Switching Costs, Quality Misconceptions and Behavioral Pricing in the Pharmaceutical Market*

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Abstract

This article examines the market power of branded prescription drugs faced with generic competition. Using prescription-level and matched socioeconomic panel data of the entire Swedish population between 2010 and 2016, I provide evidence for the key role of switching costs. A discontinuity surrounding patent expirations establishes that the effect is causal. Further, by comparing medical experts to non-experts, I show that non-experts experience considerable quality misconceptions. A unique feature of the Swedish market allows me to rule out patients' inattention due to information costs as a source of market power. Therefore, switching costs and quality misconceptions are the key determinants of market power. I then estimate a dynamic oligopoly model with forward-looking firms which is used in counterfactual studies of the effect of switching costs and quality misconceptions on prices. First, an increase in the length of procurement mimics a reduction of switching costs and increase prices. While the effect of switching costs on prices in theory is ambiguous, moderate switching costs and sufficient competition for new patients increase competitive pressure. Second, if everyone acts as a medical expert and experiences fewer misconceptions prices decrease.

Keywords: Switching Costs, Misconceptions, Behavioral Pricing, Pharmaceuticals

JEL Codes: D12, I11, L13

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1 Introduction

Consumers in various markets stick to products they have purchased before and prefer to buy known brands even when cheaper alternatives of similar quality are available. Previous research has put forward a number of possible reasons for such habit persistence and brand premia: switching costs, inattention due to information costs, risk aversion, quality misconceptions or prestige effects of consuming a particular brand.[1] Such behavior is especially surprising when it comes to the consumption of prescription drugs in developed markets where fraud is not an issue.[2] Consumers often prefer branded and familiar products even though regulations require that generic products are equivalent, and pharmaceuticals do not generally carry any value except for their treatment abilities. In addition, these markets are characterized by high prices and odd price patterns[3] despite the generic competition that, according to economic theory, should serve as an important tool to reduce prices.

This study uses individual choice data for prescription drugs covering the entire Swedish population from 2010 to 2016 to examine the underlying behavioral and cognitive reasons why consumers are willing to pay a higher price for pharmaceuticals with the same ingredients. The unique institutional setting and data sources allow to identify important determinants of consumer choice: switching costs and quality misconceptions. The article first documents patterns of the behavioral phenomena in the data and then proceeds to the structural estimation of a dynamic oligopoly model to allow for a systematic evaluation of the welfare effects of counterfactual policies. In the counterfactual analysis I show that prices in equilibrium are dependent on behavioral frictions of consumers. Behavioral pricing incorporates the idea that the pricing of a product is based on the behavior of potential customers[4] and explains high prices as well as price dynamics of pharmaceuticals under generic competition. I make contributions to three

[1] The importance of switching costs in the retail market has been documented by Erdem and Sun (2001); Dubé et al. (2009); Shcherbakov (2016); Shy (2002); Viard (2007); and Rickert (2016). There is a substantial economic and marketing literature of brand premia and the general concept of brand equity. Following Handel and Schwartzstein (2018) one may distinguish between behavioral frictions that are in line with the neoclassical assumption of correct beliefs and mental gaps. For the former, see Hortaçsu and Syverson (2004) for an example of risk-index funds and a discussion of risk aversion and possible information costs. Ackerberg (2001) discusses the importance of prestige effects. The second possibility is that consumers have mental gaps or psychological distortions (Handel and Schwartzstein, 2018). Consumers can have wrong beliefs or misconceptions. Early marketing work, such as Braithwaite (1928) and Frederic and David (1990), contends that misleading information comes from advertisements. Bronnenberg et al. (2015) demonstrate an example of brand premia due to inattention or quality misconceptions. Also, the media has covered habit persistence and brand premia, see, for example, Mullainathan (2017) for *The New York Times*.

[2] Counterfeit pharmaceuticals are a problem in large parts of the developing world. According to an OECD report (OECD, 2009) the magnitude of counterfeit medicine is 1% across all medications but an increasing problem in some Asian and African countries. Because of the increase of the black market and personal prescription drug importation, counterfeit medicine is also an increasing problem in the United States (Zullo et al., 2015). Patients may face insecurity due to counterfeit medicine and rely on branded names. The problem of counterfeit medicine in the legal pharmaceutical industry in the European Union is less severe. Especially in Sweden, counterfeit medicine in the legal distribution networks has not received attention.

[3] In the US prices of generic pharmaceuticals often rise unpredictable. In 2014 and 2015 several producers increased prices of generic products drastically (i.e. Ursodiol), see Reinhardt (2016) for a discussion. Most recently in July 2018, Pfizer announced the plans of increasing the price of a number of generics (LaVito, 2018). In the United Kingdom drug manufacturers of generic competitors have been accused of differentiating generic pharmaceuticals to increase price (Hyde, 2016). In Sweden, price cycles between producers arise. Competitors take turns each month in setting a high price (Janssen, 2018).

[4] The term behavioral pricing has been used in marketing literature. See Gannett (2012) for a general definition. Note that the term incorporates the dynamic as well as simultaneous connection between the behavior of consumers and prices. Indeed, prices shape the choice as well as future behavior of firms. However, past choices, behavior or general brand preferences also shape demand and therefore prices.

literatures: industrial organization, behavioral and health economics.

First, the panel structure of the individual choice data allows the identification of consumers' switching costs[5] after starting a medical treatment with a specific brand. Crucially, switching costs are not apparent in all prescription markets. I show that patients are 17.75% (3.22 percentage points) more likely to overpay for painkillers and 12.35% (1.16 percentage points) for antibiotics if they have consumed the identical product in a preceding month. There is no evidence for this habit persistence in markets for antiepileptics. The results withstand several robustness checks in which I explore identification strategies beyond panel data methods. For example, I compare repeated purchases of patients who start treatment with substances briefly before and after the patent of this substance has expired, I show that the estimates of habit persistence due to switching costs are robust. This clean evidence for switching costs over a wide range of pharmaceuticals is novel.[6]

Second, the regulatory background of the Swedish prescription drug market, as well as the registry data, allows the identification of mechanisms behind brand premia. In general, the explanation for brand premia is that either some brands carry a higher quality (in real terms or caused by psychological effects, i.e. prestige effects), or that consumers make suboptimal choices. I can exclude that brand premia exist due to real quality differences for two reasons. On the one hand, the market for prescription drugs is ordered into exchangeable groups that are medically equivalent. On the other hand, I exclude real quality differences by comparing purchasing behavior between experts (patients with a medical education) and non-experts (patients without a medical education) similar to Bronnenberg et al. (2015). While the approach of comparing experts to non-experts allows me to exclude real quality differences as a reason for brand premia, it is often not possible to differentiate between consumers who are inattentive and situations where the consumer has misconceptions about the quality of products (Handel and Schwartzstein, 2018).[7] In the former, information costs[8] prevent consumers from accessing all the relevant information. In the latter case, the consumer has mistaken beliefs about a product.[9] There is a growing literature that tries to isolate inattention (and

[5] Klemperer (1995) differentiate between five cost types: (1) Need for compatibility with existing equipment, (2) Transaction costs of switching supplier, (3) Costs of learning to use new brands, (4) Uncertainty about the quality of untested brands and (5) Discount coupons and similar devices.

[6] Only Feng (2017) identifies switching costs for anticholesterol drugs using a similar identification strategy of a discontinuity surrounding patent expiries.

[7] Handel and Schwartzstein (2018) report numerous examples where both phenomena may play a role. For example, the difference in purchasing behavior of over-the-counter (OTC) drugs between pharmacists and the general population in Bronnenberg et al. (2015) could be caused by lower information costs of pharmacists (who have lower search costs of comparing products) or because of a lower degree of quality misconceptions. The authors report that pharmacists have better knowledge about the ingredients of drugs, which is in line with lower information costs as well as fewer misconceptions. Note also that I explore behavior only within specific substitution groups. The products within a substitution group are equivalent from a medical perspective. Exploration and learning as described in Crawford and Shum (2005) is not important within but solely between substitution groups.

[8] Information costs are defined as the costs of time and monetary and other resources of gathering information.

[9] Handel and Schwartzstein (2018) denote the mistaken beliefs or misconceptions as part of 'mental gaps'. Indeed, their definition of a mental gap is broader: 'there is a gap between what people think and what they should rationally think given costs'. Mental gaps are psychological distortions. I interpret misconceptions as part of mental gaps that are the most important in this specific market of prescription drugs. It is helpful to distinguish here between mental gaps and the subset of misconceptions: Misconceptions precisely describe the situation where consumers intentionally insist on a specific product as a result of wrong beliefs about the real quality.

switching costs) in markets of insurance and pension choices (i.e. Ho et al., 2017). Handel and Schwartzstein (2018) argues that also in the case of insurance choices the underlying mechanisms are still based on assumptions of the authors.[10] Given the institutional setting, this study is unique as I can credibly rule out inattention as a possible reason for brand premia. In Sweden patients with a prescription from a primary health care provider are not only financially incentivized to consume the cheapest available product from a predefined group of equivalent drugs, but the pharmacist is also obliged by law to tell the patient about the cheapest product as well as of its equivalence (Sveriges Riksdag, 2002). Given that the information about equivalence is provided at the time of purchase and the cheapest equivalent pharmaceutical is always presented as a default option, inattention is not an explanation for brand premia.[11] Therefore my approach differs from the existent literature of insurance choices (Abaluck and Gruber, 2016; Bhargava et al., 2017; Marzilli Ericson, 2014; Handel, 2013; Handel and Kolstad, 2015; Ho et al., 2017; Ketcham et al., 2015; Miller, 2019) not only as I investigate consumer choices of physical consumption products but also as inattention is not an option. Instead, non-experts have misconceptions about the quality of pharmaceuticals. Comparing experts and non–experts, I show that misconceptions of painkillers lead to 26.1% (4.88 percentage points) more purchases with an overpayment. For antibiotics, misconceptions account for 26.06% (2.45 percentage points) more overpayments, and for antieplileptics for 38.21% (1.07 percentage points) more overpayments.

Third, I quantify the effect of switching costs and brand premia on firms' pricing strategies. Theory predicts that switching costs impact the price setting behavior of firms.[12] Firms have an incentive to decrease prices sporadically and set higher prices in subsequent periods to harvest consumers. Furthermore, switching costs may lead to collusion schemes where firms alternate systematically in prices (Janssen, 2018). Prices in the pharmaceutical market show cyclical price patterns. Firms with a high market share due to a period of low prices increase their prices in forthcoming months. The patterns can be explained by behavioral pricing. A structural estimation of the market allows me to extend the analysis of market equilibria and quantify the effects of switching costs and brand premia. I estimate the demand for pharmaceutical products from experts as well as non-experts, incorporating switching costs. I show that switching costs in a representative substitution group of high dosage paracetamol account for 11% to 28% of the retail price

[10] For example Handel (2013) uses similar data and mechanisms to Ho et al. (2017) and acknowledges that underlying mechanisms could include true switching costs, search costs, or miscalibrated beliefs.

[11] In a series of robustness checks I investigate if the Swedish substitution system works as intended. Patients with a prescription should get information about the cheapest available generic within a predefined substitution group at the pharmacy level. In case of opposing substitution patients have to bear additional costs. Only seldom the physician/prescriber opposes substiution from a specific brand (approx. 1-2% of all prescriptions). In *Online Appendix D* I show empirically that pharmacists follow the legislation and present the cheapest equivalent pharmaceutical. In *Online Appendix E* I analyze the role of a prescriber/physician and show that the opposed substitutions by prescribers are not a threat for identification of quality misconceptions. In *Online Appendix C.4* I show that substitution on the pharmacy level usually happens within and not between substitution groups. Advertisement of prescription drugs in Sweden is not allowed.*Online Appendix F* shows that advertisement of OTC drugs are not correlated with quality misconceptions of prescription drugs.

[12] Klemperer (1987a) and Klemperer (1987b) provide insights on the impact of switching costs on the competitive outcome in a duopoly. Note also the existence of similar models in monopolistic competition, i.e. Conlisk et al. (1984), Sobel (1984) or Villas-Boas (2006). In detail it may even be possible that monopolists under some conditions (i.e. durable goods) play a 'lock-in and harvest' strategy. Multi-period environments (Beggs and Klemperer, 1992; Padilla, 1995; Anderson et al., 2004; Anderson and Kumar, 2007; see also the survey in Farrell and Klemperer, 2007) have extended the theoretical literature on the competitive effect of switching costs in duopolies.

while quality misconceptions are for this specific drug group lay in a moderate range of 5% to 16% of the retail price. I use a two-step estimator similar to Bajari et al. (2007) to recover cost parameters of firms under the assumption that firms compete in an infinite horizon setting.

I use the structural model to investigate two counterfactual scenarios that highlight the importance of consumers' behavioral frictions for price equilibria in applied industrial organizations. The first counterfactual evaluates effects on prices and consumer welfare by changing the procurement behavior of prescription drugs in the Swedish health care system. Under the hypothetical policy, firms are allowed to change the price of their product every twelve months instead of each month. Under this scenario firms have a lower incentive to engage in behavioral pricing because it is more costly to lock in patients and less profitable to harvest them. In other words, switching costs are less important. I choose the increase of the length of procurement contracts instead of decreasing the switching costs directly as it represents a realistic policy intervention.[13] Nevertheless, the policy is well suited to explore the effects of switching costs on market equilibria.[14] Intuitively one might think that switching costs make a market less competitive and that a policy lowering their importance would result in reduced prices. In contrast, the results show that prices increase and patients' welfare decreases (consumers pay on average 2.08% more) under the alternative regime with only annual procurement. The results are in line with theoretical (Cabral, 2016; Rhodes, 2014) and empirical (Dubé et al., 2009) research that shows that moderate switching costs may lower prices. The basic reasoning is the following. Switching costs always have two effects. On the one hand, they lead to an increased market power of firms with locked-in consumers. On the other hand, they increase competition for new customers. If switching costs are moderate in size and there are sufficiently many new customers then an increase in switching costs is associated with a higher competitive pressure and lower prices in equilibrium. The result adds to the discussion about the competitive pressure of switching costs.[15] Firms have a lower incentive to reduce prices in order to lock in consumers and moderate switching costs prevent too high prices in 'harvest' periods. Further, not every patient is a frequent consumer. New incoming patients and those that do not experience switching costs profit from behavioral pricing as firms decrease their prices sporadically to lock in patients. The results are important for the interpretation of switching costs from an industrial organization perspective as well as for policymakers: First, switching costs are empirically important when it comes to evaluating price incentives of firms. Second, switching costs do not necessarily increase prices in equilibrium. A policymaker has to carefully evaluate the size and effect of switching costs in a pricing equilibrium.

The second counterfactual investigates the situation where consumers are medical experts, limiting the role of

[13] A policy of a longer contract time has been proposed by Granlund and Rudholm (2018). The authors suggest that it decreases the coordination possibilities in forms of price cycles which are empirically described in Janssen (2018).

[14] In *Online Appendix I.3* I confirm that the result is similar when decreasing switching costs on the demand side directly.

[15] Recent theoretical literature includes discussions on the possibility of lower degrees of switching costs in which competitive pressure may increase (Arie and Grieco, 2014; Cabral, 2016; Dubé et al., 2009; Fabra and García, 2015; Rhodes, 2014). A detailed discussion about previous literature and the analysis when switching costs make markets more or less competitive can be found in Ruiz-Aliseda (2016).

quality misconceptions for patients' choices. The hypothetical situation is closely related to directly targeting consumers' misconceptions or a reform that makes prescription by physicians mandatory. In such a situation substitution is absolutely mandatory if not opposed by a physician. Limiting quality misconceptions that account for 5% of the retail price are associated with price decreases by 2.7% and patients' welfare increases (costs for consumers decrease by 3.0%). With less scope for quality misconceptions, firms have less opportunity to take advantage of patients who are willing to pay brand premia. A decrease in quality misconceptions is profitable for the consumers through a direct effect of lower brand premia and an indirect effect caused by an increase in competition as firms cannot rely on brand premia.

