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ON THE EFFECT OF PARALLEL TRADE ON MANUFACTURERS' AND RETAILERS' PROFITS IN THE PHARMACEUTICAL SECTOR

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Differences in regulated pharmaceutical prices within the European Economic Area create arbitrage opportunities that pharmacy retailers can access through parallel imports. For prescription drugs under patent, parallel trade affects the sharing of profits among an innovating pharmaceutical company, retailers, and parallel traders. We develop a structural model of demand and supply in which retailers can choose the set of goods to sell, thus foreclosing consumers' access to less profitable drugs. This allows retailers to bargain and obtain lower wholesale prices from the manufacturer and parallel trader. With detailed transaction data from Norway, we identify a demand model with unobserved choice sets using retail-side conditions for optimal assortment decisions of pharmacies. We find that retailer incentives play a significant role in fostering parallel trade penetration and that banning parallel imports would benefit manufacturers as well as prevent pharmacies from foreclosing the manufacturer's product. Finally, in the case of the statin market in Norway, we show that it would be possible to decrease spending *and* increase profits of the original manufacturer through lump sum transfers associated with a lower reimbursement price, thus decreasing price differentiation across countries.

KEYWORDS: Parallel trade, pharmaceuticals, vertical contracts, demand estimation, foreclosure.

1. INTRODUCTION

MANY INDUSTRIES RELY ON A DOWNSTREAM RETAILING SECTOR TO MARKET GOODS. Not only do vertical relationships affect price competition among substitutes and differentiated goods, but retailers—as intermediaries between manufacturers and consumers—can also affect competition by engaging in strategic actions affecting final consumers' demand. In context with price discrimination across markets, there is scope for parallel trade, which affects the sharing of profits in vertical chains.

Within the European Economic Area, free movement of goods is a central force considered to increase competition and bring consumer benefits. Pharmaceutical drugs are no exception, and trade across countries is fully legal. However, drug pricing remains

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a national competence, and cross-country differences are substantial. As a result, there has been an increase in parallel trade, estimated at 5.5 billion euros in 2012, with highly heterogeneous national market shares that can be up to 25% in some countries.[12] Parallel trade of pharmaceuticals is common in a handful of European countries, including important markets like Scandinavia, Germany, and the Netherlands. Worldwide, it also affects other goods, such as cars, luxury goods, and video games. If parallel trade has a significant impact on sales, it may affect firms' strategic incentives to launch or develop new products.

In the case of medicines, cross-country price differences can be as large as 300%, driven by regulatory caps or strict government rules for price setting. Differences in price regulation depend on the aggressiveness of each member state's authorities in negotiating with manufacturers (Kyle (2007)). Not surprisingly, these price differences result in parallel imports of pharmaceuticals by high-price countries from low-price countries; that is, drugs are bought in Eastern or Southern European countries and resold in Northern European countries (Kyle (2011)). Even though there is significant price dispersion across EU countries, Ganslandt and Maskus (2004) reported that parallel imports might have led to a reduction in drug prices on the order of 12–19% for drug segments subject to parallel imports entry in Sweden. At the same time, there are large variations in parallel import penetration across otherwise similar countries. These differences seem to have a clear link to regulation governing margins at the pharmacy and domestic supply level (Kanavos and Vandoros (2010)).

As parallel traders need to enter through pharmaceutical retailers, retailers' incentives are potentially decisive in determining the extent of parallel trade due to retailers' role as intermediaries in the supply chain. The strategic role of profit-maximizing pharmacies, toward both drug manufacturers providing directly imported drugs and parallel traders providing parallel imports, can thus be important in the organization of the pharmaceutical sector. Though essentially the same product, direct and parallel imports are potentially differentiated by trade name, appearance, packaging, and source of origin from the consumer point of view. Differentiation in appearance and specification across countries has been linked to attempts to reduce the scope for parallel trade (Kyle (2009, 2011)). Parallel imports create an alternative upstream supply for pharmacists, which may have significant implications for the distribution of surplus in the market. In the case of prescription drugs under patent, the monopoly rights of the manufacturer allow them to extract consumers' willingness to pay when setting prices either directly to the market or when negotiating prices with governments. Past research has shown that innovation is indeed elastic to this reward (Acemoglu and Linn (2004), Dubois, de Mouzon, Scott-Morton, and Seabright (2015)). However, if intermediaries such as pharmacies or parallel traders manage to extract a large share of the monopoly rent of manufacturers, the innovation incentive may be inefficiently reduced. It is therefore important to study how the organization of retailing and parallel trade affects profit sharing. While the European market is smaller than that of the US, it can still have an effect (the US represents one-third of total world pharmaceutical spending, while Europe is 22%), and our findings shed light on mechanisms that must be known and taken into account for possible future policies on parallel trade in the US.

[1]Firms specializing in parallel trade require necessary logistical capacity and facilities suitable for drug repackaging. Repackaging is required for drugs for which the imported package and accompanying information sheets is in a language other than the language of the destination country.

[2]European Federation of Pharmaceutical Industries and Associations 2008 report https://www.efpia.eu/media/361960/efpia-pharmafigures2018_v07-hq.pdf

Contribution. To study the sales of parallel-imported pharmaceutical drugs, we develop a structural model of demand and supply with intermediaries (pharmacists and parallel traders). Specifically, we address the question of how price differences across countries incentivize retail pharmacies to sell parallel imports. Our model explains how parallel imports capture substantial market shares by retailers restricting the supply of less profitable products to increase purchases of more profitable ones. This mechanism consists of the pharmacy chain foreclosing access to direct imports. This foreclosure mechanism is different from the usual anticompetitive practice of deterring a firm from a market as it results from the equilibrium bargaining of wholesale prices by the manufacturer with Norwegian chains and could be avoided with lower wholesale prices. However, the retailer must trade off foreclosing access to lower margin products and staying attractive to consumers, as restrictions in their choice set might repel consumers with a preference for an unavailable product. Indeed, although parallel and direct imports are the same drug, some consumers may prefer the direct import variety due to aversion to products that have been traded and transported across intermediate countries from their production site. Rare safety problems may explain this preference. Moreover, pharmacists must inform patients when a drug is parallel imported, and packaging will usually display the name of the parallel importer and differ in visual appearance. As consumers may be skeptical about parallel imports, we consider the incentives of the retail side of the market to explain the penetration of parallel imports. We take the reimbursement and regulatory price setting in Norway as given since this is determined in an initial stage, usually following market authorization when the manufacturer enters. Given the reimbursement price set by the Norwegian government, we model the retail pharmacist's decision and negotiations of wholesale prices with the manufacturer and parallel traders, as well as price negotiations in other European countries from which parallel traders eventually import. We model the wholesale price setting between pharmacy chains and the manufacturer or the parallel traders as a simultaneous Nash-bargaining problem. However, we do not model the dynamics of entry and exit across countries, and we do not try to explain the observed network of parallel traders with pharmacy chains. In some of our counterfactuals, we model the effects of a reduction in the reimbursement retail price taken as given in our estimation. We do so by taking into account the behavior of the manufacturer, parallel traders, pharmacy chains in the Norwegian market, and changes in wholesale prices in source countries.

We use rich microdata on the Norwegian pharmaceutical market, where we observe detailed demand data and pharmacy margins. In particular, we observe all purchases by individual consumers over time, the pharmacy chain at which a given purchase happened, and whether the specific drug dispensed was imported through the original manufacturer (direct import) or by parallel traders. We also observe pharmacy retail prices for all transactions, in addition to wholesale prices paid by pharmacy chains to upstream firms for each specific drug package. Thus, we observe the gross margin obtained by the chain on all products, which affects retailers' incentives to dispense parallel imports.

As the choice set of consumers potentially changes across pharmacies and is not observable to the econometrician, we develop an estimation method based on observed transactions with unobserved choice sets. To identify choice probabilities without observing choice sets, we nest the Nash equilibrium in pharmacies' strategic choice sets in the probability of each observed choice. The demand model can be identified due to exogenous variation in pharmacy margins for parallel and direct imports that lead to varying choice sets in equilibrium. Our nested fixed-point algorithm could be applied to other settings in which retailer incentives to propose varying assortments of products can be characterized by an equilibrium condition. We find that inclusion of retailer incentives in our

model plays an important role in explaining consumer choices. We identify the bargaining weights of each party using the Nash-in-Nash equilibrium equations for wholesale price determinations and exogenous price shocks in source countries together with exchange rate shocks that affect the opportunity value of parallel imports versus direct imports. We then use the estimated bargaining model to simulate three counterfactual situations related to *(i)* the possibility for pharmacy chains to use parallel imports, *(ii)* their ability to use foreclosure strategies, and *(iii)* the level of the retail price cap imposed by the government.

Our counterfactual simulations imply that even though, on average, consumers prefer directly imported products, parallel imports allow retail pharmacy chains to capture a much larger share of industry profits than would otherwise be the case, particularly at the expense of the manufacturer. In the atorvastatin market (patented and marketed by Pfizer under trade name Lipitor during 2004–2007), the manufacturer's profit would double (+104%) if there was no parallel trade, and pharmacy chains could lose all their profit as manufacturers would be able to set wholesale price at the maximum retail reimbursement price. The shift in profits to retailers is driven by two mechanisms: *(i)* the creation of price competition between the upstream firms from chains' ability to shift sales as a response to differences in profitability, and *(ii)* the outside option a chain gains from the ability to sell parallel-imported drugs when bargaining over wholesale prices with the direct importer. The counterfactual results show that a ban on parallel trade would thus substantially increase the profit of the manufacturer in Norway at the cost of decreasing it slightly in the source country we model (France), showing that the existence of parallel trade leads to higher prices and profit in France than without. In the counterfactual case where closure is banned, the manufacturer gains and causes the pharmacies' profits to decrease, although not by a large amount. This result shows that the differentiation of drugs and the possibility of pharmacy chains to purchase parallel imports at lower prices still allow them to capture a large part of profits. Finally, we perform counterfactuals in which the retail price cap is lowered by 20%. The results demonstrate that most of the reduction is borne by pharmacy chains and parallel traders because the margin of negotiation is considerably reduced by the lower difference between prices in source countries and the maximum allowed retail price. The manufacturer loses very little profit, whereas the total government expenses in this market are reduced by 20%. Thus, a lower reimbursement price in Norway would reduce parallel trade, and despite decreasing the profit of the manufacturer both in Norway and in the source country, it decreases the profit much less than what the Norwegian state would save in reimbursement, thus allowing much lower prices that make both the manufacturer and taxpayers better off with a lump sum transfer to compensate the lower price.

