$. However, these name changes are not necessarily indicative of changes in market structure, as the name of the selling company could be affected by company name changes, re-branding or licensing deals. As an example, we observe drugs in the data that are initially sold by the pharmaceutical company Actavis. Consider the following four events: (1) Actavis is bought by Watson Pharmaceutical in 2012 and its drugs are re-assigned to Watson's portfolio. (2) One year later Watson decides to change its name to that of the merger target, Actavis. Again, we see this change in the data, only this time it does not signify a change in competition, as only the name changes. (3) A few years later, in 2015, the former Watson (now Actavis) buys Allergan and changes its name again - to Allergan. Thus, the name changes again, this time signifying a change in ownership for some drugs: while the drugs previously owned by Actavis and now sold by the (new) Allergan only have a change in name, the drugs of the merger target, formerly Allergan, change owner. (4) Finally, in 2016, Teva buys Allergan's generic drug business, leading to another ownership change. This example illustrates the complexities of drug ownership and the need for a thorough verification procedure: events (1) and (4) correspond to ownership changes for all affected drugs, event (3) for some drugs, while event (2) is a mere name change.

We therefore cross-reference the list of potential mergers (i.e. name changes in the sales data) with Thomson Reuters SDC database and verify all matches with secondary research, making sure that the timing of events is consistent with our data. Thus, changes in market structure are corroborated through i) observing a name change of the selling entity in the sales data, ii) finding a corresponding merger in SDC, and iii) conducting secondary research on financial and pharmaceutical news sites. We identify 56 mergers affecting product sales in Austria. The mergers vary in size, with mean (median) deal values of $9.7 bn ($3.6 bn) ranging up to more than $60 bn and totalling more than $411 bn in the 2009 - 2017 period. These M&A have led to 724 changes in ownership of products in Austria, which represent the population of ownership changes of drugs due to mergers.

The drug portfolio of the acquiring firm after a merger (i.e. the union of acquirer and target

[13] While our data contain monthly sales for the 2004-2017 period, ownership changes are only observed for the 2009-2017 period. Thus, the 2004-2008 data are used for the calibration of the demand models, but do not contain treated drugs.

drugs) constitutes the primary treatment group in our study. We will examine changes in the price, quantity and variety of these drugs after acquisition. Additionally, we also investigate the strategic reactions of 920 competitor drugs. We define a drug to be a competitor drug, when another drug in the same ATC4 is taken over (differentiating regulated and unregulated markets). As many ownership changes have a negligible impact on competition, we only record competitor treatments when the market share of the newly acquired drugs is at least 20%. Thus, whenever drugs that have a market share of at least 20% change owner due to a merger, we analyze what happens to other drugs in the same market. Table 2 summarizes the changes in market structure and product ownership in the data.

Table 2: Ownership changes by year

			Treated products	
Year	Deals	Total value	Merging firms	Rivals
2009	11	126538	87	122
2010	10	23985	290	325
2011	3	20076	50	108
2012	2	6733	59	37
2013	6	14405	21	44
2014	7	47514	44	48
2015	8	111639	58	67
2016	7	77184	102	102
2017	2	371	13	67
Total	56	428444	724	920

Notes: Column 1 contains the number of M&A per year, column 2 the total deal values in million USD (excluding 12 transactions for which no deal values were found). Column 3 reports the number of products changing owner, column 4 the number of rival products.

A list of all mergers in the sample period is reported in table A13. From this list and from the discussion above it becomes clear that these mergers are worldwide in nature and that the decisions to merge can be viewed as being independently determined from the regulatory conditions in Austria.[14] Therefore, we treat the market structure changes induced by these mergers as exogenous to pharmaceutical prices and product variety in Austria.

4.3 Estimation of Merger Effects

We estimate the effect of changes in market structure using a difference-in-difference approach, where the acquirers' post-merger drug portfolio (i.e. acquirer and target drugs) and rival drugs

[14]None of the acquiring companies and only one of the target companies (EBEWE Pharma) are Austrian. As omitting this transaction does not affect our findings, we prefer to retain the population of relevant mergers as treatments.

within the same ATC4, respectively, constitute the treatment groups and the time period after the change in ownership constitutes the treatment period.

$$p_{i,t,c,m} = \alpha_{i,c,m} + \gamma^M \left(\text{post}_{i,t,c,m} \times H_{i,t,m}\right) + \gamma^R \left(\text{postriv}_{i,t,c,m} \times H_{i,t,m}\right) + \mathbb{X}_{i,t,m}\Gamma + \epsilon_{i,t,c,m} \quad (7)$$

The log price of drug i sold in month t by company c to market m (regulated or unregulated) is regressed on a full set of drug fixed-effects ($\alpha_{i,c,m}$) and an indicator for treated drugs in post-acquisition periods ($\text{post}_{i,t,c,m}$). Effects are dissected for different subsamples, indicated by $H_{i,t,m}$. $H_{i,t,m}$ is used to estimate effects separately for regulated and unregulated market segments and to further distinguish heterogeneous effects. The ATT on post merger acquirer drugs (in the clusters defined by $H_{i,t,m}$) is then measured by γ^M. Similarly, $\text{postriv}_{i,t,c,m}$ denotes post-acquisition periods for rival drugs when at least 20% of sales in the relevant market are acquired. Thus, γ^R measures the average price reaction of rival drugs. The control groups are ATC4 markets without ownership changes in regulated and unregulated market segments respectively.

Further fixed-effects are collected in the matrix $\mathbb{X}_{i,t,m}$. Depending on the specification we include fixed effects for all months in the data (168 regressors), the age of a drug in years (56 regressors) and available varieties (36 regressors) of the various drugs and - in the most stringent specification - fixed effects for the number of active substances (24 regressors), years of shelf life (5 regressors) as well as indicators for the drugs' launch status, protection status and patent expiry. Further, we include dummies for generic drugs (as well as biosimilars), drugs with abuse potential, drugs distributed only through pharmacies, drugs requiring cold storage and drugs requiring a physicians' prescription. Thus, in addition to including unit fixed-effects, our econometric specification controls for a large number of drug characteristics. Standard errors $\epsilon_{i,t,c,m}$ are allowed to cluster at the ATC4 level. In some regressions, we replace the dependent variable of equation (7) with the log of units sold in order to study the impact on quantities.