The paper is organized as follows. In Section 2 I examine the behavioral phenomena in a stylized choice model. Section 3 presents an overview of the institutional background, and Section 4 describes the data sources as well as the markets of the studied substances. In Section 5 I identify switching costs and quality misconceptions. I develop the model in Section 6 and describe the estimation techniques in Section 7. The results of the model are presented in Section 8 and the counterfactuals are presented in Section 9. Finally, Section 10 concludes.

2 Switching Costs and Quality Misconceptions in a Stylized Choice Model

To frame the definitions of consumers' switching costs and quality misconceptions in the prescription drug market, I outline a stylized choice model.[16] The model intends to solely capture the basic intuition of the behavioral features.

Let there be i patients. Each patient chooses between $j = 1, ..., N$ products. Prices of products are denoted by p_j. There are two kinds of patients in the market, experts (with a medical education) and non-experts (all others). Let us consider a patient i: The utility that experts attach to a product is denoted by u_j^E whereas the non-experts attach a utility of u_j to a product. Drugs are used for treatment of a disease such that there is no outside good. Experts choose a product j_E^* that maximizes net utility, $\max_j\{u_j^E - p_j\}$. Non-experts choose j^* such that $\max_j\{u_j - p_j\}$. One may observe the same product choice between experts and non-experts, so $j_E^* = j^*$, or the product choice differs, that is, $j_E^* \neq j^*$. Behavioral phenomena may affect (1) the product choice in general, that is, j^* and (2) the difference in product choice between experts and non-experts. In the following I briefly describe possible factors that influence choices of a patient.

1. *Switching Costs:* Switching costs affect utility of patients, independently if it is an expert or not. The utility of product j is not only defined by the quality of usage $\underline{u}_j$ but also the previous usage of j affects utility by a

[16] The model shares some similarities to Bronnenberg et al. (2015), however, extends the basis to switching costs and a multiple product environment.

factor β_j. So if j has been used in the previous treatment, utility increases by β_j to $\underline{u}_j + \beta_j$. Switching costs influence the decision of non-experts and experts, $\max_j \{u_j - p_j\}$, and result in habit persistence/state dependence which means that consumers tend to purchase the same product/brand in subsequent occasions even though the environment, such as prices or choice sets, have changed.

2. *Quality Differences:* Even though there is a medical equivalence and absence of counterfeit pharmaceuticals in the Swedish market, the model allows for quality differences. Quality difference means that the quality of usage (medical quality) is not equal among drugs, that is, it may be possible that $\underline{u}_j \neq \underline{u}_k$ for $k \neq j$. I allow for quality differences and naturally quality differences affect product decisions, that is, $\max_j \{u_j - p_j\}$. Note that real quality is the same for experts and non-experts.

3. *Quality Misconceptions:* Quality misconceptions lead to a divergence between the real quality of a product $\underline{u}_j$ and the perceived quality $\underline{u}_j + \rho_j$. In detail, patients have misconceptions that lead to erroneous perceived quality. Misconceptions are defined as solidified beliefs about a product. It may be possible that misconceptions are related to general trust in some products. Note that experts have more correct beliefs about products. Therefore the quality misconceptions influence the choice $\max_j \{u_j - p_j\}$ and may lead to different choices between experts and non-experts, that is, $j_E^* \neq j^*$.

4. *Inattention:* Inattention results in a mistaken perceived quality or price. Consumers do not evaluate quality or prices correctly such that the perceived quality is $\underline{u} + \varepsilon_j$ and perceived prices take the form of $p_j + \varphi_j$. Consumers do not know the true quality or prices exactly. Patients use heuristics or expectations and get the presented perceived quality and prices. Note that there may be a divergence between experts and non-experts as experts are able to access information easily. Inattention does *not exist* in the institutional setting because patients get information about quality of products directly from the pharmacist.

Overall the utility of j for a non-experts is defined as $u_j = \underline{u}_j + \rho_j + \beta_j$ where $\underline{u}$ presents the real quality, ρ_j the quality misconceptions and β_j is the switching costs that exist if i has consumed j before. If i is an expert the utility of j is $u_j^E = \underline{u}_j + \beta_j + \alpha\rho_j$ with α adjusting the quality misconceptions. The institutional setting allows for quality differences and excludes inattention as patients get information about quality and prices.

I identify switching costs β_j through panel data where patients start, finish or restart a treatment at a different point in time at a different price or choice environment. Treatment with prescription drugs is exogenous as patients do not start treatments due to the choice environment. In additional robustness checks, I use quasi-experimental settings to show switching costs. Further, I identify quality misconceptions ρ_j by comparing experts to non-experts. Experts have better knowledge about quality differences, that is, $\underline{u}_j \neq \underline{u}_k$ for $k \neq j$ and experience fewer quality misconceptions.

The exclusion restriction for the identification of quality misconceptions is that experts and non-experts experience the same quality from a drug.

3 The Swedish Health Care System

Health care coverage in Sweden is universal and mainly publicly funded. Prescription drugs are reimbursable.[17] I show the co-payments of patients in Table I.[18] Patients' co-payments are dependent on the yearly costs for pharmaceuticals. Costs above a ceiling are entirely covered.[19] Almost half of the revenue from prescription pharmaceuticals are by patients that have reached cost ceiling (Bergman et al., 2012).

[Table I about here.]

Considering pharmaceuticals under generic competition, patients are incentivized to acquire the cheapest available generic. Substitution for the cheapest product happens at the pharmacy level (TLV, 2016c; Sveriges Riksdag, 2002).[20] But not every patient gets dispensed the cheapest available product. Three possible reasons may prevent a substitution. First, patients may oppose substitution. In this case, patients have to pay the price difference between the cheapest available generic and the prescribed product out of pocket. Solely the price of the cheapest available product is subject to the co-payment structure. Second, a physician or health care provider has the possibility to oppose substitution.[21] Third, there exists the possibility that the cheapest available product is not in stock at the pharmacy. In such a case the second cheapest product is dispensed. In the latter two cases patients have the same co-payment structure as in Table I.

The pharmaceutical market had a market capitalization of $4.15 billion in 2015. $3.08 billion are due to prescription drugs, and patients' co-payments are $0.64 billion (TLV, 2016a). The market for off-patent drugs is ordered in substitution groups (groups of pharmaceuticals with the same substance, size and strength) that are determined by the Medical Product Agency (MPA). Since 2002, a tendering system determines prices of off-patent drugs in each

[17] Note that the decision about the exact product reimbursement is subject to the decision of the Dental and Pharmaceutical Benefits Agency (TLV). Some products are just partly reimbursed. TLV (2016e) provides detailed information.

[18] Note that the co-payment covers all prescription drugs. Costs for pharmaceuticals that are not in the benefit scheme are not covered. Also OTC drugs are not subsidized. Specific pharmaceuticals for children (less than 18 years), pharmaceuticals against communicable diseases, insulin or pharmaceuticals for persons lacking perception of own illness are fully subsidized.

[19] If patients have costs of more than 2200 SEK (approx. 200 USD) for pharmaceuticals additional costs are covered without out of pocket expenses.

[20] In detail, a pharmacist is obliged to recommend the cheapest available generic to patients. Further, pharmacists should explain the medical equivalence of the products.

[21] One may ask why this possibility exists if products are equivalent. Historically physician's prescription has been mandatory. Physicians therefore could decide about a brand. Since a reform substitutions are possible but doctors can oppose them. However, physicians seldomly oppose substitution.

substitution group.[22] In Figure I I show the details of the sealed bid first price auction. Timing is as follows. A pharmaceutical company who wishes to sell a product submits a price at the end of a month (*Month A*) for the month after next (*Month C*).[23] Prices have a ceiling, and companies have to bid a lower price than the ceiling.[24] The auctioneer publishes a preliminary list of prices in the middle of the next month (*Month B*). After the supplier of the cheapest product confirms she can service the entire Swedish market, prices are implemented.[25] Note that the pharmaceutical companies observe the preliminary list for the future month before bidding for the month after next (TLV, 2016c).

[Figure I about here.]

Retail prices are regulated and dependent on the prices in the auction. In detail, retail prices are an almost linear functions of pharmacy purchasing prices. The difference between the retail and pharmacy purchasing prices are the trade margins of a pharmacy.[26] Although pharmacies were privatized in 2009[27] pharmacies are obliged to dispense the cheapest available generic (Sveriges Riksdag, 2002). Nevertheless, profits for pharmacies are a linear function of retail prices.[28] The pharmacy can dispense the second cheapest generic in case the cheapest product is not in stock.[29]

4 Data

I use data for painkillers (ATC code:[30] N02), antibiotics (ATC code: J01) and anti-epileptics (ATC code: N03) between January 2010 and June 2016 in Sweden. The data are provided by Socialstyrlsen, the Swedish governmental agency for health and welfare. To restrict the data to reimbursable pharmaceuticals I connect the choice data to monthly prices/bids for outpatient pharmaceuticals under generic competition, provided by the TLV. Each individual that is covered by the universal health care system and purchases a product at a pharmacy with a prescription from

[22] Before 2012 the system determined the product of the month (cheapest product in a substitution group) only. After 2012 the system also determines the reserves, the second and third cheapest product in a pharmacy. The reason for the change is that pharmacies experienced difficulties in dispensing the single product of the month.

[23] Note that in case of default, the price of the previous month is taken as a bid.

[24] The usual ceiling is 35% of the original brand product price before expiration of the patent. In detail, a price ceiling exists if a brand drug is under generic competition for at least four months and the prices of a drug have fallen by 70% of the original brand product price 12 months prior to patent expiration. If no price ceiling exists, the most expensive product of the month will form the price ceiling. If an original product does not have sufficient generic competition, prices may also be reduced (7.5% reduction) if market authorization was 15 years ago (TLV, 2016b).

[25] If a firm confirms delivery but fails to do so it is subject to a penalty fee. Before 2014 the confirmation was not part of the process.

[26] I describe the exact functions between purchasing and retail prices in *Online Appendix A*. It has been changed slightly over the past years (TLV, 2016d).

[27] Two-third are privatized and one-third remain under public control.

[28] In *Online Appendix D* I provide some tests to show that the system is working as intended and pharmacies do substitute.

[29] Additionally, a pharmacy can sell the remainder of the previous product of the month the first two weeks of a new month. After these two weeks, pharmacies can sell the products for the pharmacy purchasing price without profits. Therefore the pharmacy has no incentive to overstock a product of the month.

[30] The ATC code describes each pharmaceutical substance and is ordered according to five levels. The first level describes the anatomical main group (i.e. Nervous system); the second level, the therapeutic main group (i.e. Analgesics/Painkillers); the third level, the pharmacological subgroup; the fourth level, the chemical subgroup; and the fifth level, the exact chemical substance.

a health care provider is observable.[31] The data includes a personal identifier, the dispensed product, the time of the transaction as well as information regarding if an individual, a physician or a pharmacy has opposed substitution. In cases where a patient opposes substitution one can further identify the initially prescribed product. By connecting the choices to Swedish registry data provided by Statistics Sweden (SCB), I observe the residence of a patient[32] as well as some socioeconomic characteristics. In detail, the data consist of the yearly income and detailed education information. The educational information describes the length, the degree and the subject of consumers' education.

Finally I also use advertisement expenditure for non-prescription drugs. The data are provided by Kantar Sifo and include advertisement expenditures for non-prescription drugs by pharmaceutical brands between 2010 and 2016.

Table II shows a basic market description. In terms of different substances, the market of antibiotics (24 substances) is greater than the market for painkillers (10 substances) and antiepileptics (4 substances). However, the number of substitution groups and products is the highest for painkiller (158 substitution groups, 566 products). The average number of products in a substitution group over the studied time is 1.95 within a substitution group of painkillers. The number of competing products in substitution groups of antibiotics and antiepileptics is lower on average (1.61 for antibiotics, 1.38 for antiepileptics). For all three subgroups the majority of products are generics (70% of painkillers, 75% of antibiotics, and 76% of antiepileptics), and 30% of painkillers and 19% of antibiotics are originals. For antiepileptics no originals but parallel imports are observable. The average prices for a product in the three subgroups vary from 255 SEK for antibiotics, 333 SEK for painkillers and 393 SEK for antiepileptics. Originals are on average more expensive than generics.

[Table II about here.]

4.1 The Market for Painkillers, Antiepileptics and Antibiotics

Upper part of Table III shows basic demand characteristics for all three markets. The number of purchase occasions is the number of prescriptions that are filled in during the 6.5 years. The number of purchase occasions is much higher for painkillers (approx. 38.5 million) and antibiotics (approx. 13.8 million) than for antiepileptics (0.57 million). Also the number of unique patients who got dispensed an antiepileptic is much lower (approx. 60,000 compared to approx. 3.2 million for painkillers and 4.7 million for antibiotics[33]). The average purchase occasions per patient differs for the subgroups. While painkillers and antiepileptics are often repeatedly purchased by the same individual

[31] Note that reimbursement of pharmaceutical expenses requires a prescription. The majority of the products are pharmaceuticals that require a prescription.

[32] In detail I observe the county as well as the municipality. Counties are the highest and the municipalities a lower level geographic subdivision. There are 21 counties, each with a population between 60,000 to 2.2 million. There are 290 municipalities in Sweden.

[33] Note that the Swedish population has a size of approx. 10 million in 2018.

(the average number of purchase occasions for the timespan of 6.5 years for painkillers is 12.1 and for antiepileptics it is 9.4), antibiotics have a much lower frequency of purchase occasions (2.9). Note also, that within the substitution groups of painkillers a large variability is observable (standard deviation of 26.3). The heterogeneity in frequency of purchase occasions is not surprising from a medical point of view because painkillers and antiepileptics may be used for long-lasting treatments whereas antibiotics are mostly used for the acute treatment of a bacterial infection. From a cost perspective the purchased painkillers are on average worth 46.7 million SEK a month whereas antiepileptics and antibiotics are worth 2.8 and 23.5 million SEK a month respectively. The share of co-payment is much lower for antiepileptics (25% of the total payment) compared to antibiotics (62% of total costs) and painkillers (38% of total costs). One reason for the difference in co-payments is due to the upper ceiling for medical expenses. Patients that have a longer treatment may reach the upper ceiling earlier and therefore pay lower co-payments for pharmaceuticals. Another possibility is that patients oppose substitution to the cheapest pharmaceutical more often when using painkillers and antibiotics.

[Table III about here.]

The lower part of Table III shows the substitution behavior of patients for the three therapeutic groups.[34] In line with the regulatory purpose the majority of patients get dispensed the cheapest product, the product of the month (PoM). However, heterogeneity between and within the therapeutic groups are observable: 73.4% of patients purchase the PoM when getting a prescription of painkillers, whereas 89.9% and 92.9% of patients get dispensed the PoM for antibiotics and antiepileptics respectively. Patients who do not receive the PoM belong to one of the three following groups. They opposed substitution and pay the difference out of pocket, their physician opposes substitution or the pharmacy opposes substitution as the PoM is out of stock. The first reason for an opposed substitution is most common in all three therapeutic groups. In detail, 20.9% of all patients purchasing painkillers oppose substitution. For the therapeutic groups of antiepileptics and antibiotics the fraction is smaller (9.4% for antibiotics and 2.8% for antiepileptics).[35]

[34] Further summary statistics that also analyze differences between subgroups of the population are shown in the Online Appendix.
[35] I provide further summary statistics in *Online Appendix B*.