Related Literature. A small part of the literature on vertical relationships has addressed the role of strategic actions such as choices regarding the assortment of goods (see Draganska, Mazzeo, and Seim (2009) for an example). Typical sectors in which retailers' behavior have attracted attention from economists are internet platforms and the food retailing industry with large supermarket chains. Pharmacy retailing has been comparatively less studied, although the growth in healthcare expenses among developed countries raises questions about how to design policies to contain spending on pharmaceutical drugs while ensuring or improving patient access to innovation. In Europe, most countries regulate prices of prescription drugs, although other aspects of competitive behavior, such as strategic choice of entry across different markets, also matter substantially (Danzon and Chao (2000), Danzon, Wang, and Wang (2005), Maini and Pammolli (2020)). How

pharmacists choose the assortment of drugs, proposing parallel import, direct import or both, is similar to strategically choosing to stock out or foreclose access to some versions of drugs. The previous literature has provided reduced-form evidence for this type of response to markup differences in prescription drug markets. In a simpler setting in which physicians can prescribe and dispense drugs, Izuka (2013) showed that Japanese physicians respond to markup differentials between originator and generics. In the Norwegian off-patent drug market, Brekke, Holmås, and Straume (2013) found a strong relationship between market share and differences in pharmacy margins for branded and generic drugs. Crawford, Lee, Whinston, and Yurukoglu (2018) showed similar foreclosure strategies in distribution of TV channels. Such a strategy can also be profitable in other industries, though especially so in tightly regulated markets in which price setting is constrained, as is common in many European countries for pharmaceuticals.[3] Our demand estimation with unobserved choice sets is also related to the literature regarding consideration sets or unobserved stock-outs. In a seminal paper, Goeree (2008) used advertising to identify the likely variation in consideration sets using aggregate demand data. Crawford, Griffith, and Iaria (2017) used sufficient statistics on consideration sets to estimate a discrete choice model with unobserved choice sets using individual-level transaction data. We use the retail pharmacists' incentives to manipulate choice sets to identify our demand model. In a different context, Gaynor, Proppper, and Seiler (2016) estimated a demand model that explicitly captures choice constraints imposed on patients by physicians. Our identification relies on the observation of individual choices and modeling of pharmacists' strategic choices. Conlon and Mortimer (2013) used the fact that they observe periodical stock-outs of products in vending machines to estimate a demand model with varying choice sets. Our supply-side vertical relationship model is related to the empirical IO literature using the Nash-in-Nash bargaining equilibrium. Grennan (2013) used a model of bargaining on prices of medical devices between hospitals and upstream suppliers. Gowrisankaran, Nevo, and Town (2015) modeled bargaining between managed care organization and hospitals in the US. Ho and Lee (2017, 2019) also used bargaining to model the negotiated provider prices. Finally, some studies have addressed the impact of parallel trade on pharmaceuticals in Europe. Using a structural model of demand estimated with data on the German market for oral antidiabetic drugs, Duso, Herr, and Suppliet (2014) evaluated the welfare impact of parallel imports. Their estimates imply that parallel imports have reduced the prices of on-patent drugs by 11% but that their impact on consumer surplus is modest. The effect of parallel imports on drug prices therefore depends crucially on country specific regulation of the pharmacies. In contrast to Duso, Herr, and Suppliet (2014), we explicitly model both the vertical relationship between manufacturers and pharmacy retail chains, and the strategic role of retailer incentives in the development of parallel import market shares. Using data from Norway, Brekke, Holmås, and Straume (2015) studied the interaction between price cap regulation and parallel imports across a large number of drugs. They find reduced-form evidence that original manufacturers might benefit from lower price ceilings when there is competition from parallel trade. Novel features of our paper include the strategic decisions by retailers regarding the drugs offered to consumers, the structural estimation of the bargaining model, and the analysis of counterfactual policies and incentive configurations.

[3]For details about pharmaceutical market regulation in different countries see, for example, Kanavos, Costa-Font, and Seeley (2008).

Structure of the Paper. In Section 2, we present the market and data. We present the structural model of demand and supply in Section 3. In Section 4, we describe the empirical specification and identification of our model and present the estimation results. In Section 5, we present the results from our counterfactual simulations, while Section 6 concludes. Appendix A is included in this paper. Appendix B is in the Online Supplementary Material (Dubois and Sæthre (2020)).

2. THE NORWEGIAN PHARMACEUTICAL MARKET AND PARALLEL IMPORTS

2.1. *Overview and Regulation*

The supply side of the market for prescription drugs consists mainly of three large pharmacy retail chains, which are vertically integrated with each of their upstream wholesalers. The three largest chains, Apotek 1, Boots and Vitus, cover 85% of all pharmacies, and public hospital pharmacies (6%), a smaller retail chain (5%), and independent pharmacies (4%) comprise the rest.

The Norwegian Medicines Agency is the main regulatory body for drug affairs, in charge of marketing authorization, drug classification, vigilance, price regulation, reimbursement regulation, and providing information about drugs to both prescribers and the public. With the exception of over-the-counter drugs, all drugs sold on the Norwegian market are subject to a price cap set by the Norwegian Medicines Agency. As a general rule, the price cap is set as the average of the three lowest retail prices of the same product in a fixed group of European comparison countries, consisting of Sweden, Finland, Denmark, Germany, the United Kingdom, the Netherlands, Austria, Belgium, and Ireland. This explains why there is usually scope for parallel trade, as no countries in Eastern or Southern Europe, which usually have even cheaper prices, are included. If drugs enter first in Norway, prices would be set in negotiation, with later revisions based on comparisons after entry in other countries. Reconsideration of the price caps is initiated by the Norwegian Medicines Agency, usually once per year. The price caps are set according to the active ingredient in the drug and amount of active ingredient (dosage). Per unit price caps (with the unit defined by Defined Daily Dose (DDD)) should generally be equal within the category of a given dosage for a given active ingredient.

In cases in which the patient has a long-term ailment, defined as requiring treatment for at least 3 months, and the drug under question has been deemed to be sufficiently cost-effective, government reimbursement is available. The prescribing physician is responsible for deciding whether the patient satisfies the criteria for treatment length, whereas the Norwegian Medicines Agency determines whether a drug satisfies the cost-efficiency criteria for reimbursement. When patients are reimbursed, they face a copayment of 36% of the total price, capped at 510 NOK in 2007 ($\approx$ 50€) per 3 months. The copayments for drugs and healthcare spending were capped at 1660 NOK yearly in 2007 ($\approx$ 170€).

2.2. *Parallel Trade*

Parallel traders must obtain a license from the Norwegian Medicines Agency to sell drugs in Norway, unless they have already obtained a license for sales in the European Economic Area through the centralized European Union procedure.[4] Parallel traders sell to one or more of the three vertically integrated wholesalers. A license is given for

[4]see https://ec.europa.eu/health/sites/health/files/files/eudralex/vol-1/com_2003_839/com_2003_839_en.pdf

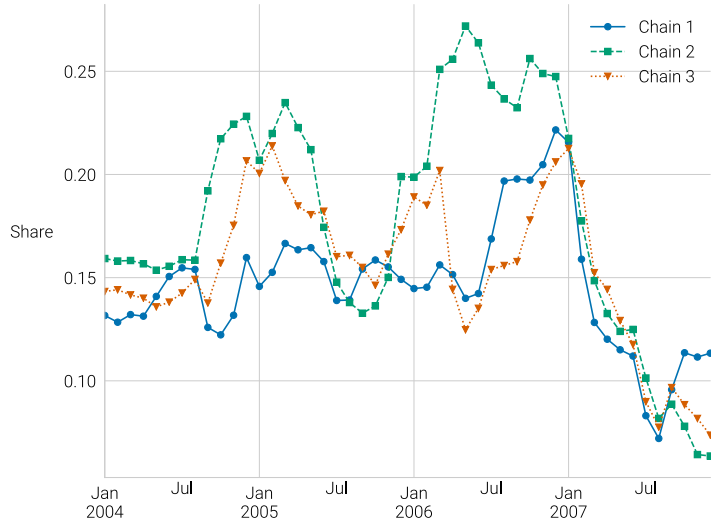

FIGURE 1.—Parallel import share of sales in DDD by chain. Notes: Graph of the 50 most important molecules featuring sales of parallel imports over the sample period. Monetary units in nominal NOK (≈ 0.12€/ 0.16 $US in the period).

a specific drug package imported from a specific country, with the exception of licenses granted through the European Union procedure.

In our dataset, which contains information about prescription filings at pharmacies in Norway for the period 2004–2007, we can identify whether each sold product is directly imported or parallel imported. Parallel trade in Norway happens most prominently in the on-patent period and makes up a negligible share when generics are present. The average share of DDD of parallel import in ATC codes (Anatomical Therapeutic Chemical classification system) with generic entry is 3%, whereas it is roughly 27% among ATC codes without generics.

Figure 1 shows the parallel import share of sales within each pharmacy chain for the 50 most important active ingredients for which parallel trade occurs. It is interesting to note the large variation both between chains and over time. When analyzing the retail prices of parallel imported and directly imported versions in each chain, it appears that the price ceiling is binding for both categories for all active ingredients, dosages and package sizes. Thus, there is no retail price difference between parallel and directly imported versions of the same molecule, and the price is equal to the price cap (i.e., the reimbursement price).

We also compare the margin that each pharmacy chain obtains. The pharmacy chain margin is defined as the sales price in the pharmacy net of the price the pharmacy chain's integrated wholesaler pays to the supplier for obtaining the drug, where the supplier is either a marketing agency of the manufacturer, in the case of direct imports, or the parallel trading firm. These margin differences shown in Figure 2 vary between 4% and 16% over the 4 years of data across the 3 chains.

The seeming correlation between margin differences and the parallel import share of sales in Figure 1 is confirmed by a significant chain-month level positive correlation between parallel import shares and margin difference between parallel and direct imports. This cannot be given a causal interpretation by itself, but it is a first indication of pharmacy incentives mattering for the composition of drugs dispensed to consumers.

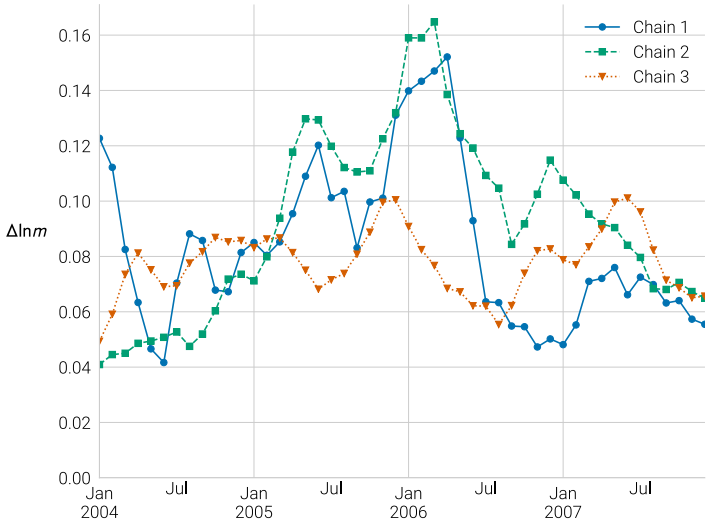

FIGURE 2.—Difference in product margin between direct and parallel imports. Notes: Margin differences (margin of parallel import minus margin of direct import) in NOK per DDD. Differences calculated for packages of the same ATC code, with same amount of active ingredient and of comparable size.

In the Norwegian market during this period, there were five companies specializing in parallel trade with any noticeable activity, namely, Cross Pharma, Euromedica, Farmagon, Orifarm, and Paranova. The share of parallel import sales within each pharmacy chain for each of these companies displayed in Figure 3 shows variation both between pharmacies and over time in terms of the relative presence of these companies. Considering the active ingredient level, each pharmacy chain works with one parallel importer at a given time, although the identity of the parallel importer varies across chains for the same drug.