To study the effects on variety we estimate a similar regression, but aggregate the data to the firm/month/ATC4/market level. We thus measure variety as the total number of formats (dosages and consumption forms, but *not* different package sizes) that a company offers at a particular point in time for a particular ATC4 class in and out of regulation.

$$v_{c,t,m,a} = \alpha + \rho_{c,t,m,a} + \gamma^M \left(\text{post}_{t,m,a} \times H_{t,m,a}\right) + \gamma^R \left(\text{postriv}_{t,m,a} \times H_{t,m,a}\right) + \mathbb{X}_{c,t,m,a}\Gamma + \epsilon_{c,t,m,a} \quad (8)$$

The variety offered by company c, at time t, in market m and ATC4 a is regressed on the number of products in that cluster ($\rho_{c,t,m,a}$), post-acquisition indicators ($\text{post}_{t,m,a}$ and $\text{postriv}_{t,m,a}$) and a subsample-indicator ($H_{t,m,a}$, defined as above). The effect on the product variety of merging firms is estimated by γ^M, while rivals change their variety by γ^R. Fixed-effects are collected in $\mathbb{X}_{c,t,m,a}$ and include, depending on the specification, effects for ATC4 classes, monthly indicators, corporation

and corporation/year fixed-effects respectively. As above, standard errors are robust and clustered at the ATC4 level.

5 Results

5.1 Main Results

Table 3 presents the main results on the effects of mergers on drug prices in regulated versus unregulated market segments. In columns (1) to (4), we estimate four different specifications of equation 7, with each regression including consecutively more control variables. Column (1) includes only product fixed-effects of which there are 8,129, column (2) adds month fixed-effects (168), column (3) adds fixed-effects for product-age (56) and available varieties (36), and column (4), the most comprehensive estimation, controls for additional drug characteristics (see section 4.3). Since results are mostly robust across specifications, we focus the discussion on column (4).

Horizontal worldwide pharma mergers increase drug prices in Austria by economically and statistically significant 10.9% on average relative to before the merger and relative to non-merging drugs in the unregulated segment. Conversely, in the regulated segment, prices decline by 5.9% on average, relative to before the merger and relative to non-merging drugs.[15]

Rival reactions, by and large, mirror those effects, with prices increasing for unregulated drugs in a similar fashion. Prices for regulated drugs decrease insignificantly. This points to drug prices being strategic complements, as assumed by the Bertrand model with differentiated products.

Table 3: Prices of merging firms and rivals in regulated and unregulated markets

	(1)		(2)		(3)		(4)	
M&A - UnReg	0.104***	(0.039)	0.107***	(0.040)	0.110***	(0.039)	0.109***	(0.038)
Reg	-0.074***	(0.018)	-0.073***	(0.019)	-0.061***	(0.018)	-0.059***	(0.017)
Rivals - UnReg	0.132***	(0.025)	0.130***	(0.027)	0.111***	(0.027)	0.112***	(0.028)
Reg	-0.023	(0.029)	-0.028	(0.030)	-0.033	(0.025)	-0.036	(0.024)
Observations	645708		645708		645708		645708	
R^2	0.988		0.988		0.989		0.989	

Notes: Standard errors in parentheses allow for clustering at the product level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes product fixed-effects (8,129); column (2) adds month fixed-effects (168); column (3) adds fixed-effects for product-age (56) and available varieties (36); column (4) controls for additional characteristics (see section 4.3).

In table 4 we investigate whether the price changes were accompanied by corresponding changes

[15]The decrease of prices in regulated markets could be explained by entry deterrence, the discrete nature of product varieties or by marginal cost reductions. However, this finding is not robust to focusing on drugs sold in parallel (see section 5.2).

in quantities sold. We thus replace the dependent variable in equation 7 with (log) quantities sold. We find that the quantities of both merging firms and rivals decrease by 14-18% in unregulated markets, while the quantities of merging firms increase by 7% in regulated markets.[16]

Table 4: Quantities of merging firms and rivals in regulated and unregulated markets

	(1)		(2)		(3)		(4)	
M&A - UnReg	-0.084	(0.083)	-0.083	(0.088)	-0.133	(0.085)	-0.139*	(0.084)
Reg	0.138***	(0.046)	0.146***	(0.044)	0.073*	(0.040)	0.074*	(0.040)
Rivals - UnReg	-0.232***	(0.078)	-0.206***	(0.079)	-0.186***	(0.071)	-0.176**	(0.072)
Reg	0.025	(0.071)	0.061	(0.073)	0.050	(0.057)	0.051	(0.057)
Observations	645708		645708		645708		645708	
R^2	0.916		0.917		0.923		0.923	

Notes: Standard errors in parentheses allow for clustering at the product level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes product fixed-effects (8,129); column (2) adds month fixed-effects (168); column (3) adds fixed-effects for product-age (56) and available varieties (36); column (4) controls for additional characteristics (see section 4.3).

Table 5 presents the main results on the variety effects of mergers (equation 8).[17] Note that column (4) includes corporation/year fixed-effects, such that effects on variety are identified through within-company variation across markets with and without acquisitions.

Merging firms significantly increase product variety in the regulated segment relative to before the merger and relative to non-merging firms. The size of the effect is substantial, as the coefficient in column (4) of table 5 indicates that merging firms increase product variety by 21% (an increase of $\gamma^M = 0.6$ relative to a mean variety of 2.9). Conversely, while both merging firms and rivals somewhat decrease their variety in unregulated markets in specifications (1) and (2), the effect becomes insignificant once corporation fixed-effects are accounted for.[18]

Summarizing, mergers increase drug prices and decrease quantities of both merging firms and their rivals in the unregulated part of the market. Conversely, the prices of merging firms in the regulated part of the market on average decrease, while product variety increases.

[16] While the quantity reductions are consistent with the price elasticities of demand estimated below, the latter result could also be explained by the increased variety of drugs of merging firms in regulated segments after mergers (see below).

[17] Variety is measured as the total number of formats (dosages and consumption forms) but not package sizes. The number of observations declines to around 450,000, since the unit of observation changes from product/corporation/market segment/month to ATC4/corporation/market segment/month. That is, we now count the number of different variants of all drugs of a corporation within a given ATC4 market (in a given month), differentiating between regulated and unregulated segments and controlling for the total number of products.

[18] Not finding an effect on the variety of rival firms is consistent with rivals only responding to the residual demand effect (spillover from the merging firms), but not having an increased incentive to raise variety due to newly-acquired products.