5 Empirical Analysis

Switching costs result in habit persistence.[36] There is a recent and increasing empirical literature that estimates switching costs and/or the impact of switching costs.[37] This article of the Swedish pharmaceutical market differs in several dimensions. Patients in the Swedish market of prescription drugs under generic competition get a prescription from their primary health care provider and can choose between products within a pharmacy. Their health insurance reimburses them solely for the cheapest product of a predefined substitution group and consumers pay the differences if they prefer a prescribed expensive product. The substitutability between products is first determined by a medical governmental agency and further implicitly acknowledged by the prescribing physician who can oppose substitution. When choosing a product at a pharmacy the default product, which is first presented and recommended to the consumer, is the cheapest available product. In comparison to other retail markets where habit persistence may be also due to inattention, the pharmaceutical market is therefore characterized by a very clean and structured environment.[38] Nevertheless, patients may have higher trust in a specific product after a successful treatment. Switching cost are therefore a psychological cost that a consumer bears after starting the treatment with a specific product. Importantly, switching costs are induced by previous usage.

Further, consumers may have erroneous beliefs about quality differences and therefore prefer specific brands. When patients believe that branded products have a superior quality, the perceived quality differences lead to an observable brand premium. In comparison to switching costs, brand premia are not induced through past consumption.

There are several other reasons why consumers are willing to pay brand premia. First, some brands may have a higher quality, which leads to a higher utility such that consumers are willing to pay brand premia. Higher quality may be due to physical features but could also be due to a psychological effects induced by the brand (i.e. prestige effects[39]). Second, consumers may overpay since acquiring and processing information is costly. Consumers may be inattentive and purchase without analyzing all available options. Third, due to misconceptions consumers may attach the wrong quality to some products. While the first explanation for brand premia is based on heterogeneous products, the latter two are due to consumers' information costs or beliefs.[40] As emphasized by Handel and Schwartzstein

[36] Note that observed habit persistence is directly connected to switching costs. Consumers are habit persistent due to the cost of switching. I quantify switching costs by estimating a demand system in Section 7.2.

[37] Most of the evidence comes from choice data in the retail sector. Erdem and Sun (2001); Dubé et al. (2009); Shcherbakov (2016); Shy (2002); Viard (2007) and Rickert (2016) show recent evidence for switching costs in retail markets. For example, Handel (2013) and Miller (2019) focus on health insurance markets while Honka (2014) identifies switching costs in the auto insurance market. Thiel (2019) evaluates switching costs in the dutch mortgage market, and MacKay and Remer (2019) find switching costs in the retail gasoline markets.

[38] Note also that the branding of products is highly regulated. Firms have to label products in an informative manner. Advertisement for specific prescription drugs is forbidden.

[39] See Ackerberg (2001) for a summary.

[40] Handel and Schwartzstein (2018) give an overview about the second and third explanations and the importance of distinguishing between both.There is an extensive and increasing literature in behavioral and health economics that identifies situations where consumers make suboptimal decisions in healthcare markets. Consumers tend to choose dominated (not optimal) health insurance plans (Abaluck and Gruber, 2016;

(2018), it is often not possible to differentiate between consumers who have high information costs and are inattentive and consumers who have misconceptions. However, the differentiation may be important when evaluating the effect on firms' behavior. In cases where consumers have information costs and do not evaluate all available information some firms may have an incentive to obfuscate information about quality or prices.[41] A policy that reduces information costs could then increase consumers' welfare. In cases of consumers' misconceptions, firms have an incentive to invest in those 'misconceptions' by branding, that is, through advertisement. A consumer-welfare-increasing policy would be to directly inform consumers about their misconceptions. Also the effect on competition and entry as well as the effect of the competition on possible prices may differ between explanations. When patients do not evaluate all information due to information costs, firms or new entrants could increase their market shares by making information easily accessible. In cases of misconceptions, disadvantaged firms or new entrants would need to compete against existing false beliefs.

In this article I add to the literature as I am able to identify the importance of misconceptions on consumers' pharmaceutical choices. The market of exchangeable pharmaceuticals is defined by a medical product agency, and a prescriber is able to prevent substitution. Labeling as well as advertisement is regulated and manufacturers have limited possibilities to differentiate themselves.[42] Therefore this study differs from most of the evidence in retail markets where products could potentially have a higher degree of differentiation.[43] Nevertheless, specific pharmaceutical brands may carry a higher quality in physical[44] or psychological terms.[45] It is possible that products have quality differences when using the approach of Bronnenberg et al. (2015).[46] My approach uses the same method, however, instead of evaluating drug choices dependent on the occupation, I use health-care-relevant education, namely the education to be a physician, as the proxy for an informational advantage. I control for true quality differences by comparing choices of experts (patients with a medical education) to others.[47] Figure II provides some preliminary graphical evidence for the effect of education on substitution decisions of painkillers.[48] Dependent on the subject of

Handel, 2013; Handel and Kolstad, 2015; Ho et al., 2017; Ketcham et al., 2015), treatments (Baicker et al., 2015; Pauly and Blavin, 2008) and pharmaceuticals (Bronnenberg et al., 2015). Also in other markets consumers often make seemingly suboptimal decisions. An overview of examples and studies is listed in Handel and Schwartzstein (2018).

[41] See for example Ellison and Ellison (2009) for an example of obfuscation.

[42] Advertisement of prescription drugs is not allowed in Sweden. In *Online Appendix F* I show that advertisement expenditure of over-the-counter drug manufacturers is not correlated with overpayment of prescription drugs of the same manufacturer

[43] Just two examples of a large literature of brand preferences are Sullivan (1998) and Smith and Brynjolfsson (2001).

[44] A original branded pharmaceutical may have a higher quality.

[45] Patients may view an original product as having a greater treatment effect than generic alternatives. Some placebo effects may be due to the branded product. (Branthwaite and Cooper, 1981; Kamenica et al., 2013).

[46] The authors estimate that if consumers in a health-care-related occupation, such as physicians, consume different headache remedies than others, they would find significant differences between the choice of consumers with and without a health-care-related occupation. For example, pharmacists buy national brands of headache remedies 9% of the time whereas the average consumer purchases the more expensive version of a substance 26% of the time. Bronnenberg et al. (2015) argue that informational advantages such as the knowledge of ingredients of pharmaceutical products are important explanations. Bronnenberg et al. (2015) survey physicians who knew on average 90% of the active ingredients of headache remedies while the average respondent knew 59%.

[47] The approach is further acknowledged by the literature, for example Handel and Schwartzstein (2018) argues that 'the ... strategy (comparing acknowledged experts to non-experts) is probably the most robust approach ..., assuming that expert can be appropriately differentiated'.

[48] Further graphical evidence is provided in *Online Appendix C.11*.

education, I show the mean of patients that opposes substitution within the substitution groups of painkillers. Patients with a medical education have a lower possibility of substituting.

[Figure II about here.]

After controlling for the first explanation of brand premia it is still possible that consumers cannot evaluate all information or that consumers have misconceptions about the true quality. Bronnenberg et al. (2015) are not able to differentiate between these two explanations. It is possible that the consumers of the nonprescription headache remedies do not evaluate all available information, like reading the ingredients or comparing all prices in the retail shelf. On the other hand people may have perceived quality differences due to misconceptions. Comparing experts to non-experts allows for both explanations as experts may have lower information costs as well as fewer misconceptions about quality (Handel and Schwartzstein, 2018). Due to the regulation in the prescription drug market I am able to identify suboptimal choices due to misconceptions and exclude explanations of information costs and inattention. Patients get a prescription of a product from their physician and are financially incentivized to substitute at the pharmacy level.[49] In cases where patients have a prescription for a product that is not the cheapest product within predefined medical equivalent drugs they have to pay the price difference between the cheapest and the more expensive product out of pocket, and they are informed at the pharmacy that there is a cheaper available product with the same ingredients and that they may switch. The pharmacy explains that the two products are equivalent and may solely differ in their brand name. The patients therefore get all available information about ingredients and equivalence. Furthermore, it is not possible that a patient has to search for cheaper products (Sveriges Riksdag, 2002). Indeed, the patient has no information costs so I am able to exclude the reasoning that patients have too high information costs and are therefore inattentive. Patients who oppose substitution and pay a brand premium are doing so as they believe in the superiority of a product. The erroneous beliefs are not influenced by general information provision. Instead patients have solidified beliefs about the quality of products. Given that I compare experts, patients with a medical education, to non-experts and thereby exclude real quality differences, the reason for brand premia are misconceptions. Thereby, I add to the literature of behavioral economics by disentangling inattention and wrong beliefs.

Finally, simultaneous identification of switching costs and different sources of brand premia is of importance. It may be that the initial choice is due to quality misconceptions or other reasons of brand premia. Following repeated choices, may be due to misconceptions or other brand premia or due to switching costs. It is of importance to separately identify both frictions.[50]

[49] The pharmaceutical substitution groups are fixed and determined by a medical product agency (MPA). Substitution usually happens within a substitution group and not between groups. An empirical test for this claim is provided in *Online Appendix C.6*.

[50] The general approach of this paper follows existing approaches in the literature as for example Handel (2013). I disentangle brand preferences from switching costs but further try to estimate quality misconceptions.

I turn to show reduced form evidence.[51] The estimation strategy to identify switching costs and quality misconception is equivalent to the one in the demand estimation in section 6.1 where I use a choice model. The major advantage of the reduced form framework is that it allows to evaluate the importance without estimation of price elasticities. Consider the following model

$$P(OpposeSubst_{ijt} = 1) = \alpha + \beta_1 D_{ijt-1} + \beta_2 Med_{it} + \beta_3 D_{ijt-1} \times Med_{it} + \rho X_{it} + D_{ij0} + \gamma_{st} + \varepsilon_{ijt}, \quad (1)$$

where outcome variable is the dummy of 'opposes substitution' that takes the value 1 if individual i in period t opposes substitution of product j, which belongs to substitution group s. In substitution group s all products of the unique size $\times$ strength $\times$ size combinations are grouped. Opposing substitution corresponds to the case where the patient does not purchase a PoM *and* pays the price difference to get another product. D_{ijt-1} is a dummy which takes the value 1 if the last purchase of the product occurred within a month of the current purchase.[52] Med_{it} is the variable of interest, namely it examines the impact if a patient has a medical education as a physician. X_{it} are controls such as the logarithm of income, the geographical location, or the general education level.

I use fixed effects of substitution groups at each period in time (γ_{st}). Therefore I examine variation among individuals who purchase a product within a given month. Note that the fixed effects absorb important factors that may affect the switching behavior or misconception of customers, for example, the price differences between products.[53]

State dependence due to switching costs is measured by β_1 and quality misconceptions by β_2. It is important to separately identify switching costs and quality misconceptions. To identify switching costs it is important to consider unobserved individual heterogeneity which may be correlated with the lagged product choice dummy D_{ijt-1}.[54] I tackle the problem in two different ways. First, I recover true state dependence due to switching costs by condition opposing

[51] Descriptive evidence of switching costs and quality misconception are presented in *Online Appendix B and C*.

[52] In detail, it is required that the patient purchased the product within the last calendar month. The dummy takes the value 0 if the last occasion has been in the same month as the current purchase or if the last purchase has not been in the calendar month before. The reason for the specification is that for a specification of the same month the choice environment has not changed. In detail, fixed effects would capture the corresponding differences in the outcome variable. Within this specification I look on short induced state dependence with potential different choice environments as the prices and PoM may have changed. In *Online Appendix C.2* I show robustness for a more lenient definition of previous consumption.

[53] The price difference between the prescribed product and the product of the month is identical for all patients. However, the absolut co-payment may vary across patients. For example, one patient may have reached the co-payment ceiling and receives the PoM for free and would have to pay solely the price differences to the prescribed product when opposing substitution, while another patient pays a distinct amount for the PoM and the same amount plus the difference to the prescribed product in case of opposing substitution. In general it would be possible that this reference dependence to the general price level is (1) correlated with state dependence or medical education and (2) effects the probability of opposing substitution. In *Online Appendix C.3*, I show that higher co-payment levels are associated with a higher probability of opposed substitution, but the co-payment level does not influence estimates of switching costs or quality misconceptions. Further, I integrate patient specific fixed effects in *Online Appendix C.5*.

[54] Specific individuals for example have high brand preferences and choose repeatedly the same product independent from switching costs. See also further discussion in Dubé et al. (2010).

substitution decisions on the initial choices D_{ij0}, a dummy which takes the value one if patient i has consumed j in the first observed period. Intuitively, unobserved heterogeneity beyond state dependence would be captured by the initial choice of a product. However, the approach assumes that the initial choice within the data is random and not correlated with unobserved heterogeneity (initial condition problem).[55] Using sub-samples of patients without observed consumption in the first years of the six year long panel I show robustness in *Online Appendix C.4*. Secondly, I provide quasi experimental evidence for switching costs in *Appendix A* to show robustness.[56]

To estimate quality misconceptions I evaluate if patients with a medical education as a physician have a higher or lower likelihood to oppose substitution towards a cheaper equivalent. Assuming that the real quality of a product is independent on the education, I approximate the real quality differences of products by choices of medical experts. Having excluded that inattention due to lower information costs plays a role, as patients get an information treatment at the pharmacy level, perceived quality differences are measured by β_2. The perceived quality difference that are not due to information costs are quality misconceptions. Reasons for quality misconception that result in perceived quality difference may be due to risk aversion or trust.

Finally, simultaneous identification of state dependence and quality misconception depends on the time in-variance of quality misconceptions. In case that quality misconceptions (or the difference of medical education) increases over time independent of consumption, I would underestimate quality misconceptions and overestimate state dependence. However, I argue that the instiutional background of the Swedish pharmaceutical market as estimation of quality misconceptions is suitable to exclude time variance in quality misconceptions. First, potential factors that are time dependent but independent of previous usage would need to effect patients with a medical education differently. Second, the Swedish pharmaceutical market is highly regulated, forbids advertisement and therefore reduces the importance of goodwill. Finally, I include the interaction of D_{ijt-1} and Med_{it}. As state dependence is induced through past consumption and not affected by quality misconceptions, I expect that β_3 is not significant different from zero.

I proceed to show results of the reduced form evidence of model 1 in Table IV. For each subgroups (painkillers,

[55] As I do not observe the entire medical history this is unlikely the case for all patients. Following Wooldridge (2005) it is possible to use a reduced form approach of conditioning the unobserved household effects on the initial values and exogenous variables. Rabe-Hesketh and Skrondal (2013) recommend a slight adjustment of using the within means of time varying variables as well as including the initial periods. Rabe-Hesketh and Skrondal (2013) argue that the inclusion of the initial condition of time varying covariates as well as the within means may reduces the bias. In comparison to approaches in the literature as for example Erdem and Sun (2001), Skrondal and Rabe-Hesketh (2014) or Rickert (2016), I do not observe sufficient time variant covariates of products as they do not differ besides their brand. I argue that the homogeneity between products and clean choice environment reduces the problem of unobserved heterogeneity as well as of the endogeneity of the initial condition. In *Online Appendix C.4* I follow a approach similar to Wooldridge (2005) using only time-variant individual characteristics when estimating a structural demand model.

[56] A discontinuity surrounding patent expirations and monthly price changes establishes that the effect is causal. In the first robustness check, I compare repeated purchases of patients that initially have started with an original in the time before to those that started just after a patent expiry. The approach is related to the work of Feng (2017). In the latter robustness check, I use monthly price changes as a discontinuity by comparing repeated purchases of patients that initially started a treatment before a price change to those that started after a price change. You can find the results of discontinuities by price changes in *Online Appendix C.10*.

antibiotics, and antiepileptics) I show results of the full model including all fixed effects and covariates. In *Online Appendix C.1* I show results for without controlling for unobserved heterogeneity or control variables. I further explore the role of a more lenient definition of the lagged choice D_{ijt-1} in *Online Appendix C.2*.[57] Additionally, I show robustness using patient fixed effects in *Online Appendix C.5*.