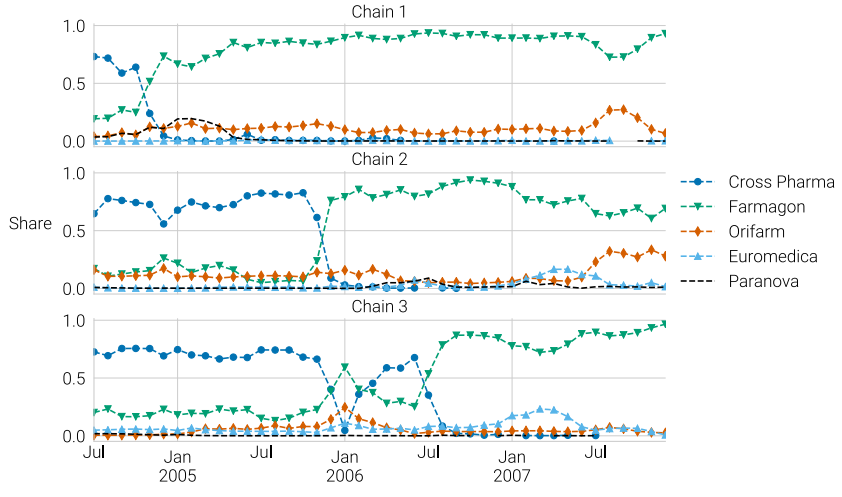

FIGURE 3.—Composition of parallel importers. Note: Share of parallel import sales DDD within a pharmacy chain for each parallel importer.

3. A STRUCTURAL MODEL OF DEMAND AND THE SUPPLY CHAIN

We build a model that explains the behavior of consumers, pharmacy chains, parallel traders, and manufacturers while also determining the price setting in other countries that serve as source countries of parallel imports in Norway.

Parallel trade occurs in the European Economic Area when patented drugs have entered in several countries. It has been shown (Danzon, Wang, and Wang (2005), Maini and Pammolli (2020)) that once marketing authorization is obtained, entry is typically sequential—from countries that accept high prices to countries that ask for lower prices—rather than simultaneous. On average, delays between Western European countries and Eastern or Southern European countries are about 1–2 years. We do not model this part of the game, as done by Maini and Pammolli (2020), but only the price setting after drugs have entered in most countries. Delays in launch decisions cannot be too long because patents have a limited duration and entry is much less valuable after patent expiration where generic competition draws prices to lower levels. Due to high price caps, Norway is typically among the first countries to experience entry of drugs. The retail price, denoted as $\bar{p}_t$ in our model, is the regulated price ceiling based on international comparison (see Section 2), which we take as given in our model. This price is certainly lower than the theoretical monopoly price that would prevail otherwise on an isolated Norwegian market because the manufacturer anticipates trade of drugs after their launch in other countries. Given the retail price in Norway, we assume that the manufacturer negotiates wholesale prices with Norwegian pharmacies as well as other countries. Simultaneously, parallel traders negotiate wholesale prices with the pharmacy chains. Then, given the resulting prices and margins, pharmacies compete to attract consumers. We thus start by modeling the consumer behavior given all wholesale prices and then model the bargaining supply game that determines these prices.

3.1. *Consumer Behavior and Demand for Parallel-Traded Products*

We assume that the consumer has an exogenous need for a drug with a particular active ingredient and dosage. We abstract from therapeutic choice by prescribers, which, as we show in the online Appendix B.3, is not significantly affected by the availability of parallel-traded versions of the drug or by pharmacy margin differences and can thus be considered exogenous to the main mechanisms of our model.

The consumer chooses which pharmacy chain c to visit and—once in the pharmacy—makes a choice among the available products in the pharmacy. When the consumer chooses a pharmacy c, he does not know if parallel-imported (PI) or directly imported (DI) versions of the drug will be available, although we assume that the consumer is aware of the expected availability. Because pharmacies potentially have higher margins on drugs that the consumer does not strictly prefer, they face a trade-off between not proposing the lower-margin drug to induce consumers to buy the other option and proposing consumers' preferred drug with a nonzero probability to attract them. This phenomenon is confirmed by casual observation, and the fact that pharmacists do consider this policy of nonpermanent availability is acknowledged in discussions with them. We assume that consumers know the probabilities of availability chosen by the pharmacy chains. Dubois and Sæthre (2018) presented an alternative demand model in which consumers have heterogeneous beliefs about the products available at each pharmacy chain and show that the results from our preferred specification are robust to this alternative modeling of demand. Note that we also assume that consumers do not search over multiple outlets because, unlike more differentiated products such as cars (Moraga-Gonzalez, Sandor, and Wildenbeest (2015)), it seems unlikely in the case of a choice between PI and DI of the same branded

prescription drug without price differentiation. We also show in the online Appendix B.2 that consumers switch across versions of the drug within a pharmacy chain more than they switch across chains for the same version of the drug.

For a given active ingredient, the choice set at pharmacies can be {PI}, {DI} or $B \equiv$ {DI, PI}. We let the origin of the drug be indexed by $k \in \{0, 1\}$ where 0 denotes PI and 1 denotes DI. We denote by θ_{ct}^0 and θ_{ct}^1 the probabilities that the choice sets are {PI} or {DI}, respectively, and thus, $1 - \theta_{ct}^0 - \theta_{ct}^1$ is the probability that the choice set is $B = \{\text{DI, PI}\}$. We assume that the utility of consumer i is given by

$$u_{ikct} = V_{ikct} + \varepsilon_{ict} + \lambda_c \epsilon_{ikct},$$

where V_{ikct} is the mean utility consumer i obtains from choosing the drug of origin k in pharmacy chain c in market t and ε_{ict} and ϵ_{ikct} are chain-specific and product-specific sequentially observed shocks, respectively. We assume that they are distributed independently across drugs and chains according to a Gumbel distribution. However, our choice model is not a nested logit but rather a model with two extreme value distributed shocks observed sequentially by the decision maker, where ϵ_{ikct} is observed after choosing to purchase at chain c.

Thus, as ϵ_{ikct} is i.i.d. extreme value distributed, the probability that consumer i chooses $k \in \{0, 1\}$ conditional on choice of pharmacy chain c when both products are available is

$$s_{ikt|c,B} = \frac{e^{V_{ikct}/\lambda_c}}{e^{V_{i0ct}/\lambda_c} + e^{V_{i1ct}/\lambda_c}}.$$

Then the choice probability of product k conditional on the choice of pharmacy c is

$$\underbrace{s_{ikt|c}}_{\substack{\text{choice probability of } k \\ \text{conditional on going to chain } c}} = \underbrace{\theta_{ct}^k}_{\substack{\text{probability that only} \\ k \text{ is available at } c}} + \underbrace{\left(1 - \theta_{ct}^0 - \theta_{ct}^1\right)}_{\substack{\text{probability that both} \\ \text{versions are available at } c}} \underbrace{s_{ikt|c,B}}_{\substack{\text{choice probability of } k \text{ given both} \\ \text{versions are available at } c}}.$$

The consumer chooses a chain by taking expectations with respect to the possible choice sets and with respect to the shock ϵ_{ikct}. The consumer utility of visiting pharmacy c is then $I_{ict} + \varepsilon_{ict}$, where

$$I_{ict} \equiv \sum_{k \in \{0,1\}} \underbrace{\theta_{ct}^k}_{\text{prob. only k available}} \underbrace{V_{ikct}}_{\text{utility of k}} + \underbrace{\left(1 - \theta_{ct}^0 - \theta_{ct}^1\right)}_{\text{prob. both versions}} \underbrace{E_{\epsilon_{ikct}}\left[\max_{k \in \{0,1\}} \left(V_{ikct} + \lambda_c \epsilon_{ikct}\right)\right]}_{\text{expected utility preferred version}}$$

with the log-sum formula for the inclusive value in case the choice set contains both products

$$E_{\epsilon_{ikct}}\left[\max_{k \in \{0,1\}} \left(V_{ikct} + \lambda_c \epsilon_{ikct}\right)\right] = \lambda_c \ln\left(\sum_{k \in \{0,1\}} e^{V_{ikct}/\lambda_c}\right)$$

which is always greater than $\max(V_{i0ct}, V_{i1ct})$. Then, as ε_{ict} is extreme value distributed independently across chains, patient i chooses chain c with probability

$$s_{ict} = \frac{e^{I_{ict}}}{\sum_{\tilde{c}} e^{I_{i\tilde{c}t}}},$$

which allows us to obtain the individual choice probability as $s_{ikct} = s_{ict} s_{ikt|c}$.

It should be noted that in equilibrium, patients will choose a pharmacy without knowing for sure which drug will be proposed only when $\theta^0_{ct} + \theta^1_{ct}$ is strictly between 0 and 1 but will know what version will not be proposed when $\theta^0_{ct} = 0$ or $\theta^1_{ct} = 0$. A patient who has really strong taste differences in favor of k will put more weight on choosing a pharmacy with θ^k_{ct} close to 1 so that she can obtain it with certainty.

The aggregate choice probability or market share of drug k sold by c in period t is

$$s_{kct} = \int s_{ikct}\, dF(\mathbf{V}_{it}|\boldsymbol{\beta}), \tag{3.1}$$

where $F(\cdot|\boldsymbol{\beta})$ denotes the c.d.f. of consumer preferences $\mathbf{V}_{it} \equiv (V_{i01t}, \ldots, V_{i0Ct}, V_{i11t}, \ldots, V_{i1Ct})$ conditional on the parameter vector $\boldsymbol{\beta}$.

3.2. *Pharmacy Chain Behavior*

Let us now turn to the behavior of the pharmacy chains. The profits of chain c normalized by total market size at time t are

$$\pi_{ct} = \sum_{k\in\{0,1\}} (p_{kct} - w_{kct}) s_{kct},$$

where p_{kct} is the retail price and w_{kct} the wholesale price of drug k in pharmacy c at t. As retail prices are regulated with a price ceiling that applies to both the direct and parallel import versions of a drug, pharmacies can choose the set of products they prefer to sell but cannot have prices higher than the price ceiling ($p_{kct} \leq \bar{p}_t$). However, since retail prices are always equal to the price ceiling (as for almost all on-patent drugs), we treat the price ceiling chosen by the regulator as binding ($p_{kct} = \bar{p}_t$). We show in online Appendix B.7 that it may be constrained-optimal for the pharmacy to set both prices of parallel and direct imports at the price ceiling.

Pharmacy chains choose the optimal θ values after setting the wholesale prices with the manufacturer and the parallel trader. We denote by $m_{kct} \equiv \bar{p}_t - w_{kct}$ the product price-cost margin. We assume the existence of a Nash equilibrium in θ values across the C pharmacy chains and use the conditions necessary for equilibrium.