Table 5: Product variety of merging firms and rivals in regulated and unregulated markets

	(1)		(2)		(3)		(4)	
M&A - UnReg	-0.194*	(0.106)	-0.219**	(0.110)	-0.169	(0.131)	-0.141	(0.136)
Reg	0.530***	(0.151)	0.507***	(0.148)	0.561***	(0.147)	0.602***	(0.160)
Rivals - UnReg	-0.351**	(0.159)	-0.380**	(0.162)	-0.279	(0.185)	-0.293	(0.205)
Reg	-0.042	(0.088)	-0.068	(0.093)	-0.069	(0.094)	-0.092	(0.099)
Observations	450958		450958		450958		450958	
R^2	0.708		0.708		0.753		0.758	

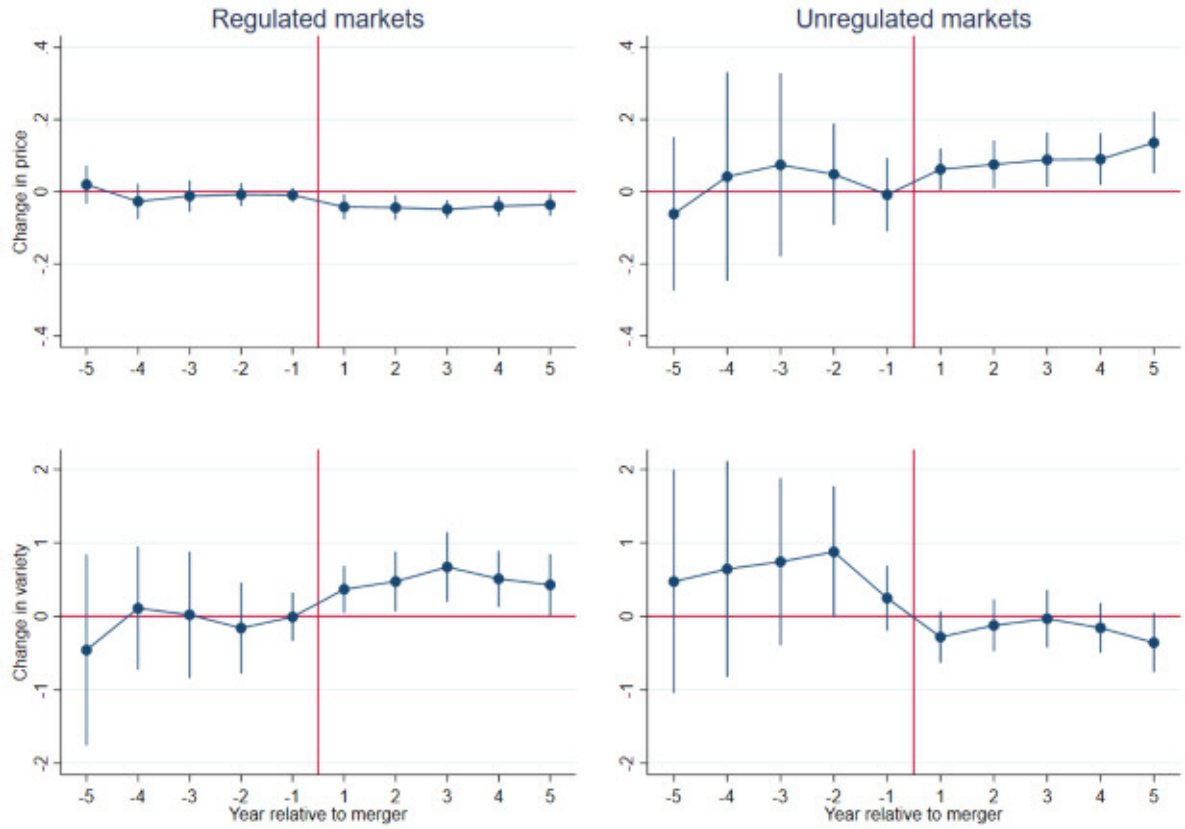
Notes: Standard errors in parentheses allow for clustering at the ATC4 level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes ATC4 fixed-effects (416); column (2) adds monthly fixed-effects (168); column (3) additionally controls for corporation fixed-effects (556); column (4) adds corporation×year fixed-effects (4,754). All regressions control for the number of products sold.

The illustrative model from section 3 can explain this pattern of results. The unregulated part of the market can best be described by Bertrand competition with differentiated products. Due to the increased unilateral market power after a horizontal merger merging firms increase drug prices. Via strategic complementarity their rivals follow suit and prices increase by 11%. In the regulated segments of the market, however, firms cannot increase drug prices and price regulation becomes more binding due to the merger. Thus, incentives to increase product variety are higher under regulation than without regulation after a horizontal merger. Instead of increasing prices, merging firms increase product variety under regulation.

Figure 1 provides additional evidence on the timing of the estimated effects. The four subgraphs plot period-specific treatment coefficients and 99% confidence intervals, ranging from five years before until five years after acquisitions in regulated and unregulated markets. The two upper subgraphs show that price effects in regulated (left) and unregulated (right) markets manifest directly after acquisitions and are significant at the 1% level in all five post-acquisition periods. Conversely, no significant differences to the control group can be observed prior to treatment. Similarly, the variety of treated products in regulated markets (bottom left) does not differ from the control group prior to treatment, but increases in post-periods. In unregulated markets (bottom right), we find – as in table 5 – no significant effects on variety.

Thus, the graphs in figure 1 provide some evidence that the treated drugs did not exhibit different trends in prices and varieties prior to being acquired: all estimated pre-treatment coefficients are insignificant. Additionally, pre-treatment differences are numerically small in the first three subgraphs, while – conversely – the variety of treated drugs in unregulated markets seems somewhat higher pre-treatment. Further, figure 1 shows that the differences in prices and varieties reported above manifest directly after acquisitions and remain significant for at least five years. This increases our confidence that these changes are caused by the M&A and are non-transitory.

Figure 1: Effects on price and variety, pre- and post-treatment



Notes: The figures display period-specific treatment effects along with 99% confidence intervals. The rows distinguish effects on prices (first row) and variety (second row), while the columns distinguish regulated (left) and unregulated markets (right).

5.2 Parallel Sales in Regulated and Unregulated Markets

We presented the main results using all available data on pharmaceutical sales. Under the assumption that the mergers in the data were not determined by the market structure and the regulatory situation in Austria, the main results provide us with causal estimates of the effects of mergers with and without regulation. We have argued that this assumption is likely to hold, as (i) large, international mergers are unlikely determined by a single, national market and (ii) the regulatory situation depends predominantly on medical considerations (e.g. whether the drug exhibits an essential additional therapeutic benefit or not), and not on price or market structure. Further, the pre-treatment effects presented in figure 1 suggest that our sample of treated drugs is not selected.

In this section, however, we relax this assumption, thereby providing an important robustness check. We show that when we restrict the sample to drugs being simultaneously sold by the

same company in and out of regulation (we refer to this as "parallel sales"), most results remain unchanged. In such a setting, we identify the effects of mergers through within-product variation of prices, quantities or varieties of a drug over time, when the drug is sold in the regulated market, while other varieties of the same drug are not regulated. Importantly, level differences in outcomes between e.g. different consumption forms will be captured through the inclusion of fixed-effects.