A purchase of a product within the last month increases the probability of opposing substitution for painkillers significantly by 3.32 percentage points (17.75%). For the subgroup of antibiotics, previous consumption is associated with a significant increase of 1.16 percentage points (12.34%). For antiepileptics results are different. Now a previous purchase of the same product in the last month decreases the probability of opposing substitution and overpayment. I interpret the positive coefficient of painkillers and antibiotics as real state dependence due to switching costs. For antibiotics results differ, previous consumption is negative associated with overpayment, even though the size of the effect is small. One explanation for the lack of switching costs is that patients of antibiotics differ systematically. Patients who repeatedly consume a product of antiepileptics are on a longer treatment and likely to know about the equivalence and possibility to substitute.

Secondly, Table shows that a medical education is associated with a significant lower probability to oppose substitution and overpay (Painkillers: 4.88 percentage points/ 26.1%, Antibiotics: 2.45 percentage points 26.06%, Antiepileptics: 1.07 percentage points / 38.21%). I interpret the difference as perceived quality differences due to quality misconceptions. Note that the interaction between previous consumption and the medical education is insignificant for all subgroups. In other words, medical association is not associated with higher or lower switching costs. The non-effect supports that quality misconceptions and switching costs induced by previous consumption are uncorrelated. Consumers who oppose substitution pay on average approx 1.4 USD more than for the cheapest product.[58]

[Table IV about here.]

I provide a series of robustness check in the Appendices. In *Online Appendix D* I present a robustness check about the role of pharmacies. I show that there is no indication that pharmacies are responsible for patients opposing substitution. In *Online Appendix E* I investigate the role of prescribers. While the main model investigates the most frequent observation of patients and not physicians who oppose substitution (Painkillers: 20.9%, Antibiotics: 9.4%, Antiepileptics: 2.8%) also physicians may oppose substitution on the prescription (Painkillers: 2.4%, Antibiotics: 0.5%, Antiepileptics: 1.8%). I show that patients with a medical education are much less likely to pay for another

[57] In detail, I investigate the effect of defining dummy D_{ijt-1} such that it takes the value one if patient i has consumed it in the previous purchase occasion rather than in the last purchase occasion that took place in the last month.

[58] Note that the distribution of overpayment is right skewed with the majority of patient overpay only a small amount. I show details in *Online Appendix B.2*.

painkiller. Roughly half of the effect is due to a lower likelihood of opposing substitution as shown in Table IV, the other half of the effect is due to a higher possibility that the prescriber opposes substitution.*Appendix A* and *Online Appendix C.9 and C.10* present quasi-experimental evidence for switching costs.

6 A Structural Model of Demand and Supply

This section introduces a model that allows me to structurally estimate the demand as well as the supply side of a market of Swedish pharmaceuticals. The reasons for the usage of a model are manifold. First, an estimation of a demand function allows evaluation of how high switching costs and misconceptions about quality are in monetary forms. Second, given the demand estimates it is possible to relate the phenomena of switching costs to general price levels, that is, one may address the open research question if switching costs make markets more or less competitive. Finally, modeling the supply side allows us to evaluate how firms' pricing strategies and how consumers' costs would change under counterfactual scenarios. This section is divided in two parts. I first present the model setup of the demand side, then the supply side. The demand side uses standard approaches from demand estimation that incorporates state dependence from consumers. The approach builds on standard discrete choice setting in the fashion of Berry (1994). On the supply side I assume that firms compete in an infinite horizon. Similar to Bajari et al. (2007), I use a two-step estimator to recover cost parameters.[59] The cost parameters are of importance when evaluating counterfactuals.

6.1 Demand

The utility of individual i purchasing product j in substitution group s at time t is defined as

$$u_{ijst} = \gamma_{ijs} + \rho_{is} y_{ijs,t-1} + \alpha_{is} p_{jst} + h_{ijs} + \varepsilon_{ijst}.$$

Consumers are myopic and not forward looking.[60] Each product j is part of a set of products that form a substitution group. Each coefficient of utility varies at least over the substitution group. First, there is a random brand-specific intercept γ_{ijs}. $y_{ijs,t-1}$ is a dummy that takes the value 1 if a consumer i has purchased product j already during the last calendar month. ρ_{is} captures the impact of switching costs and varies across each patient within a substitution group.

[59] The applications of two-step estimators are growing. Some examples are Misra and Nair (2011), Goettler and Gordon (2011), Sweeting (2013), Ryan (2012) and Collard-Wexler (2013).

[60] Note that a prescription is connected to a fixed quantity. Patients do not have the possibility to stockpile. Additionally, I show in *Online Appendix G.6* that lower prices are not correlated higher purchases when filling a prescription. Patients do not increase their purchases during sale periods as expected with forward looking consumers (Hendel and Nevo, 2006) as quantity is fixed by prescriptions.

p_{jst} is the price of product j at time t.[61] The price coefficients α_{is} also varies across consumers within a substitution group. h_{ijs} denotes the unobservable heterogeneity of patients, and ε_{ijst} is an error term.

Estimation requires two adjustments to ensure identification of the price elasticity and switching cost estimates. Both variables are important structural parameters of the demand side. In detail, it is possible that prices p_{jst} are correlated with unobserved product characteristics, that is, $[p_{jst}\varepsilon_{ijst}] \neq 0$. The second bias is due to the correlation of the lagged product choice and the unobserved heterogeneity of individuals. Some patients may have characteristics that lead to a repeated choice of a specific product. The repeated choice would not be due to switching costs but due to personal characteristics.

I tackle the identification threats by two methods. First, I use a control function approach to deal with the endogeneity of prices. In the first stage of the control function I regress instruments Z_{jst}. Z_{jst} are prices of other products from the same brand for the same therapeutic segment (painkiller, antiepileptic or antibiotic). The instruments are comparable to the Hausman instruments (Hausman, 1996). If a brand produces several painkillers in different strengths, forms or sizes, the prices of the products in other substitution groups are used as instruments. The intuition of the assumption is that all products of a brand have correlated prices due to shared cost factors (supply chain, procurement of substances), however their demand is uncorrelated. The control function takes the following form: $p_{jst} = Z_{jst}\gamma + \kappa_{jst}$. The exclusion restriction requires that the idiosyncratic error term κ_{jst} is independent from Z_{jst}, $E[Z_{jst}\kappa_{jst}] = 0$. As an individual prescription is for a substitution group it is likely that there is no demand effect between substitution groups. Also effects of advertisement should not violate the exclusion restriction.[62] As usual for the control function, the residuals κ_{jst} enter the main estimation equation, and the error term of the main equation is adjusted accordingly:[63]

$$u_{ijst} = \gamma_{ijs} + \rho_{is} y_{ijs,t-1} + \alpha_{is} p_{jst} + h_{ijs} + \lambda \kappa_{jst} + \varepsilon_{ijst}.$$

Second, I try to control for unobserved heterogeneity among consumers. As in section 5, I control for the initial

[61] Note that due to the co-payment function the price varies across consumers. However, I use the absolut price of products (including co-payment and reimbursement costs) as a regressor. The price captures the decisions for all products as price differences are out of pocket expenses. In Appendix I show a robustness check where individual specific prices are used. A disadvantage of using patient specific prices is the higher variance and weakness of instruments. However, results are robust to individual-specific price specification.

[62] Advertisement may affect demands of brands in all substitution groups such that prices as well as unobserved demand characteristics are correlated. First, the strong regulation of the Swedish pharmaceutical market does not allow for advertisement of prescription drugs, i.e. the pharmaceutical products considered in this study. However, it could be possible that advertisement for over the counter drugs have spillover effects on demand for prescription drugs. In *Online Appendix F* I show that the correlation between advertisement expenditure and quality misconceptions is low. Further, I show in *Online Appendix G.7* that (lagged) advertisement expenditure of OTC drugs are not correlated with prices of prescription drugs. I argue that OTC advertisement does not violate the exclusion restriction.

[63] In detail, let the old error be $\varepsilon_{ijst} = \lambda \kappa_{jst} + \varepsilon_{ijst}$. As p_{jst} is a function of Z_{jst} and u_{jst} it is uncorrelated with the new error ε_{ijst}. Note that the control function approach is connected to strong functional assumptions. To show sensitivity I always report results without the control function.

product choice of individuals that I observe in my sample.[64] The final structural equation that incorporates the control function approach, as well as controls for unobserved heterogeneity, takes the following form:

$$u_{ijst} = \gamma_{ijs} + \rho_{is} y_{ijs,t-1} + \alpha_{is} p_{jst} + \mu_{is} y_{ijs,FIRST} + \lambda \kappa_{jst} + \varepsilon_{ijst}. \tag{2}$$

Where $y_{ijs,FIRST}$ is a dummy that takes the value 1 if the patient has taken product j in the first observable period in the sample when the consumer purchases a product of substitution group s.

6.2 Supply

Each period $t = 1, ..., \infty$ there are N_{ts} firms in substitution group s. Given that supply is separate for each substitution group I drop the subscript s. Each firm $j = 1, ..., N_t$ sets a price p_{jt} at t. p_{jt} has to be lower than a regulatory price ceiling R. Note that each product is from a different firm within the substitution group. I assume that firms do not condition their prices on other substitution groups. I model the supply side with independent substitution groups for two reasons. First it is reasonable that demand of substitution groups is independent as prescriptions are on a specific substitution group. In *Online Appendix C.6* I further challenge the assumption of independent demand in substitution groups.[65] Secondly, the assumption allows for a tractable model solely investigating a specific substitution group. Prices p_{jt} are linearly connected to the wholesale prices. As retailers (pharmacies) get a fixed markup for each dispensed product I do not model pharmacies as separate agents. Within the estimation I calculate for each wholesale price p_{jt} a retail price that is a structural parameter of the demand, that is, I take care of the difference between demand and supply price.[66] However, for simplicity I do not denote the difference between the manufacturer price and retail price.

The per-period profit of a firm at period t is defined as

$$\pi_{jt} = [p_{jt} - c_{jt}] m_{jt} Q_t.$$

Where c_{jt} represents the marginal costs of firm j in t, m is the market share of j at time t. Note that the market share is a function of several variables associated with the demand side. Finally, the exogenous quantity (measure of market

[64] Similar to the analysis in section 5, the identification of state dependence requires that a previous choice is not correlated with unobserved heterogeneity. In the main specification I solely control for the initial condition and assume that the initial condition is indeed unrelated to unobserved heterogeneity. In the *Online Appendix G.3* I extend the approach by following the approach of Rabe-Hesketh and Skrondal (2013) and Wooldridge (2005). Further, I show that the demand estimation is robust to the a sub-sample analysis of patients that have not purchased any product within the first years of the sample.

[65] In detail, I test if the share of a substitution group is associated with the relative price of the cheapest product compared to other substitution groups. As I do not find an effect, I conclude that substitution between substitution groups is seldom.

[66] The difference between the demand and supply side price is determined by the trade margins of the pharmacies, see *Online Appendix A*. For the substitution group of interests (under considering the price ceiling), the relation between purchasing (supply side) and retail price (demand side) is linear.

size) of the substitution group s is given by Q_t.

Before turning to the continuation profits of a firm, I make two assumptions. First, costs are defined as the sum of a constant and a random privately observed shock within each period. So besides the marginal costs c_{jt} that differ across time and brand, a random shock $\varepsilon_{jt} \sim N(0,1)$ enters the marginal costs. The assumptions about the marginal costs are rather weak. I allow for changes of marginal costs during time as well as differences between periods.

The second assumption considers beliefs of firms about future demand. The beliefs affect the continuation payoffs as firms form expectations about future payoffs. In each time period firm j makes a decision about setting its own price. Such a dynamic game has a continuum of Nash equilibria. Following previous literature (Maskin and Tirole, 1988; Ericson and Pakes, 1995) I reduce the equilibrium space to symmetric Markov perfect equilibria. One restricts subgame perfect equilibria to only the pay-off relevant strategies of a subgame. State variables are sufficient to determine a payoff. In detail, firms condition their strategy σ_j on the cost shock ε_{jt} and the state variables $\mathscr{S}_{jt}$, which include the lagged market shares (m_{jt-1}), the lagged number of firms ($|N|_{t-1}$), a dummy which indicates if firm j was the cheapest product in the previous period (PoM_{jt}) and the total market size of the segment (Q_t). Formally, the strategies are defined as the mapping of the state variables and the cost shock to the prices ($\sigma_j : (\mathscr{S}_{jt}, \varepsilon_{jt}) \rightarrow p_{jt}$). Given that firms discount future profits with $\delta \in (0,1)$ the value function of firm j is

$$V_{jt}(\mathscr{S}_{jt}, \varepsilon_{jt}) = (p_{jt} - c_{jt}) m_{jt} Q_t + \delta E[V_{jt+1}(\mathscr{S}_{jt+1}, \varepsilon_{jt+1} | \mathscr{S}_{jt})].$$

The first term is the per-period profits. The market share of a product is dependent on the state variables. The marginal costs c_{jt} are private information to the firm and equal to the cost shock ε_{jt} and the market size Q_t is fixed because patients with a prescription do not have an outside option. The second term describes the expectation from the valuation at period $t+1$. It incorporates the expectation of how the state vector evolves. I make distinct assumptions about firms' beliefs regarding the development of the market share to reduce the computational burden and state space. I assume that firms are not able to predict future patients and their random coefficients perfectly. However, firms have knowledge about important key factors of the dynamic demand. I assume that firms know (1) the share of consumers that stay in a market at t, (2) have knowledge about the average coefficients of the demand side described in the previous section and (3) know about the average product choice of consumers when those have started a treatment in their first period. Correspondingly, the expectation about future market shares is a discrete function, dependent on the transition probability of consumers between periods as well as the demand estimates:

$$E[m_{jt+1}, \mathscr{S}_{jt+1} | \mathscr{S}_{jt}] = \phi_t E[\tilde{m}^S_{jt+1}] + (1 - \phi_t) E[\tilde{m}^{NS}_{jt+1}] \tag{3}$$

ϕ_t of the consumers at $t+1$ have been already present in t. Those consumers who were present in the last period consume $\tilde{m}^S_{jt+1}$ times product j in period $t+1$. The market share is evaluated from firm j's point of view at time period t. Firm j does not know the customer base in the forthcoming period and approximates it by the average customer of the current period. The demand model presented in Model 2 with average coefficients among customers is used for calculating the market shares. For parameters of the patient-specific first consumption $y_{ij,FIRST}$, I use the average of consumers in t. For $\tilde{m}^S_{jt+1}$, $\bar{y}_{jt-1}$ is given by the market shares in t, m_{jt}. $(1-\phi_t)$ presents the patients who purchase a product in the forthcoming period but are new. Here I again use the average parameter values of all parameters and coefficients except for $\bar{y}_{jt-1}$ which is set to zero as the consumers are new.[67]

All in all, firms estimate future profits in t by assuming that the average patient is the same as in t. However, they incorporate the dynamic effects of state dependence and new entering patients. The assumptions decrease the computations described in the forthcoming section while incorporating the most important demand features.

A strategy forms a Markov perfect equilibrium if and only if for all $j \in N^s$ the strategy σ^*_j, $V_j(\sigma^*_j, \sigma^*_{-j}, \mathscr{S}_{jt}, \varepsilon_{jt}) \geq V_j(\sigma_j, \sigma^*_{-j}, \mathscr{S}_{jt}, \varepsilon_{jt})$, for all $\mathscr{S}_{jt}$ and ε_{jt}. A Markov perfect equilibrium is also subgame perfect. Note that uniqueness is not guaranteed. The estimator presented in the preceding section does not assume that there is a unique equilibrium. However, it builds on the assumption that firms play and stick to one equilibrium.

7 Estimation

The demand as well as the demand-side estimations are based on some distinct assumptions. In the following I present the assumptions as well as the econometric details of the estimation for the demand and supply sides respectively. The extensive individual choice data of individuals allows the estimation of the demand and supply sides separately.