We show in Appendix A.1 that it must be that $\theta^k_{ct} = 0$ for the lowest-margin product. For simplicity, in the following, we assume that in equilibrium after the bargaining stage, parallel imports (good 0) are the high-margin product for all chains (which is the case in our data, as we will show later). Thus, we can set the probability of proposing direct imports alone to zero $\theta^1_{ct} \equiv 0$ in the following and define the probability that both goods are available in pharmacy chain c as

$$\theta_{ct} \equiv 1 - \theta^0_{ct}.$$

Then the individual choice probabilities can be written:

$$s_{i1ct} = \frac{e^{V_{i0ct}+\theta_{ct}\delta_{ict}}}{\sum_{\tilde{c}} e^{V_{i0\tilde{c}t}+\theta_{\tilde{c}t}\delta_{i\tilde{c}t}}} \theta_{ct} \frac{e^{V_{i1ct}/\lambda_c}}{e^{V_{i0ct}/\lambda_c} + e^{V_{i1ct}/\lambda_c}} \quad \text{and}$$

$$s_{i0ct} = \frac{e^{V_{i0ct}+\theta_{ct}\delta_{ict}}}{\sum_{\tilde{c}} e^{V_{i0\tilde{c}t}+\theta_{\tilde{c}t}\delta_{i\tilde{c}t}}} \left(1 - \theta_{ct} \frac{e^{V_{i1ct}/\lambda_c}}{e^{V_{i0ct}/\lambda_c} + e^{V_{i1ct}/\lambda_c}}\right),$$

where δ_{ict} is the incremental utility from having both drugs available as opposed to parallel import alone:

$$\delta_{ict} \equiv \lambda_c \ln\bigl(1 + e^{(V_{i1ct} - V_{i0ct})/\lambda_c}\bigr).$$

The Nash equilibrium across chains now implies the following optimality condition for each chain c at t:

$$\frac{\partial \pi_{ct}}{\partial \theta_{ct}}(\boldsymbol{\theta}_t) = m_{0ct}\frac{\partial s_{0ct}}{\partial \theta_{ct}}(\boldsymbol{\theta}_t) + m_{1ct}\frac{\partial s_{1ct}}{\partial \theta_{ct}}(\boldsymbol{\theta}_t) \begin{cases} \leq 0 & \text{if } \theta_{ct} = 0, \\ = 0 & \text{if } 0 < \theta_{ct} < 1, \\ \geq 0 & \text{if } \theta_{ct} = 1, \end{cases} \tag{3.2}$$

where $\boldsymbol{\theta}_t \equiv (\theta_{0t}, \ldots, \theta_{Ct})'$ is the vector of the probabilities that both goods are available and where the derivatives of shares with respect to θ_{ct} are

$$\frac{\partial s_{0ct}}{\partial \theta_{ct}} = \int \bigl(-\rho_{ict} s_{ict} + (1 - \theta_{ct}\rho_{ict})\delta_{ict} s_{ict}(1 - s_{ict})\bigr)\, dF(V_{it}|\boldsymbol{\beta}), \quad \text{and}$$

$$\frac{\partial s_{1ct}}{\partial \theta_{ct}} = \int \bigl(\rho_{ict} s_{ict} + \theta_{ct}\rho_{ict}\delta_{ict} s_{ict}(1 - s_{ict})\bigr)\, dF(V_{it}|\boldsymbol{\beta}),$$

where $\rho_{ict} \equiv s_{i1t|c,B}$ is the probability that consumer i chooses the direct import variety in chain c when both are available.[5]

From these expressions, we see that there are basically two effects of increasing the probability that both products are available. To give a better sense of how the model works, we first discuss these effects from the point of view of an individual i. The first effect is a change in the conditional choice probability of the product—that is, the choice probability given that the individual has chosen pharmacy chain c—weighted by the probability s_{ict} that chain c is chosen by individual i in the first place. This is *negative* for parallel imports, as it reduces the number of times for which it is the only product available, whereas it is *positive* for the direct import, as it increases the number of times for which it is part of the choice set. The second effect is a change in the probability of choosing chain c, weighted by individual i's conditional probability of choosing the product. This effect is *positive* for both products since the incremental expected utility of having both drugs available, δ_{ict}, is positive for all individuals; that is, more individuals will choose chain c when the variety is greater. The *aggregate* effect then depends on the distribution of individual tastes in the population. As an example, let us consider a *decrease* in θ_{ct} to induce more consumers to buy the parallel-imported variety. This will have a larger impact on the relative shares of the goods within pharmacy chain c when consumers have a strong preference for the directly imported variety on average and even more so when this correlates positively with the probability of choosing chain c in the population. However, if people on average have a strong preference for the directly imported variety, the incremental utility δ_{ict} will tend to be large, thus implying a stronger substitution away from chain c. This negative aggregate effect will be weaker if people have strong preferences for a specific pharmacy such that s_{ict} tends to be either very high or very low and also if there is a positive correlation between the taste for direct imports and chain c. From this,

[5]Note that $\delta_{ict} = -\lambda_c \ln(1 - \rho_{ict})$, which has the natural interpretation that individual i's incremental utility from having both goods available is increasing in the probability that she will choose the directly imported variety when both are available.

we can see that the distribution of tastes in the population will be central in the decision of pharmacy chains on how to foreclose the lower margin product.

The Nash equilibrium in each market t defines the vector $\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})$, with elements $\theta_{ct}^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})$ that are functions of the wholesale prices of direct and parallel imports in the market ($\boldsymbol{w}_{1t}$ and $\boldsymbol{w}_{0t}$, resp.) and of the exogenously given retail price ceiling $\overline{p}_t$ (omitted from the arguments for simplicity).

3.3. *Upstream Manufacturer and Importers*

We now turn to the modeling of the manufacturer supplying Norwegian pharmacy chains and other countries. We assume that the manufacturer simultaneously negotiates the wholesale price in the source country and the wholesale prices with pharmacy chains in Norway. Assuming that all prices satisfy a Nash equilibrium condition of simultaneous bargaining between the manufacturer and each country purchaser, the Nash equilibrium conditions determining the wholesale prices in Norway can be written with the wholesale prices in other countries as given.

Indeed, the pharmaceutical firm's combined profits from all countries (Norway and source countries for Norwegian imports) is

$$\Pi_t = \sum_c \underbrace{(w_{1ct} - c_t)s_{1ct}(\boldsymbol{\theta}_t^*)}_{\substack{\text{Profit to Manufacturer of} \\ \text{Direct Imports profit in chain c}}} + \underbrace{\left(p_{1ct}^{I(c)} - c_t\right)s_{0ct}(\boldsymbol{\theta}_t^*)}_{\substack{\text{Profit to Manufacturer of Parallel Import} \\ \text{in chain c at wholesale source price } p_{1ct}^{I(c)}}} + \sum_I \underbrace{\left(p_{1t}^I - c_t\right)q_{It}(p_{1t}^I)}_{\text{other countries profits}},$$

where c_t is the marginal cost of production, $p_{1ct}^{I(c)}$ is the manufacturer's wholesale price in the source country $I(c)$ for the units sold by the parallel importer supplying chain c from country $I(c)$, p_{1t}^I is the wholesale price determining demand in the source country I, $q_{It}(p_{1t}^I)$ is the demand for domestic consumption in source country I, and w_{1ct} is the wholesale price charged for the directly imported drug to chain c at time t. Even though $p_{1t}^{I(c)}$ is the main determinant of $p_{1ct}^{I(c)}$, we allow the possibility that they differ due to transaction costs and wholesale margins.

We assume simultaneous Nash bargaining among the manufacturer, the parallel importers and the chains as well as between the manufacturer and the other countries and characterize the equilibrium.

The bargaining surplus for the manufacturer with respect to pharmacy chain c in Norway is given by

$$\begin{aligned}(\Pi_t - \Pi_{-c,t}) &= \sum_{\tilde{c}}\left[(w_{1\tilde{c}t} - c_t)s_{1\tilde{c}t} + \left(p_{1\tilde{c}t}^{I(\tilde{c})} - c_t\right)s_{0\tilde{c}t}\right] \\ &\quad - \sum_{\tilde{c}}\left[(w_{1\tilde{c}t} - c_t)s_{1\tilde{c}t\setminus 1c} + \left(p_{1\tilde{c}t}^{I(\tilde{c})} - c_t\right)s_{0\tilde{c}t\setminus 1c}\right] \\ &= \sum_{\tilde{c}}\left(w_{1\tilde{c}t}\Delta_{1c}s_{1\tilde{c}t} + p_{1\tilde{c}t}^{I(\tilde{c})}\Delta_{1c}s_{0\tilde{c}t}\right),\end{aligned}$$

because the manufacturer profit in other countries $\sum_I (p_{1t}^I - c_t)q_{It}(p_{1t}^I)$ is unchanged whether or not the manufacturer agrees with pharmacy chain c in Norway. Concerning parallel traders exporting drugs to Norway, their Nash profit surplus when bargaining with Norwegian pharmacy retailing chains also does not depend on other possible trade

activities in other countries. Finally, the Nash profit surplus of Norwegian pharmacists also depends only on Norwegian profits.

This shows that we do not need to account for equilibrium conditions in other countries when considering the equilibrium in the Norwegian market and can take the wholesale prices in source countries as given. We therefore present the equilibrium conditions for the Norwegian market alone and later discuss how we need to account for equilibrium effects of different counterfactual policies both in Norway and in other countries.

We assume that upstream firms and pharmacy chains bargain over wholesale prices, leading to the *Nash-in-Nash bargaining* model (Horn and Wolinsky (1988)). As documented by Brekke, Holmås, and Straume (2015), the prohibition against side payments in contracts between manufacturers and wholesalers in the Norwegian pharmaceutical market explains why only linear pricing transactions are observed.

When describing equilibrium price conditions, we take as given the transactions of parallel traders. The choice of a parallel trader to work with a pharmacy chain varies with variations in the opportunity costs of drugs for parallel traders. The fact that the identity of the parallel trader company may change over time for a given pharmacy will not affect the wholesale price equilibrium, provided that the negotiation with the pharmacy chain is a bilateral negotiation that does not use threat of replacements like in Ho and Lee (2019) (explaining the network of parallel traders with pharmacy chains is left for future research).

3.3.1. *Manufacturer Behavior*

The total sales of the manufacturer of a drug in a given market (country) come from two channels: the direct import channel of its product (good 1) to all chains c and the parallel imports of the same patented active ingredient (good 0) by all chains c. Here, we hypothesize a fully rational manufacturer, internalizing the sales in a given market induced by parallel trade with other countries.

Thus, using the simpler notation $\boldsymbol{\theta}_t^*$ for $\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})$, the profits of the manufacturer are given by

$$\Pi_t\left(\boldsymbol{w}_{1t}, \boldsymbol{\theta}_t^*\right) = \sum_c \underbrace{(w_{1ct} - c_t) s_{1ct}\left(\boldsymbol{\theta}_t^*\right)}_{\substack{\text{Profit to Manufacturer of Direct Imports} \\ \text{profit in chain c}}} + \underbrace{\left(p_{1ct}^{I(c)} - c_t\right) s_{0ct}\left(\boldsymbol{\theta}_t^*\right)}_{\substack{\text{Profit to Manufacturer of Parallel Import} \\ \text{in chain c at wholesale source price } p_{1ct}^{I(c)}}},$$

where c_t is the marginal cost of production assumed to be identical across countries, $p_{1ct}^{I(c)}$ is the manufacturer price in the source country of the parallel importer supply chain c, and, as before, w_{1ct} is the wholesale prices charged for directly imported drugs to chain c at time t. In the online Appendix B.13, we describe the full bargaining model where we do not assume that it is always the same θ_{ct}^k that is at the zero corner solution for the different vectors of wholesale prices considered in bargaining. For simplicity of exposition, we propose here the bargaining game where we assume the relevant zone of negotiation is such that the pharmacy chains will never find it optimal to propose parallel imports only.