Table 6 presents the results in panels (A) to (C). The number of observations falls to around a third. Prices of merging firms significantly increase by 18% in the unregulated market (panel (A)). Again, we see that rivals - in absence of regulation - raise their prices as well. The price decreases in regulated markets are not significant in this estimation setting. Quantity effects (panel (B)) again show reductions following the price increases. Although the coefficients are similar to the main results, the effect is only significant for rivals here. In regulated markets we observe neither price nor quantity effects. Estimated variety effects (panel (C)) are similar to the main results and point to post-merger increases in variety in the regulated market for merging firm drugs, but not in the unregulated segments.

In summary, the main results on the effects of regulation hold up if we restrict the sample to drugs being sold in both the regulated and unregulated market.

5.3 Heterogeneous Effects: Merger Size, Overlap, and Market Concentration

Before we analyze demand and welfare, we dig deeper into the heterogeneous effects of the pharmaceutical mergers in the sample. We estimate equations (7) and (8) for the price and variety effects as before, but interact the post-indicators for merging firms with variables proxying for characteristics of the merger. We look at three dimensions: deal value and the number of acquired products to measure the size of the merger; the Herfindahl-Hirschman index (HHI) to measure market concentration; and ΔHHI to measure the change in market concentration induced by the merger.[19] The results on prices and variety are displayed in tables 7 and 8, respectively, again differentiating between regulated and unregulated segments.

Larger deals increase prices in the unregulated segments of the pharmaceutical industry, but do not increase prices in the regulated segments. We estimate that for each doubling of deal value prices go up by 1.5% post-merger if prices are not regulated. Similarly, the larger the number of products taken over, the larger the price effects. Consistent with the theoretical reasoning of section 3.1, a larger overlap of the merger as measured by ΔHHI as well as larger market concentration at the time of merger significantly increase post-merger prices in unregulated segments, but not in

[19] ΔHHI is defined as twice the market share of the acquiring firm times the market share of the acquired firm.

Table 6: Parallel sales in regulated and unregulated markets

(A): Price	(1)		(2)		(3)		(4)	
M&A - UnReg	0.143***	(0.049)	0.191***	(0.055)	0.187***	(0.053)	0.179***	(0.052)
Reg	-0.087**	(0.035)	-0.037	(0.036)	-0.032	(0.032)	-0.031	(0.031)
Rivals - UnReg	0.103***	(0.036)	0.148***	(0.048)	0.129***	(0.045)	0.137***	(0.046)
Reg	-0.061*	(0.036)	-0.017	(0.045)	-0.019	(0.038)	-0.019	(0.038)
Observations	201218		201218		201218		201218	
R^2	0.976		0.976		0.977		0.978	
(B): Quantity	(1)		(2)		(3)		(4)	
M&A - UnReg	-0.156	(0.130)	-0.147	(0.149)	-0.154	(0.131)	-0.144	(0.127)
Reg	0.060	(0.059)	0.058	(0.072)	-0.030	(0.063)	-0.035	(0.062)
Rivals - UnReg	-0.223*	(0.118)	-0.203	(0.132)	-0.268**	(0.106)	-0.260**	(0.106)
Reg	0.028	(0.094)	0.057	(0.103)	-0.040	(0.075)	-0.035	(0.075)
Observations	201218		201218		201218		201218	
R^2	0.889		0.890		0.902		0.902	
(C): Variety	(1)		(2)		(3)		(4)	
M&A - UnReg	-0.330**	(0.160)	-0.356*	(0.189)	-0.267	(0.294)	-0.216	(0.334)
Reg	0.492**	(0.211)	0.465**	(0.206)	0.572*	(0.306)	0.637*	(0.362)
Rivals - UnReg	-0.308	(0.257)	-0.340	(0.283)	-0.359	(0.316)	-0.413	(0.343)
Reg	-0.145	(0.108)	-0.177	(0.123)	-0.128	(0.150)	-0.156	(0.160)
Observations	154757		154757		154757		154757	
R^2	0.809		0.809		0.834		0.839	

Notes: Panels A and B: Standard errors in parentheses allow for clustering at the product level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes product fixed-effects (2,357); column (2) adds month fixed-effects (168); column (3) adds fixed-effects for product-age (56) and available varieties (19); column (4) controls for additional characteristics (see section 4.3). Panel C: Standard errors in parentheses allow for clustering at the ATC4 level. Column (1) includes ATC4 fixed-effects (61); column (2) adds monthly fixed-effects (168); column (3) additionally controls for corporation fixed-effects (258); column (4) adds corporation×year fixed-effects (2,180). All regressions control for the number of products sold.

regulated segments. The coefficient indicates that doubling ΔHHI[20] increases post-merger prices by 10.8% in unregulated segments.[21] Similarly, doubling the level of HHI[22] increases post-merger prices by 19.3% in unregulated segments. Summarizing, the findings on heterogeneous price effects are in line with theoretical reasoning in unregulated segments. In regulated segments, drug prices do not increase with measures of deal size and market concentration.

Turning to our heterogeneous non-price effects (table 8), we see consistent effects in the regulated parts of the market. Larger deals as well as deals in more concentrated markets increase the

[20]The average ΔHHI is 340.

[21]Nocke and Whinston (2020) theoretically and empirically show that the larger ΔHHI of a merger the larger required efficiencies must be in order for the merger to not decrease consumer surplus. Our results are consistent with theirs.

[22]The average HHI is 3783.

Table 7: Heterogeneous effects on prices

(A): ln(value)	(1)		(2)		(3)		(4)	
UnReg	0.015***	(0.004)	0.015***	(0.004)	0.015***	(0.004)	0.015***	(0.004)
Reg	-0.009***	(0.002)	-0.009***	(0.002)	-0.007***	(0.002)	-0.007***	(0.002)
Observations	645708		645708		645708		645708	
R^2	0.988		0.988		0.989		0.989	
(B): ln(products)	(1)		(2)		(3)		(4)	
UnReg	0.035***	(0.009)	0.035***	(0.010)	0.035***	(0.009)	0.034***	(0.009)
Reg	-0.019***	(0.004)	-0.019***	(0.004)	-0.014***	(0.004)	-0.015***	(0.004)
Observations	645708		645708		645708		645708	
R^2	0.988		0.988		0.989		0.989	
(C): Δ HHI	(1)		(2)		(3)		(4)	
UnReg	0.147**	(0.060)	0.139**	(0.066)	0.117**	(0.045)	0.108**	(0.043)
Reg	-1.518**	(0.711)	-1.421**	(0.699)	-1.112	(0.703)	-1.166	(0.725)
Observations	645708		645708		645708		645708	
R^2	0.988		0.988		0.989		0.989	
(D): HHI	(1)		(2)		(3)		(4)	
UnReg	0.203***	(0.067)	0.207***	(0.069)	0.196***	(0.066)	0.193***	(0.065)
Reg	-0.093***	(0.031)	-0.090***	(0.035)	-0.112***	(0.032)	-0.103***	(0.030)
Observations	645708		645708		645708		645708	
R^2	0.988		0.988		0.989		0.989	

Notes: ln(value) denotes the log deal value in million USD; ln(products) is the log number of acquired products; Δ HHI and HHI denote the change and the level of the Herfindahl-Hirschmann index in the affected ATC4 respectively. Standard errors in parentheses allow for clustering at the product level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes product fixed-effects (8,129); column (2) adds month fixed-effects (168); column (3) adds fixed-effects for product-age (56) and available varieties (36); column (4) controls for additional characteristics (see section 4.3).

number of variants of existing products. This is again in accord with the theoretical reasoning of section 3.2. Deprived of the possibility to increase prices in regulated segments post-merger, firms increase variety by more the more unilateral market power increases. In price regulated segments, cannibalization effects are lower, therefore firms have elevated incentives to market more variants of drugs. We do not observe such effects in unregulated segments of the market.