7.1 Demand

At each point in time an individual attaches a utility to a product (Equation 2). The institutional background of the prescription process plays an essential role that determines the choice sets, the products a patient actively compares before making a decision. Initially, a patient receives a prescription for a specific product from his physician. At the pharmacy level the prescription is a form of allowance to get dispensed one product of the substitution group. If the prescription is the cheapest available pharmaceutical product and the patient does not request another product, the

[67] In detail, the average coefficients are the same in each periods. However, I keep track of the average first choices $\bar{y}_{jFIRST}$ and average number of patients remaining in the market ϕ_t, as well as the average value of consumers having consumed a product in the period before, $\bar{y}_{it-1}$. When estimating the market share of a product using the averages I keep track of key aspects determining the demand side. First, new customers do not necessary have each product in their choice set. I follow the assumption of the demand side such that the product of the month is always part of the choice set while products that are not get weighted by their fraction of choice set considerations in the actual data (i.e. the fraction of choices in past period). Secondly, for consumers that stay in the market $\bar{y}_{jt-1}$ and $\bar{y}_{jFIRST}$ are potentially correlated. Therefore, I keep track of the correlation in the data and weight choice probabilities accordingly.

pharmacist dispenses the prescribed PoM. If the product is not equal to the cheapest available product, the pharmacist presents the option of a substitution, which reduces the costs for the patient and is medically equivalent. In general, the patient has the possibility to request a specific product of a substitution group and pay additional costs, but in practice patients either decide for the PoM or the prescribed product. I assume that the choice sets of a patient consist of three components: The prescribed product, the PoM (which is always presented by the pharmacists) and previously consumed products (products a patient actively knows). The reduction of the choice set improves the approximation of reality as consumers do not compare all products at the pharmacy level. Note that from the actual purchases within the data 98.89% are covered by the chosen choice sets. A second assumption concerns behavior of patients. I assume that patients are myopic and do not form expectations of future prices such that switching costs estimates are dependent on beliefs about future prices. Note that in comparison to most retail markets patients get prescriptions for a specific size such that stockpiling is not possible.[68]

Given the choice set, a patient compares the products and decides among those with the higher utility. Utility is estimated by the demand-side equation 5. Given each individual i and time j the choice set may change. I assume that ε_{ijst} is independent and identically distributed extreme value type one such that choice probabilities follow a logit distribution. A patient chooses a product j over k at t if $U_{ijst} \geq U_{ikst}$. I follow standard discrete choice literature, and estimate coefficients of the structural equation 5. Technical details are provided in *Online Appendix G.1*.

7.2 Supply

On the supply side I use a two-step estimator. In an initial step I estimate the policy function that characterizes the pricing of firms. In a second step I use forward simulations and the assumption that the firms play a Markov perfect equilibrium to estimate marginal costs.

The approach is based on methods proposed by Hotz and Miller (1993) and Bajari et al. (2007). The main idea is to initially recover the conditional choice probabilities from observed prices within the data. The parameters of the policy function are the state variables. Conditional on the state variables (for firm j state variables $\mathscr{S}_{jt}$ are the lagged market shares m_{jt-1}, the lagged number of firms ($|N|_{t-1}$), the market size (Q_t) as well as a dummy that indicates if j was the PoM in the previous month (PoM_{jt-1})), firms set their prices in t. In practice, I estimate the pricing policy σ^* in a reduced form least square regression:

$$p_{jt} = \alpha + \beta m_{jt-1} + \eta |N_{t-1}| + \rho Q_t + \gamma PoM_{jt-1}. \tag{4}$$

[68] In *Online Appendix G.6* I present an additional empirical test in the fashion of Hendel and Nevo (2006) and show that lower prices are not correlated with a higher purchased quantity when filling a prescription.

Note that the number of competitors in the previous period are treated as factor variables in order to increase flexibility. η therefore corresponds to a vector of coefficients.

The second stage of the estimator uses the optimal policy function (Equation 4), which is assumed to be generated by the play of a Markov perfect equilibrium to estimate unobservables that rationalize the optimal policy. I estimate the marginal costs for each competitor within each period. I can recover the marginal costs due to several key assumptions. First, I assume that firms play a single Markov perfect equilibrium. Further, I assume that the profit function is correctly specified and known up to the marginal costs. I assume that firms discount future profit with $\delta = .995$.[69] Transition probabilities from the firms' points of view are estimated as described in Section 6. The market share of the forthcoming period is a function of the demand characteristics within a period t (3). The demand estimates are from the random utility model of the consumer sample at t. $\tilde{m}^S_{jt+1}$ is the choice probability given average random coefficients (i.e. $\bar{\alpha}$ for the price coefficient) from the sample at t and $\hat{m}_{jt}$ approximates the previous consumption, so yjt within the choice model. $\tilde{m}^{NS}_{jt+1}$ is approximated by the same method but y_{jt} is 0 as all patients are new. ϕ_t describes the share of customers that stay in a market at period t. The share is estimated from the data, the share of patients who are the same in $t+1$ than in t. Within the forward simulation at a given period t the share ϕ_t is constant. All in all, the transition probability estimates incorporate the dynamic factors of prices on market shares in the future but decrease the complexity of the demand system as firms take period-specific demand as an approximation of the future. Finally, I assume the distribution of the private shocks ε_{jt} are known and given by $N(0,1)$. The assumptions are in line with Bajari et al. (2007).

Assuming that the optimal pricing strategy σ^* is a Markov perfect equilibrium, it has to hold that the expected valuation given a state vector ($\mathscr{S}^t_j$) is higher than any other pricing strategy σ. The time superscripts are dropped as the equation binds in each period.

$$V_j(\sigma^*_j, \sigma_{-j}, \mathscr{S}_{\mathbf{j}}, c_j) \geq V_j(\sigma_j, \sigma_{-j}, \mathscr{S}_{\mathbf{j}}, c_j)$$

The valuation function at each period is dependent on the marginal costs. It is therefore possible to use the theoretical assumption of this inequality of a Markov perfect equilibrium when estimating marginal costs. Before making use of the objective function, I simulate the continuation function by forward simulation. I start with 500 initial parameters of the state vector $\mathscr{S}^{\mathbf{0}}_{\mathbf{j}}$. For each initial state vector I forward simulate the valuation function over 100 periods using the optimal pricing policy σ^*. I impose the assumption of transition probabilities described in Section 6. In detail, at each point in time I simulate the path for 100 forthcoming periods under the assumption that firms are forward looking

[69] The discount rate corresponds to the monthly periods.

but do not know the exact customer base. Nevertheless, firms do incorporate the effects of dynamic demand into their pricing. Furthermore, in each period a private ε_j shock is drawn. Correspondingly, the simulation of the valuation function given a marginal cost factor $\hat{c}_j$ is given by $\hat{V}_j(\mathscr{S}_j, \sigma_j, \hat{c}_j)$.

I use 200 alternative policy functions σ that are different to σ^*. Also here I simulate valuation functions by forward simulation. I denote one of the 500 initial draws of the state vector with $\mathscr{S}_{\mathbf{j}}^{\mathbf{R}}$ ($R = 500$) and the 200 non-optimal policy functions with σ^k (K=200). Given a marginal cost parameter c^{tj}, the difference between the optimal and non-optimal valuation function is described by

$$g(\mathscr{S}_{\mathbf{j}}^{\mathbf{R}}, \sigma_j^k, \hat{c}_j) = \hat{V}_j(\mathscr{S}_j^R, \sigma_j^k, \hat{c}_j) - \hat{V}_j(\mathscr{S}_j^r, \sigma_j^*, \hat{c}_j).$$

Given that the optimal strategy represents the equilibrium, I can construct the objective function in order to estimate the marginal costs. I search for the marginal costs that minimize the following function:

$$\min_{\hat{c}_j} Q(\hat{c}_j) = \frac{1}{K}\frac{1}{R}\sum_{k=1}^{K}\sum_{r=1}^{R} \mathscr{I}\{g(\mathscr{S}_{\mathbf{j}}^{\mathbf{R}}, \sigma_j^k, \hat{c}_j) > 0\} g(\mathscr{S}_{\mathbf{j}}^{\mathbf{R}}, \sigma_j^k, \hat{c}_j)^2.$$

$\mathscr{I}$ is an indicator function that takes the value 1 if $g(\cdot) > 0$. So I minimize the squared difference between the estimated valuation functions for those cases when the alternative policy function is greater than the valuation function for the optimal policy function that represents the equilibrium.[70]

Note that I estimate marginal costs for every single period and every company. The path is calculated given the demand within the period. The approach allows for different marginal costs within time as well as across companies. Further, the companies have knowledge about the general key factors of demand. Nevertheless, I do not require knowledge of the entire demand system, that is, individual patients and random coefficients of future patients.

8 Results

In the following I separately describe the results for the demand and supply sides. Furthermore, I have to separately execute the estimation for each substitution group. Having an immense amount of data on hand, I describe the detailed results for specific subgroups where random samples of consumers are considered. I start with the analysis of estimating the model for paracetamol tablets in a high dosage of 1 gram. The random sample of consumers that is

[70] Note that I take advantage of the linearity of the profit function in the unobservables, the marginal costs. This approach reduces the computational burden of the estimation as I do not have to simulate the paths for each marginal cost estimate separately.

used covers the entire time. The randomized sample covers one-sixth of the population.[71]

Before presenting the results of the demand and supply sides I briefly describe some key facts of the studied substitution group. Paracetamol is a very common drug, however, it is a prescription drug in that high dosage. In the entire time period there are at least two competitors in the market because the patent for the substance expired. I provide basic summary statistics of the specific substitution group in Table V. The average number of competitors is 3.72, and the average price is 72.13 SEK (approx. 7.2 USD). During the six and a half years studied, three products have entered and two exited the market. On average 69,000 products were sold to 52,000 customers with a prescription a month. There are three different kinds of products in the market: an original product, a branded generic and generics. The branded generics may differ from generics as consumers know about the specific brands even though the products are not originals.

Prices in the substitution group show some volatility as shown in Figure III. From visual examination it seems that competition has lowered prices during the years.[72] However, note that the substitution group shows specific price patterns that are described in Janssen (2018). In detail, the cheapest products one month drastically increase their prices often in the later period compared to the general price differences in the substitution group. Theoretically, the price patterns are rationalized within Markov perfect equilibria given the institutional environment and switching costs. Firms are forward looking and lock in customers with low prices. Afterwards they increase their prices and 'harvest' consumers that do not switch even though there are higher costs. Note that a price ceiling of 74.25 SEK has been in place.[73]

[Table V about here.]

[Figure III about here.]

8.1 Demand

I described demand in Section 6.1 and its estimation in 7.2. I start with presenting the control function, the results of a least square regression of prices of i in t on the instruments (the average of other prices of products from the same manufacturer in other substitution groups in a specific month). For the substitution group of high dose paracetamol I

[71] In *Online Appendix G.3* provide a robustness check for the demand side using the whole sample of consumers of high dosage paracetamol. I consider a less flexible model and show that estimates of switching costs, quality misconceptions, and price coefficients confirm the results of the flexible model using a random sample.

[72] Note that there are only two competitors before 2012. Both firms do undercut the price ceiling.

[73] For two month the price ceiling has been increased to 78 SEK. I do not model the increase for two months separately.

present the first stage regression in Table VI. Results show that the first stage is strong.[74]

[Table VI about here.]

Table VII shows the results for the random coefficient model for the random sample.[75] Models 1 and 2 evaluate the demand of the entire sample whereas Model 1-Med and Model 2-Med solely consider those patients who have a medical education. First, the upper part of Table VII presents the brand-specific intercepts (for Mod.2 and Med2-Med the mean of the random brand intercepts). The middle part of Table VII shows the mean as well as standard deviation of the random coefficients for prices and the previous consumption (corresponding to α_i and ρ_i in the estimation Equation 2 respectively). In the lower part, I describe the specification of the different models. Model 1 and Model 1-Med solely use the random coefficients of previous choice and prices[76], as well as non-random brand intercepts. Model 2 and Model 2-Med further control for unobserved heterogeneity by controlling for the first observation within the sample.[77] I add the control function approach to control for potential price endogeneity in Model 2 and Model 2-Med.[78] Given that I cannot interpret the coefficient for state dependence directly, I report the mean of the willingness-to-pay for the state dependent coefficient. Formally, it is the willingness-to-pay for a consumer i that is defined as the state dependence coefficient (ρ_i) divided by the price coefficient (α_i). Table VII reports the corresponding mean across patients. Finally, I also report the willingness-to pay for a branded generic compared to an average generic. In detail, I calculate the willingness to pay from the brand intercepts of comparing *Branded Generic I* to the average values of the intercepts of *Generic I* to *Generic IV*.

The main results of Table VII are the following: First, the mean of the price coefficient for each specification is negative and significant. Note that the sample of individuals with a medical education is more price sensitive than the general sample. Second, those consumers who purchased a specific drug in the preceding period are significantly more likely to purchase a product in the current period. Also this effect is significant in all specifications, for the full sample as well as the sample with a medical education. Note that the willingness-to-pay estimates are reasonable

[74] Given the single regressor it has a t-statistic of 626.81.

[75] In *Online Appendix G.3* I use the full sample and show robustness in a less flexible model.

[76] Note that I use the total costs and do not differentiate between patients and their co-payment. While price differences between prescribed product and a product of the month is identical for all patients, the absolut payment may differ. In the reduced form analysis I show that the level of co-payments is not a threat for identification (see *Online Appendix C.3*). Further, *Online Appendix G.5* shows that the demand estimation of the structural equation 2 is robust to an alternative measure of prices that incorporates the level of co-payment.

[77] By controlling for the initial choice I try to measure true state dependence by the lagged choice. However, I assume that the initial condition is unrelated to the unobserved heterogeneity. As I do not observe the entire medical history but only the first observation in the sample the estimate may be biased (initial condition problem). I provide two robustness checks: I show reduced form evidence in section 5, in detail, I show that results are robust when considering those patients without any consumption within the first years of the sample. Secondly, I estimate demand in a less flexible model and use the approach recommended in Wooldridge (2005) in *Online Appendix G.3*.

[78] Note that a small brand does not have other products within the group of painkillers during the entire panel period such that I do run out of instrument for part of the sample. Accordingly, the sample gets smaller. I estimate another demand specification in which I substitute missing instruments with own prices in *Online Appendix G.4*.The results are similar to the ones of the main specification.

in size. Consumers are willing to pay between approximately 0.875 USD (12% compared to an average price of 7.2 USD), for a product when they have consumed it before. For the difference between the entire sample and the sample with a medical education, it is important to investigate the differences in terms of the brand intercepts as those translate to quality misconceptions. The default value is the only original product in the market. The intercepts show that branded generics have a generally higher demand within all model specifications. However, the difference to the original is higher for the entire sample than for the sample with medical education. Nevertheless, the difference between patients with and without a medical education are not very high within this substitution group. Finally, also notice that generics are less likely to be bought, everything else being equal.[79] The results are in line with the general result that brand premia, as a result of misconceptions, are observable. Patients with a medical education are less prone to those misconceptions even if not high in this substitution group.

[Table VII about here.]

8.2 Supply

The results for the supply side are ordered in several stages. First, I show and discuss results of the policy estimation. Second, I show some details about the transition estimation, which reduces the complexity of the supply side. Third, I present the final estimates of the marginal costs.

First, Table VIII presents the reduced form estimate of the policy function as described by Equation 4. Therefore, the outcome variable of a least square regression is the price of a firm j in period t (p_{jt}). I explore three different models. Model 1 solely includes the previous market shares (m_{jt-1}) and a constant. Model 2 further includes the PoM dummy of the previous month (PoM_{t-1}), and Model 3 also considers the dummies for the number of competitors in the previous period ($|N_{-1}|$) as well as the market size (Q_t). The policy function is an estimate of the equilibrium strategy of firms. Each firm plays a symmetric Markov perfect equilibrium. Therefore, the results in Table VIII do not carry any causal interpretation. However, the three models show that the previous market share, as well as the previous PoM, is correlated with a higher price in the next period. The results are stable and significant. Furthermore, more competitors are correlated with lower prices while the market size (higher demand) is correlated with higher prices.

[Table VIII about here.]