We assume that in each pairwise negotiation with the pharmacy chains, the manufacturer and chain c set wholesale prices to maximize the Nash product

$$(\Pi_t - \Pi_{-c,t})^{b_{1c}} (\pi_{ct} - \pi_{-1,ct})^{1-b_{1c}}, \tag{3.3}$$

where b_{1c} is the bargaining weight of the manufacturer when negotiating with chain c, $\Pi_{-c,t}$ is the manufacturer's profit in the absence of an agreement with chain c, and $\pi_{-1,ct}$ is likewise chain c's profit in absence of an agreement with the manufacturer.

We assume that in the case of disagreement between the manufacturer and chain c, the chain still sells parallel imports. It is true that if the wholesale price of the manufacturer is low enough, it may not be profitable for parallel traders to enter, in which case the pharmacy chain has no other supply channel. We write equilibrium conditions that are valid in the range of wholesale prices where parallel trade is still valuable. Thus, the Nash surplus of the pharmacy chain agreeing with the manufacturer can be written as the difference between the profit when the chain sells both direct and parallel imports and the profit when it sells only parallel imports at the agreed wholesale price in equilibrium (because of the Nash assumption). We assume that each bargaining manufacturer-chain pair takes as given the equilibrium wholesale prices of parallel imports in each pharmacy chain $\boldsymbol{w}_{0t} = (w_{01t}, w_{02t}, \ldots, w_{0Ct})$. This corresponds to a Nash-in-Nash equilibrium (Horn and Wolinsky (1988)) which is commonplace in the literature estimating structural bargaining models (see, e.g., Crawford and Yurukoglu (2012), Gowrisankaran, Nevo, and Town (2015), and Ho and Lee (2017)). The first-order condition for a solution to equation (3.3) is

$$b_{1c}\frac{\partial \Pi_t/\partial w_{1ct}}{\Pi_t - \Pi_{-c,t}} + (1 - b_{1c})\frac{\partial \pi_{ct}/\partial w_{1ct}}{\pi_{ct} - \pi_{-1,ct}} = 0. \tag{3.4}$$

In maximizing the Nash product, there will be an effect on the manufacturer's profit due to how changes in wholesale prices affect the equilibrium $\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})$ in the next stage of the game.

Note that in the case where the manufacturer has all the bargaining power, that is, $b_{1c} = 1$, equation (3.4) reduces to the first-order condition for an optimal take-it-or-leave-it contract on w_{1ct} for the manufacturer, whereas in the case of $b_{1c} = 0$, it can be rewritten as the condition for an optimal contract proposed by the chain.

The derivative of the manufacturer's profits with respect to the wholesale price is

$$\frac{\partial \Pi_t\big(\boldsymbol{w}_{1t}, \boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})\big)}{\partial w_{1ct}} = s_{1ct}\big(\boldsymbol{\theta}_t^*\big) + \sum_{\tilde{c}}\left[w_{1\tilde{c}t}\frac{\partial s_{1\tilde{c}t}\big(\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})\big)}{\partial w_{1ct}} + p_{1t}^{I(\tilde{c})}\frac{\partial s_{0\tilde{c}t}\big(\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})\big)}{\partial w_{1ct}}\right],$$

where $\sum_{\tilde{c}}(c_t\frac{\partial s_{1\tilde{c}t}}{\partial w_{1ct}} + c_t\frac{\partial s_{0\tilde{c}t}}{\partial w_{1ct}})$ cancels out because aggregate demand is fixed ($\sum_{\tilde{c}}(\frac{\partial s_{1\tilde{c}t}}{\partial w_{1ct}} + \frac{\partial s_{0\tilde{c}t}}{\partial w_{1ct}}) = 0$), and the derivative of chain c's profits with respect to the wholesale price w_{1ct} is

$$\begin{aligned}\frac{\partial \pi_{ct}\big(w_{0ct}, w_{1ct}, \boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})\big)}{\partial w_{1ct}} &= -s_{1ct}\big(\boldsymbol{\theta}_t^*\big) + (\bar{p}_t - w_{1ct})\frac{\partial s_{1ct}\big(\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})\big)}{\partial w_{1ct}} \\ &\quad + (\bar{p}_t - w_{0ct})\frac{\partial s_{0ct}\big(\boldsymbol{\theta}_t^*(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})\big)}{\partial w_{1ct}}.\end{aligned}$$

In the two expressions above, the derivatives of market shares with respect to wholesale prices will depend on the derivatives of market shares with respect to θ and the derivatives of equilibrium θ values with respect to wholesale prices (detailed formulas are in Appendix B.4).

By denoting the net value of agreement for the manufacturer and chain c respectively as $\Delta_c \Pi_t \equiv \Pi_t - \Pi_{-c,t}$ and $\Delta_1 \pi_{ct} \equiv \pi_{ct} - \pi_{-1,ct}$ and using vector notation for market shares

$\boldsymbol{s}_{0t} = (s_{01t}, \ldots, s_{0Ct})$ and $\boldsymbol{s}_{1t} = (s_{11t}, \ldots, s_{1Ct})$, we can then rewrite equation (3.4) governing the solution to the bargaining between the manufacturer and chain c as

$$s_{1ct} + \boldsymbol{w}'_{1t}\frac{\partial \boldsymbol{s}_{1t}}{\partial w_{1ct}} + \boldsymbol{p}^I_{1t}\frac{\partial \boldsymbol{s}_{0t}}{\partial w_{1ct}} = \frac{1-b_{1c}}{b_{1c}}\frac{\Delta_c \Pi_t}{\Delta_1 \pi_{ct}}\left(s_{1ct} - m_{1ct}\frac{\partial s_{1ct}}{\partial w_{1ct}} - m_{0ct}\frac{\partial s_{0ct}}{\partial w_{1ct}}\right). \tag{3.5}$$

The expression in parentheses on the right-hand side is the (negative of) loss in profits to chain c from a change in the direct import wholesale price, which depends on the reduction in direct import sale from the change in equilibrium $\boldsymbol{\theta}^*_t$, in addition to the gain in parallel import sale. The larger the relative bargaining power of the chain, $\frac{1-b_{1c}}{b_{1c}}$, is and the larger the net value of agreement for the manufacturer relative to that of the chain, $\Delta_c \Pi_t / \Delta_1 \pi_{ct}$, is, the larger the weight given to the (change in) profits of the pharmacy chain when determining the wholesale price.

By letting $s_{j\tilde{c}t\backslash 1c}$ denote the share of chain $\tilde{c}$'s product j in t when direct imports are not available at chain c, we can express the net value for the manufacturer, suppressing arguments $\boldsymbol{\theta}^*_t$, as

$$\begin{aligned}\Delta_c \Pi_t &= \sum_{\tilde{c}}\left[(w_{1\tilde{c}t} - c_t)s_{1\tilde{c}t} + \left(p^{I(\tilde{c})}_{1t} - c_t\right)s_{0\tilde{c}t}\right] - \sum_{\tilde{c}}\left[(w_{1\tilde{c}t} - c_t)s_{1\tilde{c}t\backslash 1c} + \left(p^{I(\tilde{c})}_{1t} - c_t\right)s_{0\tilde{c}t\backslash 1c}\right] \\ &= \sum_{\tilde{c}}\left(w_{1\tilde{c}t}\Delta_{1c}s_{1\tilde{c}t} + p^{I(\tilde{c})}_{1t}\Delta_{1c}s_{0\tilde{c}t}\right),\end{aligned}$$

because $s_{jct\backslash 1c} = 0$, and defining $\Delta_{1c}s_{j\tilde{c}t} \equiv s_{j\tilde{c}t} - s_{j\tilde{c}t\backslash 1c}$ the difference in share of product j in chain $\tilde{c}$ between the case of agreement and disagreement in the negotiations between the manufacturer and chain c.

Similarly, the net value for the chain c is

$$\Delta_1 \pi_{ct} = (\bar{p}_t - w_{1ct})s_{1ct} + (\bar{p}_t - w_{0ct})\Delta_{1c}s_{0ct}.$$

Once the demand shape is identified, together with the optimal behavior of pharmacy chains, the system (3.5) has one equation per molecule-pharmacy chain-period, with in principle one unknown parameter b_{1c}. The system also depends on the wholesale price of drugs earned by the manufacturer in the foreign country $p^{I(c)}_{1ct}$. If $p^{I(c)}_{1ct}$ is known, the system of equations (3.5) allows us to identify the bargaining weight of each pharmacy chain.

3.3.2. *Parallel Importer Behavior*

The full Nash-in-Nash solution is obtained when we also consider the conditions for bargaining between the parallel importer and each of the pharmacy chains.

The parallel importer's profits from its total sales of a drug in the importing market is given by

$$\Pi^{\mathrm{PI}}_t = \sum_c \left(w_{0ct} - p^{I(c)}_{0ct}\right)s_{0ct}\left(\boldsymbol{\theta}^*_t\right),$$

where w_{0ct} is the wholesale price paid for parallel-imported drugs by chain c and $p^{I(c)}_{0ct}$ is the price that the importer has to pay for the drug in the source country, which we allow to vary across chains c for full generality because each chain may use different source countries.

We assume that the parallel importer bargains over the wholesale price with each pharmacy chain c, where they take as given the negotiated wholesale prices of the originator product to each pharmacy chain $\boldsymbol{w}_{1t} = (w_{11t}, w_{12t}, \ldots, w_{1Ct})$. Similar to equation (3.4), the first-order conditions for the solution to the Nash bargaining between each pharmacy chain c and the parallel importer are

$$b_{0c}\frac{\partial \Pi_t^{\mathrm{PI}}/\partial w_{0ct}}{\Pi_t^{\mathrm{PI}} - \Pi_{-c,t}^{\mathrm{PI}}} + (1 - b_{0c})\frac{\partial \pi_{ct}/\partial w_{0ct}}{\pi_{ct} - \pi_{-0,ct}} = 0, \tag{3.6}$$

which, as in Section 3.3.1, can be rewritten using vector notation for prices and market shares stacked over chains c as

$$s_{0ct} + \left(\boldsymbol{w}_{0t} - \boldsymbol{p}_{0t}^{I}\right)' \frac{\partial \boldsymbol{s}_{0t}}{\partial w_{0ct}} = \frac{1 - b_{0c}}{b_{0c}} \frac{\Delta_c \Pi_t^{\mathrm{PI}}}{\Delta_0 \pi_{ct}} \left(s_{0ct} - m_{1ct}\frac{\partial s_{1ct}}{\partial w_{0ct}} - m_{0ct}\frac{\partial s_{0ct}}{\partial w_{0ct}} \right), \tag{3.7}$$

where the left-hand side is the derivative of parallel importer profits with respect to w_{0ct} and where

$$\Delta_c \Pi_t^{\mathrm{PI}} = \Pi_t^{\mathrm{PI}} - \Pi_{-c,t}^{\mathrm{PI}} \quad \text{with } \Pi_{-c,t}^{\mathrm{PI}} = \sum_{\tilde{c} \neq c} \left(w_{0\tilde{c}t} - p_{0\tilde{c}t}^{I(\tilde{c})}\right) s_{0\tilde{c}t\backslash 0c},$$

$$\Delta_0 \pi_{ct} = \pi_{ct} - \pi_{-0,ct} = (\bar{p}_t - w_{1ct})\Delta_{0c} s_{1ct} + (\bar{p}_t - w_{0ct}) s_{0ct}$$

and $\Delta_{0c} s_{1ct}$ corresponds to the change in market share of the direct imports at chain c with and without parallel imports at chain c.