5.4 Demand, Elasticities and Welfare

5.4.1 Estimation of Demand and Price Elasticities

Following the approach of Björnerstedt and Verboven (2016), we model the demand for pharmaceutical products using a one level nested logit model (where the groups constitute the nests) in a constant expenditures specification. A nested logit specification seems appropriate in our case, as

Table 8: Heterogeneous effects on variety

(A): ln(value)	(1)		(2)		(3)		(4)	
UnReg	-0.012	(0.012)	-0.012	(0.012)	-0.009	(0.014)	-0.004	(0.014)
Reg	0.077***	(0.020)	0.077***	(0.020)	0.074***	(0.018)	0.078***	(0.018)
Observations	450958		450958		450958		450958	
R^2	0.709		0.709		0.753		0.758	
(B): ln(products)	(1)		(2)		(3)		(4)	
UnReg	-0.048*	(0.028)	-0.050*	(0.029)	-0.046	(0.034)	-0.038	(0.034)
Reg	0.141***	(0.040)	0.139***	(0.039)	0.141***	(0.036)	0.153***	(0.039)
Observations	450958		450958		450958		450958	
R^2	0.708		0.708		0.753		0.758	
(C): Δ HHI	(1)		(2)		(3)		(4)	
UnReg	0.259	(0.398)	0.232	(0.401)	-0.195	(0.471)	-0.277	(0.474)
Reg	-0.759	(4.722)	-0.889	(4.702)	-6.759	(5.630)	-7.889	(6.054)
Observations	450958		450958		450958		450958	
R^2	0.707		0.707		0.752		0.757	
(D): HHI	(1)		(2)		(3)		(4)	
UnReg	-0.151	(0.149)	-0.175	(0.155)	-0.216	(0.187)	-0.221	(0.191)
Reg	0.937***	(0.235)	0.910***	(0.234)	0.892***	(0.249)	0.889***	(0.260)
Observations	450958		450958		450958		450958	
R^2	0.707		0.707		0.752		0.757	

Notes: ln(value) denotes the log deal value in million USD; ln(products) is the log number of acquired products; Δ HHI and HHI denote the change and the level of the Herfindahl-Hirschmann index in the affected ATC4 respectively. Standard errors in parentheses allow for clustering at the ATC4 level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes ATC4 fixed-effects (416); column (2) adds monthly fixed-effects (168); column (3) additionally controls for corporation fixed-effects (556); column (4) adds corporation×year fixed-effects (4,754). All regressions control for the number of products sold.

the nests in the data (ATC4 classes) refer to well-defined disease indications and substituting a drug from a neighbouring nest (ATC4 market) is usually not an option. Thus, restrictions imposed on cross-nest substitution patterns are of secondary concern. On the other hand, defining nests at the ATC5 level may be too restrictive, since several indications may be treated with different substances from the same ATC4.[23] In such a well-defined setting Grigolon and Verboven (2014) found nested logit models to outperform random coefficient models, and we therefore opt for the more tractable nested logit model.

[23]For example, ATC4 J07BD contains viral vaccinations for measles, which we assume to be substitutes one to another. At the ATC3 level (J07B), we would be including vaccinations for hepatitis and mumps as substitutes, while the ATC5 level (J07BD01 and others) would restrict substitution to vaccines that treat measles and rubella jointly, vaccines that treat measles and varicella jointly, etc. Thus the ATC4 level appears to be a good compromise.

We define a product as the collection of all package sizes, dosages and consumption forms branded under the same name, but distinguish sales by different companies as well as sales in regulated and unregulated market segments. The nests are defined at the ATC4 levels. The demand for product k at time t is thus estimated as

$$ln\left(\frac{s_{kt}}{s_{0t}}\right) = X_{kt}\beta - \alpha ln(p_{kt}) + \zeta v_{kt} + \sigma ln(s_{kt|g}) + \xi_{kt},$$

where s_{kt} denotes overall market share, s_{0t} the market share of the outside good, $s_{kt|g}$ the product k's within-group (nest) market share and X_{kt} contains exogenous demand drivers described below. Price p_{kt} is defined as revenues divided by standardized units. ξ_{kt} is an error term. Variety v is defined as the number of different formulations and dosages of a drug. The coefficients α, ζ, and σ are the coefficients of main interest, since they determine (together with market shares) the price elasticities of demand and the valuation of consumers for variety. σ is a parameter measuring how substitution patterns differ within and across nests with $0 \leq \sigma < 1$. It proxies for the degree of preference correlation between products of the same group. As σ goes to 1, the within-group (ATC4) correlation of utilities goes to 1, and in the limit consumers perceive products of the same group as perfect substitutes. If σ=0, the model reduces to the simple logit model.

As price, variety and within-nest market share are endogenous, we use an instrumental variable approach employing product-count instruments, intended to capture the degree of prevailing competition (Berry et al., 1995). We count the number of drugs in the same ATC3, ATC4, and ATC5 class and the number of drugs by the same firm in the same ATC3, ATC4, and ATC5 class.[24]

We drop product-months with zero sales and calculate the products' log price and their market shares in the potential market[25] (averaging 0.013%) and within their respective ATC4 market and segment. We estimate demand separately for each ATC1 group, but allow coefficients to vary across ATC4 groups. Thus, we estimate 15 separate regressions by ATC1 group[26] and 520 different price and within-group market share coefficients by ATC4 group.

We assume the (overall) market share of a product is - in addition to the endogenous determinants price, variety and within-group market share - determined by exogenous demand drivers (X_{kt}) including its age, launch status, protection status, an indicator for whether protection has expired or not and indicators whether the drug can only be sold through pharmacies or needs to be stored

[24] In addition, we experimented with instruments generated by estimating cost trends at the molecular level (Dubois and Lasio, 2018). We estimated the average monthly cost of each substance in the dataset and used substance-level cost trends to instrument for the price of drugs. Since results were unchanged, we opted for the more parsimonious model using only product-count instruments.