[79] To provide additional interpretation I show cross-price as well as elasticity of demand implied by the demand estimation in *Online Appendix G.2*. The elasticities confirm two observations: (1) Medical Experts are more price sensitive which translates to higher own-price elasticities for all products. (2) Experts have especially higher cross price elasticities with respect to a price change of originals and branded generics.

Second, the expectation of a firm's future market share is described in Equation 3. In detail, the market share in $t+1$ is dependent on (1) the strategy of firms, (2) the demand estimate and base of consumers in t and (3) the share of patients who stay in the market between t and $t+1$ (ϕ_t). The latter is inferred from the descriptive statistics in the data. On average across the time periods, 0.192 (standard deviation of 0.025) of the patients stay in the market.[80]

Given the two initial steps, Table IX shows the estimates from the marginal costs for each firm across time on average. The marginal costs estimates are heterogeneous across firms and vary over time.[81]. In Table IX I show the average marginal costs for each firm over the periods a firm has been present. I also present the standard for the estimates across time. There is only low variation of marginal costs over time. The two branded generics in the market seem to have slightly lower marginal costs. The estimate would suit the assumption that branded generics have a high market share in a lot of markets, which decreases marginal costs due to distribution. The estimates of the marginal costs for the branded generics are lower than for the smaller generic brands due to economies of scale. Besides the variability one may access the suitability of the marginal costs estimates by comparing variability of prices, marginal costs and markups. Biased estimates of marginal costs may be characterized by capturing all the variability or price changes such that mark-ups do not change over time. Dynamic pricing would be therefore explained by marginal costs. In *Online Appendix H.3* I show the markups as well as the correlation between prices and marginal costs. I show that there is not a strong correlation between prices and marginal costs, the variation in prices is not explained by the estimates of marginal costs.

[Table IX about here.]

9 Counterfactuals

I turn to present the counterfactual analysis. I start with presenting the implementation procedure and continue to show that an extension of the contract length which mimics a reduction of switching costs increases prices in equilibrium. In the second counterfactual all patients act as if they were physicians and prices decrease. In *Online Appendix I.3* I show the results for a direct reduction of switching costs on the patients side. The results are in line with the increased contract length, lower switching costs increase prices. Further, I investigate a counterfactual scenario in which the price ceiling is abolished. *Online Appendix I.4* shows that the price ceilings are successful regulative instrument. Without the price ceiling prices for the average consumer would increase.

[80] In *Online Appendix H.1* Figure I show ϕ_t for each time period. Note that ϕ_t is always between 0.1 and 0.25. No clear time trend is visible.

[81] Details of the estimates are presented in *Online Appendix H.2*. I present the point estimates as well as standard errors for the marginal costs of each brand within each period. I obtain the standard error by bootstrapping over different market histories. Marginal costs estimates are in each period for each firm statistically different from zero. Even though sporadic decreases of marginal costs estimates in some periods are observable, the estimates vary within reasonable bounds. The standard deviation estimates in Table IX confirm the behavior.

9.1 Implementation

Technically the implementation of counterfactuals requires me to estimate the policy that represents a Markov perfect equilibrium. Being consistent with the Markov perfect strategies in the previous section, firms condition their strategy on all state variables. As the environment or demand parameter change within the counterfactual, I cannot use the policy function presented in Section 8. Instead, I need to compute Markov perfect equilibria by value (or policy) iterations and solve for a pricing equilibrium during each iteration. As the computational burden increases exponentially with the number of state variables, I simplify the environment.

I reduce the state space $\mathbf{S}_t$ to only one variable, the PoM status. So firms condition their prices on the knowledge of which product was the cheapest in the preceding month. The reduction of the state space is rather strong. First, the reduction is motivated by the need of a simplified environment. Second, I show in *Online Appendix I.1* a model selection method (LASSO) based on the policy function.[82] I show technical details of the implementation and algorithm in *Online Appendix I.2*. In general the algorithm works as the following: I perform a value iteration that incorporates the equilibrium conditions due to the assumptions that firms play a Markov perfect equilibrium. The following steps are done in each period: As in Section 8, I take advantage of the demand parameters. I take the average consumer and assume that firms know how much patients stay in the market.[83] Firms assume that the average consumer is constant. I further use the marginal cost estimates from the previous sections. The marginal costs estimates are different across firms. For each possible state (each firm could have been the PoM in the previous month) I start with an initial guess of the value function for each firm (V^0). In each iteration k for each state I search for an equilibrium in prices. Note that the search for the mutual best reply (equilibrium) incorporates the static prices, the transition to the state of the next period ($\pi(\mathbf{S}^{t+1}|\mathbf{S}^t, p_j, p_{-j})$) and the value function that is dependent on the state ($V^k(\mathbf{S}^t)$). Given continuation values I update best replies for each player in each state,. I update the Bellmann equation and get a new estimate for the value function V^k. During each iteration I update the value function until convergence.

Note that the simplification and estimation comes with two major concerns. The first concern is a computational one. The grid of used prices may lead to different equilibria and therefore prices. Further, equilibria may not be unique and the employed algorithms may lead to another equilibrium than the ones chosen by firms. The second concern is simplification of the state space. To tackle both concerns, I explore the results of the simplified model and compare it with the observable prices before turning to the counterfactuals. Within the benchmark model I do not change the

[82] Performing a model selection, I show that the product of the month status of the previous periodas well as the quantity are the most predictive regressors. I assume that firms do not know about future quantity development such that the PoM status plays the most important role for intertemporal relationships between pricing decisions. I therefore choose the previous product of the month as the new state space. Note, that the benchmark model shows that the reduction in state space provides a good match to the actual data. The presented method of a regularization using machine learning methods in *Online Appendix I.1* is related to the solution concept by Thiel (2019).

[83] In comparison to section 8 I do not adjust the choice sets and initial purchases (and correlation to previous choices) when estimating demand. The adjustment reduces the computational burden.

environment and use the demand estimates as well as the marginal cost estimates.

Table X shows some basic statistical measures of the prices and market shares in the data as well as the benchmark model. Simulated prices of the benchmark model are slightly lower than the one in the data.[84] The divergence is due to fiercer competition between two competitors in the benchmark model. In the lower part of Table X I show comparison for market shares in data and in the simulated benchmark model. Except for the second branded generic which solely is available in a few periods of time the relation between the different brands in the benchmark model fits the data reasonably well. Overall, the benchmark model's key characteristics are close to the actual data. Finally, *Online Appendix I.2* describes several approaches to reduce concerns of multiple equilibria.

[Table X about here.]

9.2 Procurement: An Extension of the Contract Length

In the first counterfactual I do not change the demand side but change the institutional background. In detail, firms in the first counterfactual are only allowed to change their prices once each year. Note that the switching costs of consumers are still relevant as some consumers may start a treatment within one year and continue into the next. However, behavioral pricing that intends to lock in consumers and harvest them in the forthcoming period is more expensive for firms. Firms would need to have decreased prices over a longer term and therefore forgo profits. Overall this counterfactual is motivated by two aspects. First, it incorporates a realistic policy change, as it solely changes the timing of the current pricing policy. Second, the counterfactual directly reduces switching costs as (1) the number of consumers that consumes over several years gets smaller and (2) consumers tend to oppose substitution less often when the time since the last purchase of a more expensive product increases. In *Online Appendix I.3* I estimate a counterfactual where I directly reduce switching costs on the consumer side. I show that the results are analogous.

Technically, I use the same demand model as presented before. The frequency of price changes reduces from 72 to 6. Within each new period consumers are treated equally. The state variable still shows if a firm has been the PoM (the cheapest product) in the preceding period. The effect on the next period's demand is however reduced. The market share is equivalent to the one in the benchmark model. On the supply side, I assume that firms who have been present within at least one month during the year are present the entire year. This assumption increases competition over the studied time periods. However, the possible policy change would come with increased competition, because firms would only be able to enter and exit once a year and it is reasonable that firms stay longer in a market. As the length of the periods changes, I adjust the share of patients that stay in a market over two subsequent months (ϕ) as

[84] Note that the mean price of the data between Table X and Table V diverge as I compute the average over all months in Table V, while Table X is used for comparison of benchmark and data such that I use the mean across all months *and* firms.

well as the discount rate ($\delta^{NEW} = .95$). Finally, the estimation of the prices in equilibrium are equivalent to the one in the benchmark model as I solely change the sample of a single period and reduce the number of periods.[85]

Table XI compares market outcomes of the different counterfactuals and the benchmark model. The average price is higher in the scenario with a 'product of a year' rather than a 'product of a month' (70.49 instead of 69.56 SEK). This result is not necessarily surprising and in line with research of Arie and Grieco (2014), Cabral (2016), Dubé et al. (2009), Fabra and García (2015), Rhodes (2014). The authors show theoretically as well as empirically that moderate switching costs may increase the competitive pressure. The counterfactual with longer procurement periods leads to a lower possibility for firms to take advantage of switching costs. I therefore simulate a policy comparable to a case of lower switching costs which is possible to implement. In *Online Appendix I.3* I show that the results is analogous in a case of a direct reduction of switching costs. Even though switching costs increase the market power of a firm with locked-in patients and therefore induce a lock-in and harvest behavior, prices on average are lower. Due to the incentive of firms to decrease prices in order to lock in patients and due to moderate switching costs (see demand-side estimates) that prevent too-high prices in the harvest phases, prices may be lower when switching costs are present. This argumentation is strengthened by the standard deviation of market shares across all products and companies is double the size in the benchmark model compared to the counterfactual. Also this result is in line with the argumentation of dynamic pricing with higher variability of market shares in the benchmark model.

In the lower part of Table XI I show results that incorporate the behavior of consumers and corresponding market shares of products. First, I show the price of purchases of an average consumer over the entire time period. The results of the price for the average consumer are comparable to the general price statistics. In detail, the average purchase price for a consumer is 2.08% higher in the scenario of a different procurement (70.69 SEK) compared to the benchmark model (69.25 SEK). Further, the market cap for firms increases (by 4.11%) in the counterfactual scenario.

Overall, the counterfactual leads to the conclusion that the lower possibility of reacting to switching costs by reducing the frequency of price changes is on average and overall not welfare-enhancing for the consumer. The results are in line with the firms' behavioral pricing of lock-in and harvest in the benchmark model with moderate switching costs. Preventing the behavior leads to higher prices on average as firms do not reduce prices with the intent to lock consumers in. Note that the results are not uniform for all consumers. Indeed, consumers with high switching costs and frequent purchases profit from the new procurement as there is no 'harvesting' of firms who charge high prices while the new consumer or those with no switching costs suffer from higher prices because there is no 'lock in' by low prices.

[85] Note that I do not model entry and exits. I do assume existence of a product within a year if the product is available in at least two month of the respective year. Therefore I implicitly increase competition which could in principle reduce prices in equilibrium.

9.3 Misconceptions

In the second counterfactual, I show the impact of quality misconceptions on pricing (behavioral pricing) and consumers' welfare. In practice, I use the demand estimates from the reduced sample of patients with a medical degree and estimate the supply side, holding original quantity and cost factors fixed. Note that I use the state dependence coefficients from the reduced sample of experts but do not change the sample estimate of the share of patients that stay in a market over two subsequent months (ϕ).

Table XI shows descriptive statistics of the pricing equilibrium in the counterfactual with a decrease in misconceptions. On average, prices in the counterfactual, with a decrease in quality misconceptions, are lower than in the benchmark model (67.66 SEK compared to 69.56 SEK). Especially the prices of the original and branded generics decrease. Therefore the results go in the opposite direction than the counterfactual of a different procurement behavior. The reasons are that experts have lower brand preferences and have a higher price elasticity. The new demand leads to stronger competition between existing firms and therefore lower prices. However, the effects are not strong as difference of demand estimates are not particular strong in this specific substitution group.

The lower part of Table XI shows effects for the average consumer. Due to the decrease of quality misconceptions the consumer pays on average 67.15 SEK for a product. Two effects play a role. First, prices are lower as firms have less incentive to engage in behavioral pricing and take advantage of brand preferences due to quality misconceptions. Second, consumers themselves are less willing to pay brand premia as quality misconceptions have decreased. They tend to consume cheaper products. Overall, the average consumer spends 3.03% less for a product in the counterfactual scenario. When considering the entire revenue of the market within the six years, consumers overall spend 3.86% less.

[Table XI about here.]

10 Conclusion

In this article I have provided causal evidence for switching costs and quality misconceptions in the markets of painkillers and antibiotics, whereas the phenomena do not exist in the markets for antiepileptics. I estimate switching costs through several identification strategies (panel data methods, quasi-experiment of patent expiry and time discontinuities) and show that due to switching costs patients are up to 15% more likely to overpay for prescription drugs of painkillers and antibiotics. Due to a unique institutional background where patients are always informed about equivalence of drugs and price differences, and by differentiating between (medical) experts and non-experts, this paper is to my knowledge the first that identifies brand premia due to quality misconceptions. I compare drug choices between patients who have a medical education to those who do not. Incorporating the knowledge that inattention is

not the source for brand premia because (1) drugs are not displayed and patients get dispensed the drug by a pharmacy and (2) patients get explained that the drugs are equivalent, I show that quality misconceptions lead to significant over-payment by non-experts.

The results of the reduced form as well as the structural analysis are of high relevance for policymakers. Switching costs and quality misconceptions are not only important behavioral phenomena but they also shape the pricing behavior of firms. Concentrating on a specific subgroup I estimate that both switching costs and quality misconceptions are important for pricing of pharmaceuticals. While quality misconceptions result in a reduction of competitive pressure and therefore increased prices the effect of switching costs of prices may be ambiguous. While switching costs may be non-competitive I have shown with a realistic policy experiment that switching costs may decrease prices. The main intuition is that sufficient incoming patients lead to invest and harvest behavior of firms. While some patients with switching costs may overpay for their pharmaceuticals while patients without switching costs can actually profit from lower prices as firms try to lock in those patients that experience switching costs. On average patients may profit from switching costs. A realistic change in the procurement of pharmaceuticals from a public perspective does not increase overall consumers' welfare, as less dynamic pricing and 'invest and harvest' behavior increases the price for the average consumer. Before intervening in a market with switching costs a policymaker should understand the details of the market structure to evaluate if switching costs are pro- or anti-competitive.

This article also sheds light on the relevance of consumers' quality misconceptions when it comes to prescription drugs. The specific setting of the Swedish health care system show that information provision on the pharmacy level is not necessarily sufficient for substitution to cheap generics. Possibly, prescription to the cheapest generic on the physician level would help to decrease quality misconceptions.