Then one can use these optimality conditions to identify the parallel importer's bargaining parameters b_{0c}, provided that we observe or can model the prices at which imports are paid from the source country $p_{0ct}^{I(c)}$.

4. DATA, IDENTIFICATION, AND EMPIRICAL RESULTS

4.1. *Data and Descriptive Statistics*

We estimate our model on the Norwegian market for atorvastatin, which is a member of the statin drug class used to lower blood cholesterol. It is marketed by Pfizer under the trade name *Lipitor*. The patent expired toward the end of 2011, and the drug was thus under patent for the whole period from 2004 to 2007 covered by our data. The drug comes in four distinct strengths in the Norwegian market: tablets with 10, 20, 40, and 80 milligrams of the active ingredient. The prescription determines which of these strengths the consumer can obtain at the pharmacy, and the pharmacy can freely propose the directly imported or parallel-imported alternatives. Atorvastatin was used by roughly 140,000 individuals in 2004 and 2005, but the number of users dropped to approximately 100,000 in 2006 and 85,000 in 2007.[6] This change is due to a change in the recommendation of statin prescriptions in June 2005, which required simvastatin to be prescribed for all new cases requiring statin treatment and required present users to be put on simvastatin treatment within a year, unless medical considerations dictated otherwise.[7] The motivation for the

[6]The population of Norway was roughly 4.6 million in this period.

[7]More details about this regulatory change can be found in Sakshaug, Furu, Karlstad, Rønning, and Skurtveit (2007).

regulation was to reduce expenditure for the Norwegian National Insurance Administration because the reimbursement price of simvastatin was lower.

We use data on atorvastatin for our structural model estimation while including other prescription drugs under patent for reduced-form evidence. We combine data from several sources: transaction data from the *Norwegian Directorate of Health* covering all purchases of reimbursable drugs by individuals in Norway; wholesale registry data from the *Norwegian Institute of Public Health* containing monthly wholesale prices of drug wholesalers in Norway; data regarding price regulation, substitutability, and parallel marketing licenses from the *Norwegian Medicines Agency*; and data about aggregate wholesale prices in several countries from *IMS Health* (now called IQVIA). We thus have data concerning all purchases of atorvastatin in Norway for the period 2004–2007, which amounts to approximately 1.4 million transactions. The transactions were performed by approximately 170,000 individuals, where a pseudo-ID for each individual allows us to track individual choices over time. For each transaction, we know the price charged for the drug by the pharmacy chain, the copayment paid, the specific pharmacy at which the transaction happened, the number of packages bought, and the specific drug package. The normal treatment for high cholesterol is one tablet per day, and the strength depends on the initial cholesterol rate and type. Given this normal rate of administration, chronic treatment with Lipitor is enough to reach the binding maximum copayment per quarter. Given that most chronic users of Lipitor also consume other drugs, all of them usually reach the maximum copayment for medical drugs, meaning they are marginally fully reimbursed.

Table I shows the yearly size of the atorvastatin market in Norway in millions of *defined daily doses* (DDD), segmented by the amount of active ingredient.[8] We also calculated the parallel import share of DDD within each segment. For 40 and 80 mg, parallel imports often cover a substantial share of the market, constituting approximately 90% of

TABLE I

MARKET SIZE (DDD), SHARE OF PARALLEL IMPORTS, CONSUMERS AND WHOLESALE PRICES[a]

		2004	2005	2006	2007
40 mg	Defined Daily Doses (millions DDD)	23.78	31.22	26.42	29.32
	Share parallel import	0.79	0.48	0.07	0.17
	Consumer Price (p_t)	4.16	4.21	3.82	3.90
	Direct import wholesale price	3.00	3.01	2.71	2.76
	Parallel import wholesale price	2.91	2.93	2.87	2.03
80 mg	Defined Daily Doses (millions DDD)	12.03	20.12	27.38	35.69
	Share parallel import	0.93	0.86	0.96	0.63
	Consumer Price (p_t)	2.15	2.23	1.98	1.97
	Direct import wholesale price	1.55	1.60	1.40	1.39
	Parallel import wholesale price	1.52	1.50	1.38	1.35

[a]Note: Prices in in NOK/DDD.

[8]Our definition of the market includes direct purchases in pharmacies by individuals exclusively. Although there might be some usage of atorvastatin in hospitals—for instance, as part of statin treatment after heart attacks—the numbers in our data are virtually identical to official statistics regarding drug utilization in Norway for aggregate usage of atorvastatin, which leads us to conclude that this usage represents a negligible share of sales.

the 80 mg segment in the period 2004–2006.[9] The reason for the differences in parallel import shares is likely a combination of differences in parallel export opportunities, differences in profitability across parallel import locations and differences in the relative price in the source country and Norway. The online Appendix B.11 shows evidence across all products without the presence of a generic on the correlation between parallel import entry and the source countries wholesale prices in NOK that vary with exchange rate shocks. We use our model to explain the parallel imports market shares for markets in which they are present, which are the ones that we use in our estimation regarding upstream manufacturer and importer behavior.

The price to consumers reflects the regulatory price ceiling set by the Norwegian Medicines Agency, as all packages—both parallel and direct imports—are consistently priced at the price ceiling. From the wholesale prices, we see that the aggregate margin is larger for parallel imports in all cases (the exception for 40 mg in 2006 is due to the average being taken over the full year for direct imports but only for part of the year for parallel imports because the reduction in the price ceiling early that year allowed parallel importers to withdraw[10] from the market (see Figure 4)).

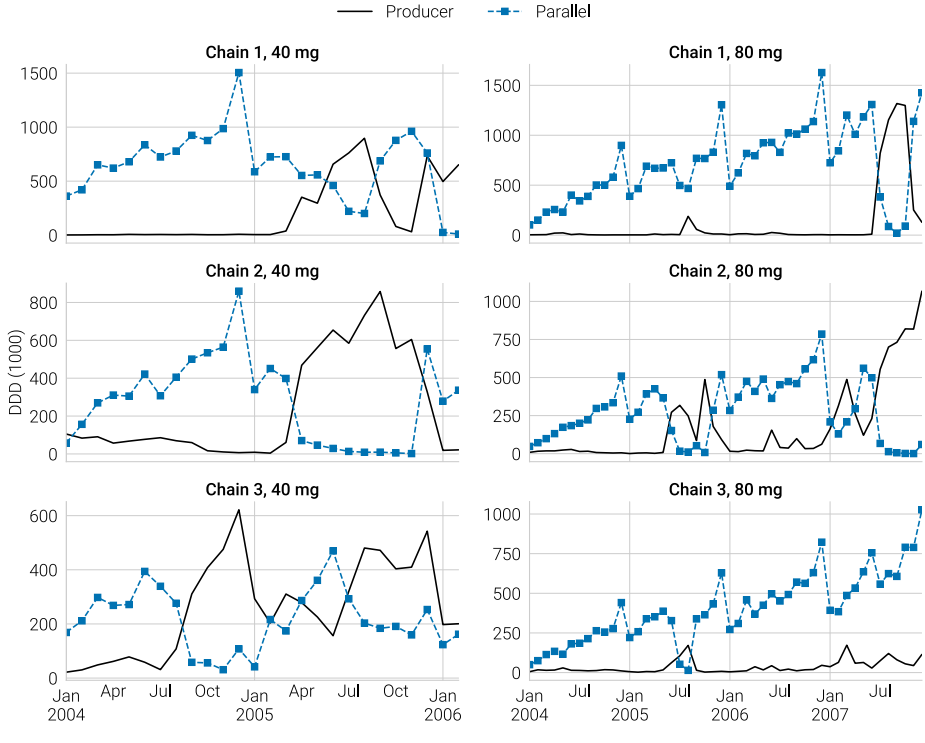

FIGURE 4.—Monthly sales in 1000 DDD of DI and PI for each chain and dosage.

[9]Parallel imports only entered in 2007 with very small market shares for the 10 and 20 mg dosage forms.

[10]In 2007, there were again some parallel imports for the 40 mg market but only in one chain, not the three, as was generally the case for 2004–2006 for the 40 mg period and for the full period for the 80 mg. Our model is still valid when not all chains use parallel imports, but we did not include this market and period in our sample period of estimation. Including 2007 data for the 40 mg market in our estimation sample is unlikely to change the results of the bargaining parameters estimates significantly.

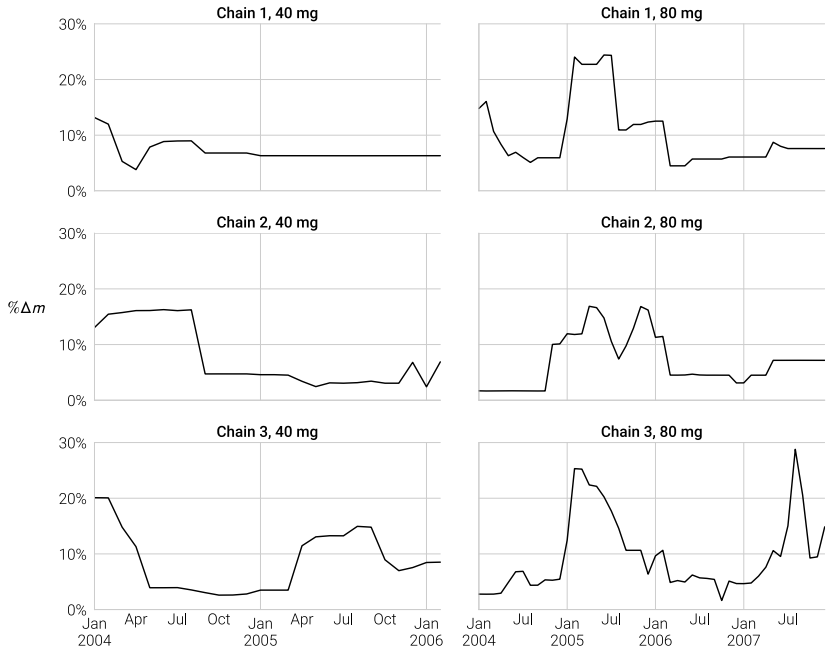

FIGURE 5.—Margin difference between PI and DI in percentage of DI wholesale price.

Pfizer holds the patent and is responsible for the direct imports, whereas Farmagon and Orifarm are parallel importers. The parallel importers have licenses to import from the United Kingdom, France, Czech Republic, and Poland. Parallel-imported drugs are repackaged by the parallel importer to be in accordance with specific national guidelines on package labels, language, and warnings.

Figure 4 shows monthly sales of parallel imports and the manufacturer (Pfizer) in thousands of DDD for each segment and pharmacy chain. These graphs show the important variation over time, products, and chains of the parallel import or direct import sales.