[25] The potential market is defined as two times the total expenditures of all pharmaceutical products, adjusted for changes in GDP (Björnerstedt and Verboven, 2016).

[26] We exclude ATC1 P (parasitology) because it contains only 0.2% of the data, leading to imprecise demand estimates.

cold. We also include indicators for generic drugs and drugs sold in the regulated market. Finally, we also include year and month fixed-effects.[27]

The results of demand estimation generally seem very plausible. The models are, on average, able to explain around 80% of variation in market share through prices, variety, market share in the ATC4 group and the other control variables. Price coefficients are mostly, but not always negative. Insignificant or positive coefficients may reflect medical necessities, which are price insensitive. ATC4-level market shares generally have coefficients $\in [0.5, 1]$, indicating that within-group (ATC4) correlation of utilities is rather high, and within most ATC4 groups considerable substitution is possible. The coefficients for generics suggest that mean utility for generics is, ceteris paribus, on average 12% higher than for non-generics. Thus, incentives to steer patients and doctors towards more cost efficient generics seem to have an effect. In both market segments, but particularly so in the regulated segment, available varieties increase consumers' mean utility. Finally, mean consumer valuation in the regulated segment is much larger than in the unregulated segment.

We use the estimated demand parameters α and σ to calculate each products' price elasticity as

$$\frac{\partial q_k}{\partial p_j}\frac{p_j}{q_k} = -\alpha\left(\frac{1}{1-\sigma} - \frac{1}{1-\sigma}s_{kt|g} - s_k\right) - 1.$$

Table 9 reports summary statistics of the demand estimation by ATC1 class. In all ATC1 classes except M (muscles and skeletal system), median price elasticities are negative. As consumers are – at least in the regulated segment of the market – not likely to be very price sensitive, it seems reasonable to assume that the observed price-elasticities are the result of incentives directed towards doctors and pharmacists prescribing and dispensing the drugs.

The σ-coefficients measure the preference correlation of products in the same group. As all means and medians are substantially larger than zero, preferences for drugs strongly correlate within ATC4 groups. As almost all σ lie between 0 and 1, we can infer that our nests at the ATC4 level are not rejected by the data.

Finally, the estimated coefficients for variety indicate that i) consumers, on average, value the availability of drug varieties (except in ATC1 V (various) under regulation, where we estimate a large negative coefficient) and that ii) variety is, on average, more highly valued in regulated markets.

5.4.2 Price Elasticity of Demand

The empirical results so far are consistent with the model outlined in section 3. Another prediction of the model is that price effects of mergers in the unregulated segments should be higher if the

[27] We have experimented with different forms of the demand specification and have found that the elasticity estimates are not very sensitive to the addition of additional control variables and the inclusion of product fixed-effects.

Table 9: Demand estimation results by ATC1 class

	Price Elasticity		σ-coefficient		Variety coefficient	
ATC1	Mean	Median	Mean	Median	Reg	UnReg
A	-1.09	-1.12	0.71	0.73	0.18	-0.07
B	-1.08	-1.09	0.65	0.71	0.11	0.47
C	-0.06	-0.55	0.70	0.68	0.27	-0.27
D	-0.31	-0.43	0.73	0.79	0.12	0.19
G	-1.98	-1.68	0.70	0.73	-0.05	0.74
H	-0.61	-0.80	0.71	0.59	0.04	0.41
J	-1.97	-1.69	0.76	0.71	0.42	-0.44
K	-0.54	-0.86	0.72	0.80	1.69	-0.07
L	-1.71	-1.10	0.71	0.78	0.22	0.33
M	-0.41	-0.03	0.77	0.66	-0.03	-0.44
N	-0.85	-0.89	0.71	0.63	0.16	0.25
R	-0.36	-0.82	0.49	0.35	0.11	0.53
S	-1.65	-1.07	0.86	0.70	0.43	0.43
T	-2.91	-0.13	0.70	0.77	1.28	0.20
V	-0.32	-0.82	0.64	0.46	-1.23	0.66
Total	-0.95	-0.94	0.70	0.69	0.17	0.10

Notes: This table reports the mean and median of the distributions of price elasticities and the coefficients of within-group market shares (σ) by ATC1 code. Both are estimated at the ATC4 level and aggregated for this table. It also reports the estimated consumers' preference for variety for regulated and unregulated drugs.

price elasticity of demand is low, since a given price increase leads to a smaller reduction in quantity. Table 10 presents the results splitting the sample into inelastic markets (ϵ is lower than the median ϵ in absolute terms) and elastic markets (ϵ is larger than the median ϵ in absolute terms). Again we estimate separate effects for unregulated and regulated drugs, and for merging firms and their rivals.

The drug prices of merging firms in unregulated markets increase by an average of 14.9% if demand is inelastic, while the increase is indistinguishable from zero in elastic markets. Conversely, price elasticities do not play a discriminating role in the regulated part of the market. Rival prices increase in unregulated markets and are not significantly affected in regulated markets, independently of the elasticity of demand.

Variety increases in regulated markets (table 11), irrespectively of whether markets are elastic or not. While the increase is somewhat larger in inelastic markets (where market power increases more strongly), the difference is not statistically significant. Thus, consistent with equation 6, the incentive for merging firms to increase variety in regulated markets exists independently of the

Table 10: Price changes and the elasticity of demand

		(1)		(2)		(3)		(4)	
M&A									
UnReg -	low ε	0.160***	(0.036)	0.162***	(0.036)	0.156***	(0.035)	0.149***	(0.033)
	high ε	0.060	(0.061)	0.063	(0.063)	0.074	(0.061)	0.077	(0.061)
Reg	low ε	-0.060***	(0.018)	-0.059***	(0.018)	-0.044**	(0.018)	-0.043**	(0.018)
	high ε	-0.089***	(0.031)	-0.086***	(0.031)	-0.077***	(0.027)	-0.074***	(0.027)
Rivals									
UnReg -	low ε	0.161***	(0.026)	0.160***	(0.028)	0.132***	(0.025)	0.127***	(0.027)
	high ε	0.089**	(0.045)	0.086*	(0.047)	0.080	(0.051)	0.091*	(0.052)
Reg	low ε	-0.014	(0.036)	-0.020	(0.037)	-0.020	(0.027)	-0.024	(0.028)
	high ε	-0.030	(0.042)	-0.033	(0.042)	-0.043	(0.036)	-0.045	(0.035)
Observations		645708		645708		645708		645708	
R^2		0.988		0.988		0.989		0.989	

Notes: Standard errors in parentheses allow for clustering at the product level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes product fixed-effects (8,129); column (2) adds month fixed-effects (168); column (3) adds fixed-effects for product-age (56) and available varieties (36); column (4) controls for additional characteristics (see section 4.3).

price elasticity of demand. Conversely, variety decreases in unregulated, high-ε markets. This is consistent with the findings of Fan (2013), who shows that content quality of newspapers decreased.