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Figure I: Timeline of Auction

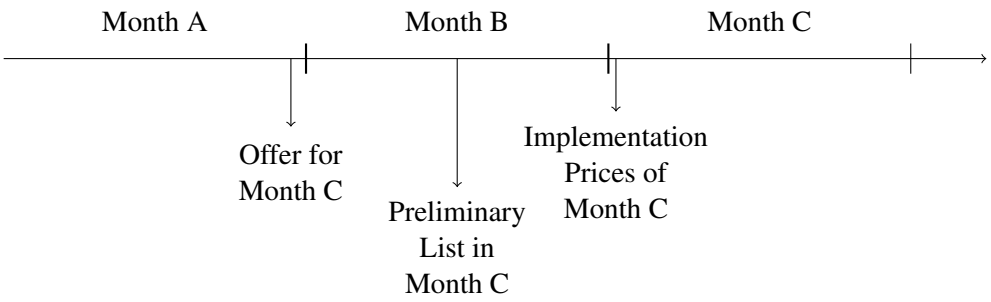
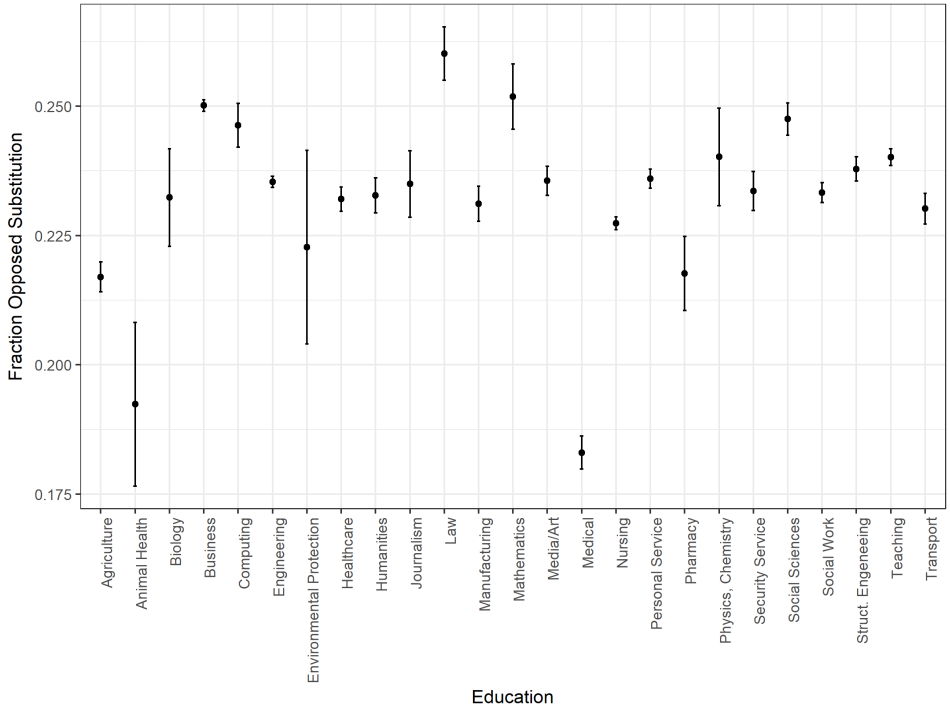
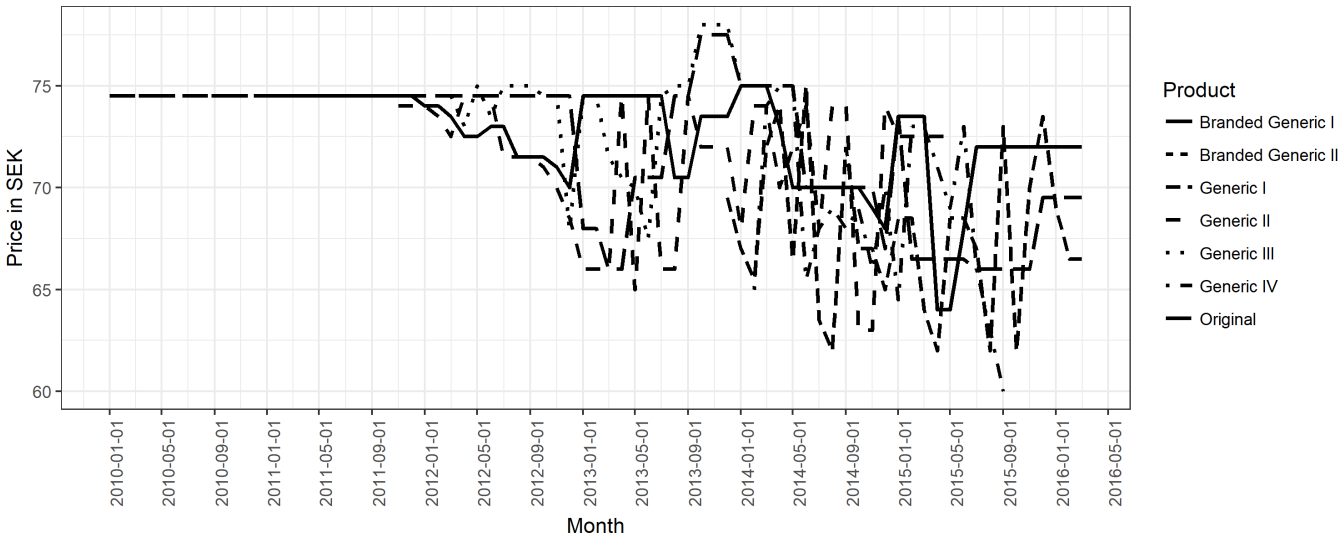


Figure II: Subject of Education and Substitution Decision



Notes: Fraction of patients that oppose substitution when consuming painkillers dependent on the subject of education. The education is divided in 25 different subjects, ordered alphabetically. The error bars correspond to a 95% confidence interval.

Figure III: Monthly Prices in Substitution Group



Notes: Monthly prices of the substitution group of Paracetamol, 1g, 30 tablets between 2010 and 2016.

Table I: Co-Payment Structure

Price	Reimbursment	Max. Sum out of Pocket Payment
$p \geq 4300$	100%	
$3500 \leq p < 4300$	90%	1800 SEK
$1700 \leq p < 3500$	75%	1700 SEK
$900 \leq p < 1700$	50%	1300 SEK
$p < 900$	0	900 SEK

Price	Reimbursement	Max. Sum out of Pocket Payment
$p \geq 5400$	100%	
$3900 \leq p < 5400$	90%	2200 SEK
$2100 \leq p < 3900$	75%	2050 SEK
$1100 \leq p < 2100$	50%	1600 SEK
$p < 1100$	0	1100 SEK

Notes: Co-payment structure for cumulative health care expenditure (including prescription drugs) before (upper table) and after (lower table) 2012. Reimbursement is calculated for expenses during an entire year, beginning with the first expenditure. Prices are in SEK. 10 SEK are approximately 1 USD.

Table II: Summary Statistics

	Painkillers	Antibiotics	Antiepileptics
Number of Substances	10	24	4
Number of Substitution Groups	158	147	36
Number of Products	566	438	72
Average Number of Prod. in Substitution Grp.	1.95	1.61	1.38
	(1.13)	(0.83)	(0.39)
Percent Original	0.3	0.19	0
	(0.35)	(0.32)	
Percent Generics	0.7	0.75	0.76
	(0.35)	(0.35)	(0.33)
Average Price (in SEK)	333.2	255.7	393.3
	(390.2)	(344.4)	(275.7)
Average Price Original (in SEK)	395.6	334.6	
	(487.4)	(355.4)	
Average Price Generics (in SEK)	299.7	221.7	352.1
	(355.5)	(344.7)	(265)

Notes: Summary statistics for the three market segments of painkillers, antibiotics and antiepileptics. Prices are in SEK (10 SEK is approx. 1 USD). Standard deviations are displayed in parentheses.

Table III: Summary Statistics of Purchases

	Painkillers	Antibiotics	Antiepileptics
No. Purchase Occ. (in m)	38.54	13.79	0.57
No. of Patients (in k)	3,196	4,731	60
Avg. Purchase Occ. per Patient	12.1	2.9	9.4
	(26.3)	(3.5)	(14.1)
Avg. Monthly Total Costs (in m SEK)	46.73	23.46	2.87
Avg. Monthly Co-Payment (in m SEK)	17.88	14.66	0.73
Fraction Consumption PoM	0.734	0.866	0.929
	(0.44)	(0.34)	(0.26)
Fraction Opp. Sub. by Patient	0.209	0.094	0.028
	(0.41)	(0.29)	(0.16)
Fraction Opp. Sub. by Physician	0.024	0.005	0.018
	(0.15)	(0.07)	(0.13)
Fraction Opp. Sub. by Pharmacy	0.034	0.03	0.026
	(0.18)	(0.18)	(0.16)

Notes: Summary statistics for the three market segments of painkillers, antibiotics and antiepileptics. The number of purchase occasions is the sum of purchase occasions across consumers in between January 2010 and June 2016. The average purchase occasions shows the number of purchases of the average patient. The total costs include costs the for the insurance as well as the patient (co-payment). The total costs as well as co-payment measures are in SEK per month on average. The lower part describes substitution decisions by patients. The fraction of consumption of the PoM describes the fraction of purchase occasions where a patient has consumed the PoM. If a patient does not consume the PoM it is due to one of the three displayed reasons (opposed substitution by the patient, opposed substitution by the physician or opposed substitution by the pharmacy). Standard deviations are displayed in parentheses.

Table IV: Regression Evidence, Probability of Opposed Substitution

	Painkillers 'Opp.'	Antibiotics 'Opp.'	Antiepileptics 'Opp.'
D_{t-1}	0.0332***	0.0116***	-0.00401***
	(0.000262)	(0.000570)	(0.000516)
Med	-0.0488***	-0.0245***	-0.0107**
	(0.00173)	(0.000676)	(0.00391)
$D_{t-1} \times Med$	-0.00304	0.00101	0.00650
	(0.00390)	(0.00354)	(0.00659)
$log(Inc)$	-0.0000237	0.000680***	0.0000675
	(0.0000909)	(0.0000369)	(0.000128)
$Constant$	0.108***	0.0799***	-0.00888***
	(0.00121)	(0.000610)	(0.00244)
Education	Yes	Yes	Yes
Control Heterogeneity	Yes	Yes	Yes
Geogr. Fixed Effects	Yes	Yes	Yes
Observations	32923856	12326138	500363
R^2	0.264	0.121	0.063
Fixed Effects	'SubGroup*Time'	'SubGroup*Time'	'SubGroup*Time'
Mean Opp. Subst.	0.187 (0.39)	0.094 (0.291)	0.028 (0.164)
Mean Price USD	9.46 (15.2)	13.3 (12.5)	39.3 (39.1)
Mean Overpayment USD	1.12 (2.66)	1.4 (2.44)	1.44 (2.99)
D_{t-1} Incr.	17.75%	12.34%	-14.32%
Med Incr.	-26.1%	-26.06%	-38.21%

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Linear least square regression results for the segment of painkillers, antibiotics and antiepileptics. One observation corresponds to one specific purchase occasion by a patient. The outcome variable is a dummy variable that takes the value a if a patient opposes substitution in order to receive a more expensive product. The patient bears the additional costs. D_{t-1} is a dummy that takes the value one if a patient has consumed the product in the previous purchase occasion in the last month. Med is a dummy that takes the value one if an individual has a medical education as a physician. Log(Income) is the logarithm of income. Education indicates if the model controls for the level of education according to the grades in a six-step grid. Geographical indicates if the model controls for county-level fixed effects. Fixed Effects indicates if the model controls for substitution group × month fixed effects. In the lower part of the table I show the average fraction of opposed substitution as well as the price and average payment of those that oppose substitution (in USD, 1 USD are 10 SEK). Finally, I also state the percentage increase of opposed substitutions that are associated to past consumption (switching costs) and a medical education (quality misconceptions). Standard errors are clustered on the individual level and adjusted for heterogeneity. Standard errors are reported in parentheses.

Table V: Summary Statistics, Paracetamol 1 g.

	Paracetamol, 1 gr.
Avg. Number Competitors	3.72
	(0.99)
Avg. Price (in USD)	7.213
	(0.259)
Entries	3
Exists	2
Avg Purchase Occasions per Month	509,843
	(38,945)
Unique Customers per Month	315,864
	(15,847)

Notes: Summary Statistics for substitution group of Paracetamol, 1 g., 30 tablets. One USD corresponds to approximately 10 SEK. The average values show the average over months. Standard deviation in parentheses.

Table VI: First Stage of Control Function

	(1) Price
Price of Other Painkillers	0.2361***
	(0.00037)
Constant	53.877***
	(0.0735)
N	623,017

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Results of the first stage estimation. One observation is the price of a product in the substitution group paracetamol, 1 g., 30 tablets. The regressor is the average price of other products of the same manufacturer in the Swedish market for painkillers. Standard errors in parentheses.

Table VII: Regression Evidence, Demand Model

	Mod.l	Mod.1-Med	Mod.2	Mod.2-Med
Branded Generic I	.609***	.280**	.815***	.606***
	(.007)	(.086)	(.015)	(.165)
Branded Generic II	.245***	.122	-.671***	-.834**
	(.009)	(.110)	(.024)	(.261)
Generic I	-.792**	-.632***	.024	-.155
	(.015)	(.164)	(.021)	(.265)
Generic II	-1.164***	-.631***	-.487***	-.604**
	(.013)	(.139)	(.016)	(.182)
Generic III	-1.894***	-1.731***	-.796***	-.609
	(.020)	(.213)	(.045)	(.711)
Generic IV	-1.180***	-.856**	-.599***	-.508
	(.024)	(.271)	(.031)	(.358)
Random Brand Intercepts	No	No	Yes	Yes
Price Mean	-.097***	-.167***	-.109***	-.135***
	(.003)	(.028)	(.002)	(.024)
σ	.396***	.285***	.169***	.216***
	(.004)	(.041)	(.003)	(.032)
State Dependence Mean	2.02***	1.70***	.955***	1.093*
	(.022)	(.353)	(.020)	(.467)
σ	.756***	.038	.103***	.269
	(.034)	(.764)	(.032)	(.682)
Control Function	no	no	yes	yes
Unobserved Heterogeneity	no	no	yes	yes
WTP State Dependence (USD)	2.08	1.02	0.875	0.81
WTP BrandGeneric to Avg Generic (USD)	1.92	0.74	1.17	0.80
Log-Likelihood	-170,687	-1,197	-110,005.36	-849.08
N	655,228	3,873	555,685	3,267

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Results from the mixed logit estimation. One observation is a patient choice in the substitution group of paracetamol 1 gr., 30 tablets. The outcome variable is a dummy that indicates if an individual has chosen a product. Mod.1 and Mod.2 considers the random sample (1/6th of the full sample, random selection) whereas Mod.1-Med and Mod.2-Med solely consider patients with a medical education within the random sample. The upper part of the table shows product-specific intercepts, dependent on branded generics and generics, the default value is the original. Note that the coefficients are partly random and estimates of standard deviations are excluded. The lower part of the table shows the random coefficients for price and the state dependence. Note that I also report the standard deviation or the random coefficients. Control Function indicates if the control function approach for endogenous prices has been used. Unobserved Heterogeneity indicates if the model controls for problems due to unobserved heterogeneity. WTP State Dependence shows the point estimates of the average willingness to pay for state dependence in USD, i.e. how much an average patient is willing to pay in order to receive the same product as in the last period. WTP BrandGeneric to Avg Generic describes the willingness to pay to receive a branded generic compared to a the mean of all other generics. Standard errors are reported in parentheses.

Table VIII: Policy Estimation

	Price		
	(1)	(2)	(3)
Share (t-1)	2.598**	2.568***	1.589*
	(0.817)	(0.727)	(0.797)
$I(NoComp.(t-1)=3)$			0.062
			(0.350)
$I(NoComp.(t-1)=4)$			−0.286
			(0.478)
$I(NoComp.(t-1)=5)$			−1.092
			(0.683)
PoM(t-1)		2.481***	1.752***
		(0.386)	(0.474)
Quantity			0.0001***
			(0.00003)
Constant	71.066***	70.080***	61.182***
	(0.370)	(0.411)	(2.203)
N	272	272	272
R^2	0.028	0.142	0.262
Notes:	*** $p<0.001$, ** $p<0.001$, * $p<0.05$		

Notes: Linear least square Regression results for the estimation of the policy function. One observation corresponds to the monthly price of a product in the substitution group of paracetamol 1 g., 30 tablets. The outcome variable is the price of a product in period t. All regressors are state variables of the supply side: Share$(t-1)$ is the market share in the preceding period. $I(NoComp.(t-1)=3)$, $I(NoComp.(t-1)=4)$, and $I(NoComp.(t-1)=5)$ are dummies that take the value 1 if in the preceding period the number of firms was equal to 3, 4 or 5. PoM$(t-1)$ is a dummy that takes the value 1 if the firm was the cheapest product in the previous month. Standard errors are reported in parentheses.