Figure 5 shows the percentage margin difference between parallel and direct imports separately for each segment and pharmacy chain. As the consumer price is always equal to the price cap for both the directly and parallel-imported varieties, the retail pharmacist margin difference between parallel and direct imports is exactly equal to the wholesale prices difference of parallel and direct imports. Margins of parallel imports are consistently higher than direct imports because wholesale prices are consistently lower than the direct import wholesale price.

Figure 4 shows that the sales of the 40 mg version of parallel imports are more important than sales of direct imports and that the former grew over time during 2004 across the three chains. However, they decreased strongly after that period for chains 1 and 2, as the margin advantage of parallel imports decreased simultaneously in 2005 for both chains, as seen in Figure 5. For chain 3, the parallel import sales decreased earlier in the second part of 2004, when their margins decreased relative to those of direct imports, but during 2005, unlike in those in chains 1 and 2, parallel import sales in chain 3 increased again and exhibited at the same time a growing margin compared to direct imports. For the 80 mg version, parallel imports dominated sales over direct imports, except at the end of 2007 for chain 2 and temporarily for chain 1. These figures show that sales of Lipitor vary significantly over time between parallel and direct imports.

4.2. *Reduced-Form Evidence*

To further investigate the descriptive evidence of correlation between pharmacy margins and sales of different versions of the same drug, we perform a set of reduced-form regressions showing that sales of parallel imports do react to the pharmaceutical chain margins. We do so for all prescription drugs under patent for which there is substantial parallel imports over the period 2004–2007 as well as for Lipitor only, which is the product market for which we estimate our structural model. As s_{kjct} stands for the market share of drug j version k in pharmacy chain c at month t (where $\sum_{c\in\{1,\ldots,C\},k\in\{0,1\}} s_{kjct} = 1$), we regress the log relative within-chain share of direct imports ($\ln(s_{1jct}/(s_{0jct} + s_{1jct}))$) on the margin of the pharmacy chain for each version k.

Table II below shows that the margins of parallel imports and direct imports of the pharmacy chain affect the relative sales of each version within the chain in a way suggesting that pharmacy chains manage to steer sale towards the most profitable version of the drug.

The regressions in columns (1) and (2) are for all prescription drugs under patent for which there is substantial parallel imports and (3) and (4) are for Lipitor only. In the case of Lipitor only, drug class (ATC5) fixed effects are useless as the regression is done on one product only. These regressions show that the larger the parallel import margin is and the lower the direct import margin is, the larger the sales of parallel imports versus direct imports. As patients' unobserved preferences for one version over the other could change over time (e.g., because of demographics) and be observed by the pharmacy chain, wholesale price negotiations could lead to margins correlated with these unobserved preferences. We therefore instrument margins in a two-stage least squares regression in columns (2) and (4) using as instruments the average quarterly wholesale prices of the drug in Czech Republic, France, Germany, Italy, Spain, and the UK, in addition to the NOK exchange rates with US dollar, Euro, UK pound, Czech koruna, and Swiss Franc. Costa-Font (2016) found a similar effect using data from the Netherlands by regressing the market share of parallel imports of statins on price differences in source countries and other distance variables, showing that they are driven by cross-country differences in margins. We thus have clear evidence that strategic behavior of pharmacies allows them to sell more of the drugs for which they have a higher margin. The trade-off mechanism ex-

TABLE II

REDUCED FORM EVIDENCE OF RELATIONSHIP BETWEEN PARALLEL IMPORTS AND PHARMACY MARGINS[a]

	All Prescription Drugs		Lipitor Only	
Dependent Variable ($\ln \frac{s_{1jct}}{s_{0jct}+s_{1jct}}$)	(OLS) (1)	(2SLS) (2)	(OLS) (3)	(2SLS) (4)
Direct imports margin m_{1jct}	0.013	0.052	1.863	2.433
	(0.043)	(0.014)	(0.574)	(0.602)
Parallel imports margin m_{0jct}	−0.058	−0.035	−0.244	−0.572
	(0.013)	(0.009)	(0.070)	(0.119)
Chain-year fixed effects	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes
ATC5 fixed effects	Yes	Yes	No	No
N	3333	3333	574	574

[a]Notes: Standard errors in parenthesis are clustered at the molecule level in columns (1) and (2) and at market level in columns (3) and (4).

hibited in our model is consistent with these findings, predicting that pharmacies will sell even more of the high-margin version of the drug when the margin difference increases.

Similarly, Brekke, Holmås, and Straume (2013) showed that in the case of off-patent drugs, the share of generics versus the originator brand are related to pharmacy-chain margins even controlling for (consumer) price differences. This shows that pharmacies manage to steer patients to choose the higher margin product when substitution is possible.

Moreover, we also show that pharmacy chains' margins and profits increase with the entry of parallel imports. Table X in Appendix A.3 shows a positive correlation between the presence of parallel imports for a given product, chain, and time period, and the total profit or average margin across the DI and PI versions of the drug in chain c at period t. Instrumenting the presence of PI for a given product with the wholesale price in source countries and exchange rates, the two stage least squares regressions show a strong positive and significant effect. This shows that pharmacy chains can use parallel import to increase profit.

4.3. *Econometric Identification and Estimation*

Our structural model of demand and supply can be estimated using data regarding consumer choices between parallel trade and directly imported versions of a drug and data about the pharmacy retail chain margins or wholesale prices. We first show how to estimate the discrete choice model developed in Section 3.1, in which consumers choose between pharmacy chains and direct versus parallel-imported drugs. Our random utility model resembles a classic random coefficients discrete choice model, although with the difference that random utilities depend on pharmacies' unobserved strategic choices on assortment of parallel trade versus direct imported drugs. To address this issue, we simultaneously estimate preference parameters and the assortment set probabilities of pharmacy chains using the profit maximization conditions explained in Section 3.2 in the likelihood function as shown below. In a second step, we use the estimated parameters to identify the bargaining parameters using the vertical chain bargaining model developed in Section 3.3.

4.3.1. *Demand Identification With Consumer and Pharmacy Chain Behaviors*

From the discrete choice demand model described in Section 3.1, the individual choice probability for consumer i choosing version $j \in \{0, 1\}$ at pharmacy chain c and period t is given by

$$s_{ijct}(\boldsymbol{\theta}_t) = s_{ict} s_{ijt|c} = \frac{e^{V_{i0ct}+\theta_{ct}\delta_{ict}}}{\sum_{\tilde{c}} e^{V_{i0\tilde{c}t}+\theta_{\tilde{c}t}\delta_{i\tilde{c}t}}} \left(1_{\{j=0\}} + (-1)^{1_{\{j=0\}}} \theta_{ct} \frac{e^{V_{i1ct}/\lambda_c}}{e^{V_{i0ct}/\lambda_c} + e^{V_{i1ct}/\lambda_c}}\right), \tag{4.1}$$

where $\delta_{ict} = \lambda_c \ln(1 + e^{(V_{i1ct}-V_{i0ct})/\lambda_c})$. We specify individual i's utility from product version j bought at pharmacy chain c in market t as

$$V_{ijct} = \alpha_{jct} + \nu_{ijct},$$

where α_{jct} is the average utility in market t for product j at chain c, common to all individuals, and ν_{ijct} is the individual deviation from the mean utility for that good, capturing heterogeneity in consumers' tastes. Just as there is typically significant heterogeneity

in preferences for generics related to education (Bronnenberg, Dubé, Gentzkow, and Shapiro (2015)), a similar source of unobserved heterogeneity is possible for parallel imports. In our setting, unobserved heterogeneity in the consumers' distances to stores, for example, could be important, as could other chain-specific variation in preferences. Since the common mean effects α_{jct} vary freely across version-chain-market, they can capture unobserved market effects for each product in addition to chain effects.

We allow a flexible distribution of preferences modeling ν_{ijct} as a mixture of normal distributions as

$$\nu_{ijct} = \underbrace{\delta_j^{g_i} + \sigma_j^{g_i}\nu_i^j}_{\text{Drug version specific taste}} + \underbrace{\delta_c^{g_i} + \sigma_c^{g_i}\nu_i^c}_{\text{Pharmacy specific taste}}, \tag{4.2}$$

where ν_i^k is individual i's taste characteristics for characteristic k, which is either the product version j or a specific chain c; $g_i \in \mathcal{G}$ denotes the latent group of i; and $\mathcal{G}$ is the set of groups in the population. We assume that ν_i^k obeys a standard normal distribution in the population with $\delta_k^{g_i}$ as the mean deviation in taste for k for individuals in this group and $\sigma_k^{g_i}$ as the standard deviation of this individual heterogeneity. After some initial estimates and tests with a growing number of latent classes, we allow four latent classes, where one is arbitrarily chosen as the base group, $g = 0$ with $\delta_j^0 = \delta_c^0 = 0$.[11] Each group g has a population share τ_g to be estimated in the likelihood. We denote by $\boldsymbol{\beta} = (\delta_j^g, \sigma_j^g, \delta_c^g, \sigma_c^g, \lambda_1, \ldots, \lambda_C, \tau_1, \ldots, \tau_G)$ the full vector of parameters governing heterogeneous preferences.

Then, the likelihood of individual i's choice sequence is given by

$$L_i(\boldsymbol{\beta}; \alpha_{0ct}, \alpha_{1ct}, \theta_{ct}) = \sum_{g\in\mathcal{G}} \tau_g \int \left(\prod_{p\in\mathcal{P}_i} s_{ij(p)c(p)t(p)}(\boldsymbol{\nu}_i) \right) dF(\boldsymbol{\nu}_i|\boldsymbol{\beta}), \tag{4.3}$$

where $\mathcal{P}_i$ is the set of purchase events of consumer i, $j(p)$ and $c(p)$ denote consumer i's choice of product and chain under purchase event p, and $t(p)$ is the market in which purchase event p happens. Thus, $s_{ij(p)c(p)t(p)}(\boldsymbol{\nu}_i)$ is individual i's choice probability conditional on his unobserved heterogeneity $\boldsymbol{\nu}_i \equiv (\nu_i^j, \nu_i^c)$ and $F(\boldsymbol{\nu}_i|\boldsymbol{\beta})$ is the cumulative distribution function of $\boldsymbol{\nu}_i$.

As the parameters θ_{ct} are unobserved, we use the pharmacy chains' Nash equilibrium to solve for them within the likelihood calculation which gives us a nested fixed-point algorithm as follows.

Inner Loop for Given Preference Parameters $\boldsymbol{\beta}$. We first find the mean preference parameters α_{jct} and the choice set parameters θ_{ct} that satisfy the conditions necessary for Nash equilibrium across pharmacy chains and the equality condition between observed and simulated market shares given the vector of parameters $\boldsymbol{\beta}$.