Summarizing, after large horizontal mergers, firms increase prices – if they can, which they do in unregulated markets – predominantly when markets are characterized by inelastic demand. Rivals follow suit. If merging firms cannot increase prices, since the market is price regulated, they increase product variety instead.

5.4.3 Welfare Considerations

We can evaluate the changes in consumer surplus for a representative consumer of acquired drugs as in Train (2009) and Small and Rosen (1981):

$$\text{CS}_{treated} = \frac{1}{\alpha} \times ln \left[1 + \sum_t \sum_k exp^{\delta_{kt}} \right],$$

where δ_{kt} can be interpreted as the mean utility derived from consumption of product k in period t. We run three counterfactual scenarios for merging firms and rivals using the estimated effects of the mergers on prices and product variety of tables 3 and 5, columns (4). First, for unregulated drugs, we elevate the prices charged by merging firms by +10.9% and those of rival firms by +11.2% post merger, while decreasing the prices of merging firms in regulated markets by 5.9%. Second, we increase the product variety of regulated drugs sold by merging firms by 0.6 (while setting prices back to their original level). Third, we add up the welfare changes induced by price and variety

Table 11: Product variety and the elasticity of demand

		(1)		(2)		(3)		(4)	
M&A									
UnReg -	low ε	0.071	(0.163)	0.044	(0.169)	0.053	(0.181)	0.073	(0.184)
	high ε	-0.438***	(0.114)	-0.459***	(0.116)	-0.379***	(0.131)	-0.350**	(0.137)
Reg	low ε	0.756***	(0.251)	0.734***	(0.246)	0.779***	(0.232)	0.810***	(0.242)
	high ε	0.296*	(0.156)	0.274*	(0.160)	0.327*	(0.175)	0.374**	(0.184)
Rivals									
UnReg -	low ε	-0.343	(0.250)	-0.373	(0.254)	-0.281	(0.298)	-0.308	(0.338)
	high ε	-0.355***	(0.126)	-0.379***	(0.124)	-0.263*	(0.135)	-0.259*	(0.143)
Reg	low ε	-0.162	(0.116)	-0.187	(0.118)	-0.157	(0.124)	-0.182	(0.133)
	high ε	0.050	(0.118)	0.024	(0.124)	-0.003	(0.121)	-0.025	(0.128)
Observations		450958		450958		450958		450958	
R^2		0.709		0.709		0.753		0.758	

Notes: Standard errors in parentheses allow for clustering at the ATC4 level, * p<0.1, ** p<0.05, *** p<0.01. Column (1) includes ATC4 fixed-effects (416); column (2) adds monthly fixed-effects (168); column (3) additionally controls for corporation fixed-effects (556); column (4) adds corporation×year fixed-effects (4,754). All regressions control for the number of products sold.

effects. We thus estimate consumer surplus changes for a representative consumer being affected by the merger relative to the situation before the merger. Table 12 presents the results.

Consumer surplus increases in the regulated segments and decreases in the unregulated segments of the pharmaceutical market after horizontal mergers. We estimate an increase in consumer surplus due to the price effect of +4.2% and due to the variety effect of +10.9% in the regulated segments of the pharmaceutical market.[28] In the unregulated segments of the market, there are only negative price effects of -6.6% for merging firm drugs and of -2% for affected rival firm drugs. Taken together consumer surplus increases by 11.5% under price regulation (and decreases by more than 6% if there is no price regulation). Regulation thus protects consumers from market power effects after mergers.

How do these findings compare to the literature? Dubois and Lasio (2018) find that pharmaceutical prices in France are on average 6% lower due to the constraints imposed by price regulation. The corresponding annual changes in consumer surplus range from +1.1% to +10.2%, with an average of +3.8%. Thus, the impact that prices have on consumer welfare is very similar to our estimates (with a 1% change in prices leading to an approximated 2/3% change in consumer surplus). Dubois and Lasio (2018) do not, however, analyze variety effects of regulation.

Branstetter et al. (2016) estimate large consumer surplus gains caused by paragraph IV regulation

[28]Note that the price decreases of merging firms in regulated markets were not found in the sample consisting only of drugs sold in parallel in both markets (section 5.2); all other reported effects are robust across samples.

Table 12: Utility of a representative consumer

	Base	Price Effect	Variety effect	Total effect
Merging firm products				
Reg	1.000	1.042	1.109	1.153
UnReg	1.000	0.934	1.000	0.934
Rival products				
UnReg	1.000	0.980	1.000	0.980

Notes: Welfare is calculated from the utility function of a representative consumer, by calculating the ratio of utility with and without the diff-in-diff effects reported in tables 3 and 5. We exclude observations where price increases lead to increases in utility.

leading to generic entry. In a random coefficients logit model they estimate consumer surplus in the US market for hypertension drugs to be around $72 bn. In counterfactual predictions without paragraph IV generic entry, consumer surplus decreases to around $30 bn. While we do not analyze generic entry, we also obtain substantial consumer curplus gains due to a larger variety of products. In our case this may be explained by the large share of reimbursed drugs, particularly so in the regulated segments. Thus, consumers only pay a small fraction of the ultimate cost of drugs, and consequently value variety a lot.

The question remains, whether total welfare is increased or reduced due to mergers, and whether regulation makes a difference. We have shown, that since prices increase and variety remains unchanged in unregulated market segments, consumer surplus unambiguously decreases in this part of the market. Producer surplus increases in the unregulated segments, since prices increase and variety stays the same (no rent dissipation). If, however, marginal costs do not decrease strongly, total welfare is unambiguously lower after mergers in the unregulated segments.

In the regulated parts of the market, prices of merging firms as well as their rivals stay constant or even go down, while variety increases. Thus, we have shown that consumer surplus unambiguously increases after mergers and that regulation is the driving force.[29] The question whether total welfare increases in the regulated segments therefore depends on producer surplus. In summary, while consumer surplus increases due to regulation the effects on total surplus are ambiguous in the regulated segments.

[29] However, in both cases we cannot rule out that dynamic efficiency is negatively affected, e.g. through the delayed introduction of new drugs.