Table IX: Marginal Cost Estimates

Firm	**Mean Marg. Cost**	**Standard Deviation**
Original	14.82	5.50
Branded Generic I	13.75	2.11
Branded Generic II	11.68	2.86
Generic I	16.89	3.23
Generic II	14.52	1.25
Generic III	14.01	2.18
Generic IV	14.41	1.84

Notes: Summary of marginal cost estimates (in SEK, 10 SEK approximately 1 USD) for different firms in the market of paracetamol, 1 g. 30 tablets. Note that the marginal costs are the means of the the marginal costs estimated for each period a product has been present. Standard deviations are reported in the second column

Table X: Benchmark Model, Products

	Mean Data	SD	Mean Benchmark Model	SD
		Prices		
Mean Price	71.80	3.65	69.56	2.49
Original/Avg Generic	1.013		1.024	
		Market Shares		
Mean Share	0.27	0.1	0.26	0.1
Original	0.32	0.16	0.25	0.17
Branded Generic I	0.53	0.17	0.53	0.08
Branded Generic II	0.49	0.29	0.31	0.10
Generic I	0.15	0.13	0.17	0.04
Generic II	0.08	0.09	0.14	0.04
Generic III	0.03	0.07	0.12	0.03
Generic IV	0.07	0.11	0.11	0.02

Notes: Comparison between data and prediction from the reduced model (benchmark model). The upper part of the Table shows comparison of prices Prices are reported in SEK. The second and third column shows the results from observable prices in the substitution group of paracetamol 1 g., 30 tablets. The fourth column and fifth column shows the prediction from the reduced model with one state variable, the benchmark model. The mean prices corresponds to the mean across all periods and all available products. The lower part considers statistics of market shares. Note that not all products are available in each month.

Table XI: Results of Counterfactuals

	Benchmark Model	Counterfactual Proc.	Counterfactual QM
		Average Prices:	
Mean Price	69.56	70.49	67.66
	(2.49)	(3.13)	(2.72)
Original	70.71	71.15	68.83
Branded Generic I	69.67	73.10	67.48
Branded Generic II	68.80	66.40	66.28
Generic I	70.48	72.70	69.01
Generic II	68.93	68.68	67.01
Generic III	68.20	68.30	65.92
Generic IV	68.14	69.25	67.13
		Shares	
Mean Share	0.26	0.22	0.28
	(0.1)	(0.05)	(0.09)
		Average Expenditures and Revenue:	
Price for Avg. Consumer	69.25	70.69	67.15
Compared to Benchmark		2.08%	−3.03%
Total Revenue (in m)	265	276	255
Compared to Benchmark		4.11%	−3.86%

Notes: Comparison between Benchmark Model and the two counterfactual scenarios. The upper part of the table reports prices in SEK. The first scenario is the counterfactual of the different procurement behavior. The second conterfactual mimics the case of a decrease in quality misconceptions. The middle part of the table shows the average shares of all products across all periods. The lower part considers measures of consumer costs and total revenue. The Price for Avg. Consumer shows the price a average consuemer would pay. The following row shows the percentage change to the benchmark model. The Total Revenue considers the total market revenue (price and fixed quantity) during the six year period. Standard deviations in parentheses.

Appendix

Patent Expiries: Switching Costs

I use a quasi-experimental setting to show causal evidence for state dependence due to switching costs. The results serve as a robustness check for the general evidence of the general regressions. Similar to Feng (2017), I take advantage of the introduction of generic products after patent expiries. Correspondingly, I compare the repeated purchasing behavior of consumers who start their treatment with a drug for the first time briefly before to those patients who start a treatment briefly after a patent expired.

I begin by describing a specific but representative example of a substance for which a patent has expired. Figure A.1 describes the monthly market shares of different brands within a substitution group of the substance Oxycodone. Oxycodone is an opioid and used as a strong painkiller. Oxycontin as the branded version of Oxycodone had patent protection until October 2012. Figure A.1 shows a steady reduction of the original's market share after the patent expired. After the patent expired, the original lost market share to the new competitors. The main reason for this development is that consumers now get reimbursed for the cheapest product, which is a new authorized generic product.

[Figure A.1 about here.]

I reduce the sample to patients who started taking a product in this substitution group for the first time in the sample three months before and three months after the patent expired. The former is the control; the latter, the treatment group. I consider the repeated purchases of the two different groups after the initial purchase. Figure A.2 shows the difference in market shares of products between the group who started three months before the patent expiry and the patients who started three months after the patent ran out. It is observable that the original branded product has a higher market share among those that started with the original for more than one year after the generics entered.

[Figure A.2 about here.]

I continue with presenting the general framework of estimating the impact of state dependence due to switching costs. First of all, I identify those substitution groups where a patent has ran out. I use eleven substitution groups of Oxycodone, six substitution groups of Rizatriptan (a painkiller used against migraines[86]) and three substitution groups of Clindamycin (an antibiotic[87]). I reduce each sample to the purchase of those patients who started with purchasing

[86] Rizatriptan has the ATC code N02CC04. The original brand name is 'Maxalt'.
[87] Clindamycin's ATC code is J01FF01. It is used against a number of bacterial infections. The brand name is Dalacin.

a product three months before or after patent payout. The treatment group is the group who started with one of the entering generics three months after patent payoff. Correspondingly the group of patients starting treatment three months before is the control group. The basic intuition is that the groups are randomized as they cannot influence their medication starting date.

$$Y_{it} = \alpha + \beta_t Y_{i0} + \varepsilon_{it}$$

Y takes the value 1 if a patient i consumes one of the newly entered products (generics). Given that I use the sample where the initial consumption lies between three months before and after a patent expiry, t is the number of months after the initial consumption, which is notated with $t = 0$. I instrument Y_{i0} by Z_i which shows whether a consumer is in the treatment group. Note that the sample only includes repeated purchases by consumers. The exclusion restriction of the approach relies on the assumption that patients are randomly selected into the treatment and the control groups. Given that patients need prescriptions from a primary health care provider for all three substances and given that patients of the studied substances need immediate treatment when prescribed, it is unlikely that patients self-select into one of the two groups.

Table A.1 as well as Figure A.3 show coefficients for β for the first three months (β_3) and the fourth to sixth months (β_6) after the initial purchase for each substitution group containing the substance Oxycodone.[88] Within Table A.1 each row corresponds to an individual substitution group. The first two columns describe the regression results where the outcome variable Y_{it} takes the value 1 if a patient takes a new entering product during the first three months after initial consumption. The first column shows the coefficient of the first stage in the instrumental approach whereas the second column is the coefficient of the second stage.[89] The third and fourth column present the first and second stages where the outcome is the fourth to sixth months. Figure A.3 shows the second stage coefficients (β_3 as well as β_6) for each substitution group containing the substance Oxycodone.

The first stage is strong for all different specifications. The results of the second stage suggest that there is a strong state dependence during the first three months in the substitution groups of Oxycodone.[90] For the longer time horizon the state dependence diminishes. In general, patients who start with a generic are more likely to consume a generic three months later than those who started with an original product. The analysis for the different group of substances

[88] Note that I include detailed tables for the substitution groups of Maxalt (the original brand of Rizatriptan) and Dalacin (the original brand of Clindamycin) in *Online Appendix C.9*. Results are similar.

[89] Note that I document display intercepts for simplicity.

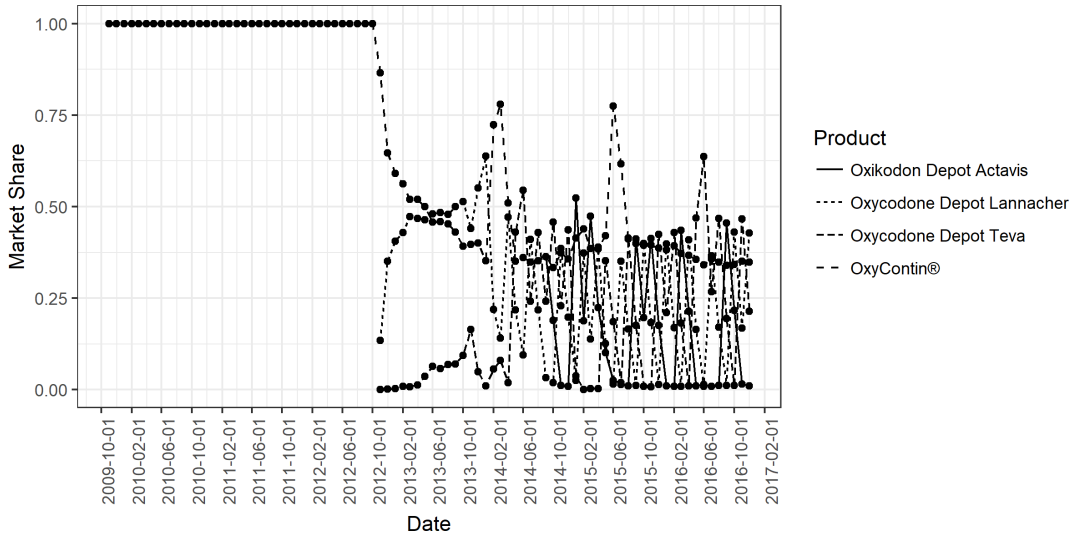
[90] The results of Rizatriptan and Clindamycin show similar results as shown in *Online Appendix C.9*

is in line with the general regression evidence. Patients experience habit persistence or they have switching costs.

[Table A.1 about here.]

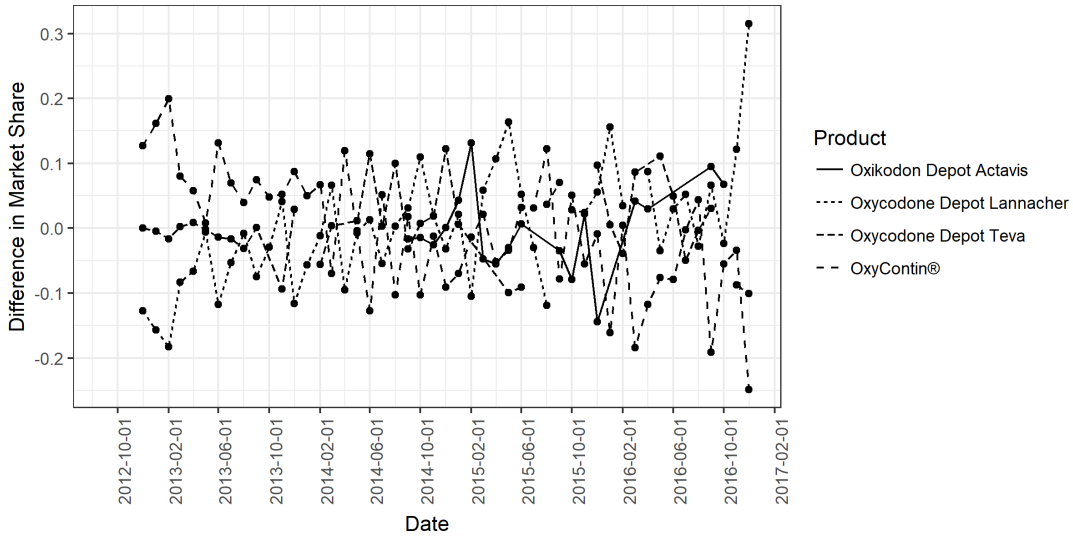
[Figure A.3 about here.]

Figure A.1: Market Shares, Oxycodone



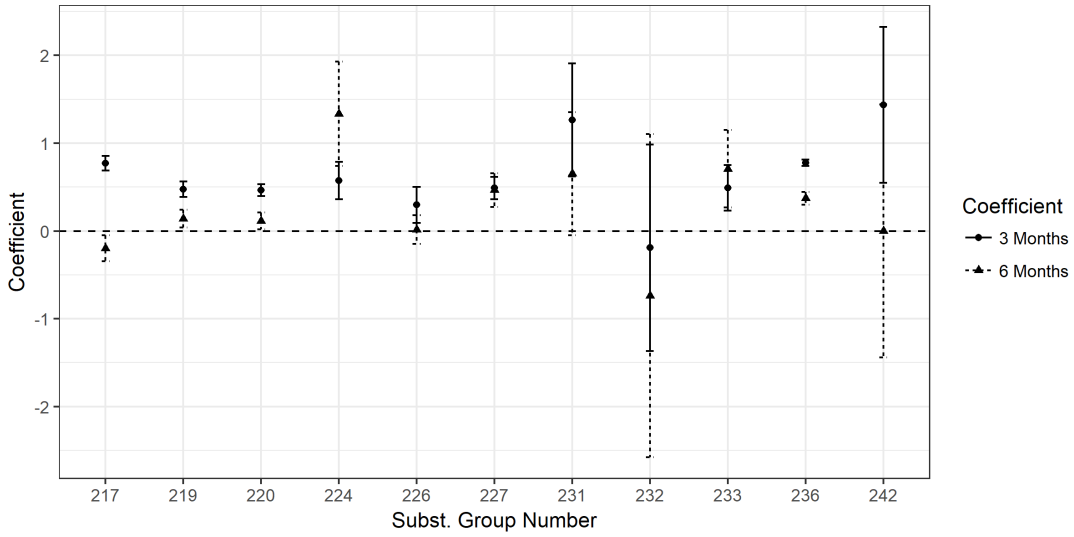
Notes: Monthly market shares in the substitution group of Oxycodone before and after patent expiry of the original product Oxycontin. Each observation stands for the monthly market share of a brand.

Figure A.2: Difference in Market Shares, Oxycodone



Notes: Considering only repeated purchases of consumers who started purchasing an Oxycodone substance for the first time three months before or after a patent expiry. The graph shows the differences between market shares of the repeated purchases by patients who started three months before and three months after the patent expired. The group that started in the three months before the patent expiry initially consumed Oxycontin, while the patients who started after the patent expiry either consumed Oxycontin or a generic. A share over 0 implies that a product is purchased relatively more often across consumers who started before the patent expiry compared to the patient who started after the patent expiry.

Figure A.3: Instrumental Variable Regression Results, Oxycodone



Notes: Coefficients of second stage for different substitution groups of Oxycodone. Coefficients for each substitution group are divided into coefficients for the initial three months and months four to six. A coefficient for the first three months equal to $\beta_3 = .5$ says that the initial consumption of a generic increases the possibility of purchasing a generic again during the following three months by 50%. Note that I include 95% confidence intervals.

Table A.1: IV Regression Results, Oxycodone

Subgroup	First Stage 3 M	β_3	First Stage 6 M	β_6
242	0.185***	1.4385***	0.125***	-0.002
	(0.045)	(0.45)	(0.045)	(0.729)
231	0.269***	1.2645***	0.2775***	0.6525*
	(0.05)	(0.326)	(0.067)	(0.354)
227	0.341***	0.4895***	0.3215***	0.4655***
	(0.016)	(0.065)	(0.02)	(0.097)
224	0.304***	0.5735***	0.2115***	1.3325***
	(0.023)	(0.108)	(0.031)	(0.302)
220	0.416***	0.4655***	0.4125***	0.1165**
	(0.011)	(0.035)	(0.015)	(0.049)
217	0.437***	0.7725***	0.4395***	-0.1975**
	(0.013)	(0.042)	(0.024)	(0.076)
233	0.288***	0.4915***	0.2495***	0.7075***
	(0.028)	(0.133)	(0.035)	(0.224)
232	0.021***	-0.191	0.0125***	-0.736
	(0.008)	(0.599)	(0.007)	(0.937)
226	0.068***	0.2985***	0.0955***	0.015
	(0.006)	(0.105)	(0.01)	(0.083)
219	0.108***	0.4765***	0.1135***	0.1415***
	(0.005)	(0.045)	(0.006)	(0.051)
236	0.32***	0.7755***	0.4165***	0.3715***
	(0.005)	(0.019)	(0.01)	(0.037)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes: Results of the instrumental variable regression for different substitution groups of Oxycodone. The first column differentiates between the substitution groups. The first stage of the IV regression is shown in columns two and four, first for the initial three months and second for months four to six. The coefficients for the second stage are in columns three and six. Standard errors in parentheses.