6 Conclusion

We estimate the effects of mergers on prices, quantities and product variety in pharmaceutical markets. One novelty of our approach is to distinguish effects in regulated and unregulated parts of the market. Another contribution lies in the scope of the evaluation exercise: instead of focusing on a single case, we analyze 56 worldwide mergers during the 2004 - 2017 period, inducing all ownership changes of drugs due to mergers in Austria in that period. We argue that the decisions to merge can be viewed as being independently determined from market structure and regulatory conditions in Austria. Therefore, we treat these changes in market structure as exogenous to pharmaceutical prices, quantities, and product variety. Importantly, we can identify the effects of regulation by exploiting the fact that some parts of the pharmaceutical sector are (price) regulated and other parts – even within the same relevant market – are not. We employ monthly price and quantity data for all drugs offered in Austria and estimate price elasticities of demand using a nested logit model. Our empirical analysis is guided by Bertrand models with differentiated products, either under no regulation or under conditions of price regulation. Our main results are as follows:

The unregulated parts of the market can be described by the classic Bertrand oligopoly model with differentiated products. A horizontal merger increases market power, and merging firms as well as their rivals – via strategic complementarity – increase drug prices. We estimate a nearly 11% increase in prices in the unregulated segments of the pharmaceutical market. In the regulated segments of the market, however, firms cannot increase drug prices after a merger and price regulation becomes more binding. Instead, a regulated firm has an incentive to increase post-merger product variety. We estimate that after mergers product variety – defined as the number of the available dosages and consumption forms of a drug – increases by around 20% in the regulated segments but stays the same in unregulated segments. Consistently, we find that price effects are larger in inelastic markets, where the average price effect of mergers is +14.9%, while price effects are indistinguishable from zero in elastic markets. Moreover, in the unregulated segments, price effects are larger for larger deals, deals where more products are taken over, deals with larger overlap and initial market concentration. We do not witness these heterogeneous effects in regulated segments, however in these segments variety goes up more in larger deals, if more products are taken over, and where initial concentration is larger. Finally, merging firms in regulated *and* inelastic segments of the market increase product variety the most after horizontal mergers. Thus, under regulation firms increase product variety more when unilateral market power increases are (would be) higher.

The analysis of welfare effects shows that consumer surplus decreases after mergers in the unregulated segments, since prices increase and variety remains constant. We estimate a drop of more than 6% in the welfare of a representative consumer. The reverse holds in the regulated segments,

since prices decrease or remain constant, while variety increases. Under price regulation, we estimate a 15% increase in consumer surplus, the largest part of which is due to increased variety. Thus, price regulation in pharmaceutical markets can be justified on the basis of increasing static consumer surplus.

Conversely, our analysis has not addressed dynamic welfare effects due to regulation, such as R&D incentives and generic proliferation. Also our measure of product variety is more akin to product differentiation and we therefore have not estimated the welfare effects of new treatments. We leave these questions for future work.

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Table A13: List of mergers

Year	Acquirer	Nation	Target	Nation	Value	Year	Acquirer	Nation	Target	Nation	Value
2009	AESICA	UK	ABBOTT	UK		2013	PFIZER	US	FERROSAN	Denmark	
2009	ALMIRALL	Spain	SHIRE	UK	213	2013	TEVA	Israel	MERCK KGAA	France	364
2009	GALENICA	Switzerland	GLOBOPHARM	Switzerland		2013	THEA	Spain	NOVARTIS	Switzerland	
2009	GLAXOSMITHKLINE	UK	STIEFEL LABS	US	3600	2013	VALEANT PHARMA	Canada	BAUSCH & LOMB	US	8700
2009	JOHNSON & JOHNSON	US	PFIZER	US	16600	2014	ACTAVIS	US	FOREST	US	25439
2009	MEDA	Sweden	WYETH	Sweden	78	2014	AENOVA GROUP	Germany	HAUPT PHARMA	Germany	154
2009	MEDA	Sweden	NOVARTIS	Switzerland	135	2014	ASTRAZENECA	Sweden	BRISTOL-MYERS SQB.	US	4325
2009	MERCK & CO	US	SCHERING PLOUGH	US	38615	2014	BAYER	Germany	MERCK & CO	US	14200
2009	PFIZER	US	WYETH	US	67285	2014	GEDEON RICHTER	Hungary	GRUENENTHAL	Germany	334
2009	SPEPHARM	US	PROCTER & GAMBLE	US		2014	HRA PHARMA	France	BRISTOL-MYERS SQB.	US	
2009	TEOFARMA	Italy	ABBOTT	US	11	2014	MEDA	Sweden	ROTTA	Italy	3059
2010	ABBOTT	US	SOLVAY	Belgium	7603	2015	ALLERGAN	US	ACTAVIS	US	68445
2010	BIOVITRUM	Sweden	SWEDISH ORPHAN	Sweden	584	2015	CONCORDIA	Canada	AMDIPHARM MERCURY	UK	3547
2010	IROKO PHARM	US	MERCK & CO	US		2015	MYLAN	US	ABBOTT	Netherlands	5725
2010	MYLAN	US	MERCK KGAA	Hungary		2015	NOVARTIS	Switzerland	GLAXOSMITHKLINE	UK	16000
2010	NOVARTIS	Switzerland	EBEWE PHARMA	Austria	1272	2015	PERRIGO	Ireland-Rep	OMEGA PHARMA	Belgium	4538
2010	RIEMSER	Germany	SAARST FATOL	Germany		2015	PFIZER	US	HOSPIRA	US	15820
2010	SINCLAIR	UK	SOLVAY	France	25	2015	SIEGFRIED	Switzerland	HAMELN PHARMA	Germany	62
2010	STADA	Iceland	ACTAVIS	Germany	6467	2015	SUN PHARMA	India	RANBAXY	India	3225
2010	TEVA	Israel	RATIOPHARM	Germany	4931	2015	VALEANT PHARMA	Canada	CROMA PHARMA	Canada	
2010	WARNER CHILCOTT	US	PROCTER & GAMBLE	US	3100	2016	3SBIO	China	SIRTON PHARM	Italy	34
2011	MEDA	Sweden	NORGINE	Netherlands	79	2016	AESICA	UK	UCB	Germany	
2011	TAKEDA	Japan	NYCOMED PHARMA	Switzerland	13686	2016	CSL	Australia	NOVARTIS	US	275
2011	TEVA	Israel	CEPHALON	US	6310	2016	GLAXOSMITHKLINE	Egypt	NOVARTIS	Egypt	1
2012	JAZZ PHARMA	US	EUSA PHARMA	US	730	2016	MYLAN	US	MEDA	Sweden	7170
2012	WATSON	US	ACTAVIS	Switzerland	6002	2016	SHIRE	Ireland-Rep	BAXTER INT	US	30951
2013	ACTAVIS	US	WARNER CHILCOTT	US	5096	2016	TEVA	Israel	ALLERGAN	US	38750
2013	BAYER	Germany	STEIGERWALD	Germany	243	2017	ASPEN	South Africa	GLAXOSMITHKLINE	UK	371
						2017	RECORDATI	Italy	PRO FARMA	Switzerland	

Source: Thomson Reuters SDC, deal values are in million USD.