For a given vector $(\boldsymbol{\theta}_t, \boldsymbol{\beta})$, we know from Berry (1994) and Berry, Levinsohn, and Pakes (1995) that one can solve for all $\alpha_{0ct}, \alpha_{1ct}$ such that for all j, c:

$$\hat{s}_{jct} = s_{jct}(\boldsymbol{\theta}_t, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta}), \tag{4.4}$$

[11]This normalization is necessary for identification since the α_{jct} average utility parameters will pin down the baseline mean utility of version and chain across the unobserved groups.

where the simulated shares are

$$s_{jct}(\boldsymbol{\theta}_t, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta}) = \sum_i s_{ijct} = \sum_i \sum_{g \in \mathcal{G}} \tau_g \int s_{ijct}(\boldsymbol{\nu}_i)\, dF(\boldsymbol{\nu}_i|\boldsymbol{\beta}).$$

Therefore, we can uniquely define $\alpha_{0ct}(\boldsymbol{\theta}_t, \boldsymbol{\beta})$, $\alpha_{1ct}(\boldsymbol{\theta}_t, \boldsymbol{\beta})$ that are continuous in all θ_{ct}. Then, for any α_{0ct}, α_{1ct} we assume that there exists a Nash equilibrium in $\boldsymbol{\theta}_t$ across the chains so that we can define $\theta_{ct}(\boldsymbol{\alpha}_{0t}, \boldsymbol{\alpha}_{1t}, \boldsymbol{\beta}) \in [0, 1]$ that solves for all c:

$$\theta^*_{ct} = \underset{0 \le \theta_{ct} \le 1}{\arg\max}\, \pi_{ct}\big(m_{0ct}, m_{1ct}, \boldsymbol{\theta}^*_{-ct}, \theta_{ct}, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta}\big) \tag{4.5}$$

with $\pi_{ct}(m_{0ct}, m_{1ct}, \boldsymbol{\theta}_t, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta}) \equiv m_{0ct} s_{0ct}(\boldsymbol{\theta}_t, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta}) + m_{1ct} s_{1ct}(\boldsymbol{\theta}_t, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta})$.[12]

For each pharmacy chain c, the profit function π_{ct} is continuous in all θ_{ct}, the best response of each chain is well-defined, and we only require best response functions to cross. We will assume this is the case, which can be verified empirically. $\theta_{ct}(\boldsymbol{\alpha}_{0t}, \boldsymbol{\alpha}_{1t}, \boldsymbol{\beta}) \in [0, 1]$ are continuous in all α_{0ct}, α_{1ct} because $\pi_{ct}(\boldsymbol{\theta}_t, \alpha_{0ct}, \alpha_{1ct}, \boldsymbol{\beta})$ is continuous in all θ_{ct} that belong to [0,1]. Then, assuming that the image of $[0, 1]^C$ by $\boldsymbol{\theta}_t(\boldsymbol{\alpha}_{0t}(\cdot, \boldsymbol{\beta}), \boldsymbol{\alpha}_{1t}(\cdot, \boldsymbol{\beta}), \boldsymbol{\beta})$ is $[0, 1]^C$, we can use Brouwer's fixed-point theorem and obtain that there is a vector $\boldsymbol{\theta}_t$ that is solution of

$$\boldsymbol{\theta}_t\big(\boldsymbol{\alpha}_{0t}(\boldsymbol{\theta}_t, \boldsymbol{\beta}), \boldsymbol{\alpha}_{1t}(\boldsymbol{\theta}_t, \boldsymbol{\beta}), \boldsymbol{\beta}\big) = \boldsymbol{\theta}_t.$$

This proves that there is a vector $(\boldsymbol{\alpha}_{0t}(\hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}, \boldsymbol{\beta}), \boldsymbol{\alpha}_{1t}(\hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}, \boldsymbol{\beta}), \boldsymbol{\theta}_t(\hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}, \boldsymbol{\beta}))$ solution of (4.4) and (4.5). At this step, we can search for the possibility of multiple solutions over the support of θ, which has the advantage of being bounded below and above.[13]

Outer Loop Maximizing the Likelihood in $\boldsymbol{\beta}$. We then maximize in $\boldsymbol{\beta}$ the likelihood function

$$\begin{aligned} &L_i(\boldsymbol{\beta}; \hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}) \\ &\quad = L_i\big(\boldsymbol{\beta}; \boldsymbol{\alpha}_{0t}(\hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}, \boldsymbol{\beta}), \boldsymbol{\alpha}_{1t}(\hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}, \boldsymbol{\beta}), \boldsymbol{\theta}_t(\hat{\boldsymbol{s}}_t, \boldsymbol{m}_{0t}, \boldsymbol{m}_{1t}, \boldsymbol{\beta})\big). \end{aligned} \tag{4.6}$$

The estimation routine is a nested fixed-point algorithm, where we solve for the parameters $\boldsymbol{\alpha}_{0t}(\boldsymbol{\beta})$, $\boldsymbol{\alpha}_{1t}(\boldsymbol{\beta})$, and $\boldsymbol{\theta}_t(\boldsymbol{\beta})$ conditional on the current value of $\boldsymbol{\beta}$ in the inner loop, while searching for the parameter vector $\boldsymbol{\beta}$ that maximizes the log likelihood in the outer loop.

These optimal choices of θ_{ct} mean that they can be expressed as functions of the vector of margins or wholesale prices, $\theta^*_{ct}(\boldsymbol{m}_{0t}, \boldsymbol{m}_{1t})$ or $\theta^*_{ct}(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})$, in addition to being functions of the mean utility parameters α_{jct} and the vector $\boldsymbol{\beta}$. The identification of the demand model is given by the properties of the likelihood (4.3) but does not want to rely on its functional form with the assumption that margins $(\boldsymbol{m}_{0t}, \boldsymbol{m}_{1t})$ (or equivalently wholesale prices $(\boldsymbol{w}_{0t}, \boldsymbol{w}_{1t})$) vary independently of preferences $(\boldsymbol{\alpha}_{0t}, \boldsymbol{\alpha}_{1t})$. We could allow the heterogeneity of preferences (4.2) to be time-varying provided that we also assume that the variability of margins $(\boldsymbol{m}_{0t}, \boldsymbol{m}_{1t})$ is independent of the varying heterogeneity of preferences. We do not do so for simplicity and because of the already large time flexibility

[12] We do not need to assume unicity, and we numerically search for possible multiple equilibria.

[13] We provide details about our numerical procedure corresponding to the inner loop algorithm in the online Appendix B.6.

introduced by the mean preferences $(\boldsymbol{\alpha}_{0t}, \boldsymbol{\alpha}_{1t})$. Then, observing individual choice variation across choice occasions gives us considerable identifying power with respect to mean preferences $\boldsymbol{\alpha}_{0t}$, $\boldsymbol{\alpha}_{1t}$, as individuals have time-invariant heterogeneity of preferences.

Even if there are many parameters since we have $(\alpha_{0ct}, \alpha_{1ct}, \theta_{ct})$ for each chain-market combination, by utilizing the fact that these parameters are common across consumers within each chain-market, they can be solved for by a simpler root-finding algorithm, conditional on the parameter vector $\boldsymbol{\beta}$. The intuition is that within each market t, these parameters can be set such that observed market shares are equal to predicted aggregate shares and such that the conditions for chain profit maximization hold.

Finally, we note that the corner solutions of $\theta_{ct}(\boldsymbol{\beta}) = 1$ allow some independent variation of the likelihood in parameters $\boldsymbol{\beta}$ not coming from the changes in θ_{ct} driven by $\boldsymbol{\beta}$ when θ_{ct} is interior. This intuitively allows us to separately identify the effect of preferences from the effect of choice sets. Intuitively, θ_{ct} will be equal to one when the margins for each version of the drug are sufficiently similar given the region of preference parameters $\boldsymbol{\beta}$, and the individual choices will vary only because of preferences.

4.3.2. *Identifying Bargaining in the Supply-Side Model*

We now use the vertical structure competition game developed in Section 3.3 to identify the supply-side parameters of the model. The objective is to identify all the bargaining parameters b_{0c} and b_{1c}, respectively, for the parallel importer and the manufacturer negotiation with each pharmacy chain c.

The optimality conditions (3.5) and (3.7) of the bargaining game between the manufacturer or the parallel importer and pharmacy chains relate demand and bargaining parameters to the source country opportunity costs of drugs for the parallel importer $(\mathbf{p}^I_{0t})$ and the manufacturer $(\mathbf{p}^I_{1t})$. We note that all $p^{I(c)}_{0ct}$ and $p^{I(c)}_{1t}$ can be different because of the costs related to packaging and extra logistics when importing from source countries and the pricing between the manufacturer, the source-country wholesaler, and the parallel importer. We assume that parallel importers' costs $(\mathbf{p}^I_{0t} = (p^{I(1)}_{01t}, \ldots, p^{I(C)}_{0Ct}))$ and the source countries' wholesale prices of the manufacturer $(\mathbf{p}^I_{1t} = (p^{I(1)}_{1t}, \ldots, p^{I(C)}_{1t}))$ are functions of observables X_t, such as the wholesale prices in the source countries, company-fixed effects for the manufacturer or parallel importer, and interactions with source country prices. With $\mathbf{p}^I_{0t}$ and $\mathbf{p}^I_{1t}$ from the optimal bargaining equations (3.4) and (3.6), stacked in the vector $\mathbf{p}^I_t = (\mathbf{p}^I_{0t}, \mathbf{p}^I_{1t})$ for each market t, we specify

$$\mathbf{p}^I_t(\mathbf{b}) = X_t\eta + \boldsymbol{\epsilon}_t,$$

where $\mathbf{b}$ is the vector of bargaining parameters $\mathbf{b} = (b_{01}, \ldots, b_{0C}, b_{11}, \ldots, b_{1C})$.

Then we assume that we observe instrumental variables Z_t such that $E[\boldsymbol{\epsilon}_t|Z_t] = 0$ and identify the parameter vector $(\eta, \mathbf{b})$ using the moment condition $E[\boldsymbol{\epsilon}(\eta, \mathbf{b})|Z] = 0$. The excluded instruments in Z_t include indicators for pharmacy chain identity, exchange rates NOK/$US, NOK/€, NOK/CZK, interactions of exchange rates with indicators for parallel trade and the inclusive value of the upstream firm (derived from the demand model) interacted with upstream firm type. We use the sample analogs of moment conditions $E[Z'\boldsymbol{\epsilon}(\eta, \mathbf{b})] = 0$, with a weighting matrix W such that our GMM estimator is

$$(\hat{\eta}, \hat{\mathbf{b}}) = \arg\min_{\eta, \mathbf{b}} \boldsymbol{\epsilon}(\eta, \mathbf{b})' Z W Z' \boldsymbol{\epsilon}(\eta, \mathbf{b}). \tag{4.7}$$

The intuition for identifying the bargaining parameters in light of the instrument set is that pharmacy chain identity should be informative about the overall bargaining strength

of the chain while being plausibly uncorrelated with unobserved determinants of costs related to parallel trade. We thus preclude the possibility that sorting of parallel importers across pharmacy chains is related to the costs of parallel trade.[14] The inclusive value of an upstream firm is the (average) log-sum of exponential utility for each upstream firm in the market. This instrument is derived from the demand model, and measures of how "valuable" the firm's presence is to consumers in the market. Gowrisankaran, Nevo, and Town (2015) used this type of instrument, namely, a "predicted willingness-to-pay for the hospital" when estimating the bargaining weights between hospitals and Managed Care Organizations in the US. In our case, these inclusive values measure the willingness of customers to pay for parallel imports or direct imports; they are estimated using the consumer choice model and can explain why the manufacturer or parallel importer may be able to negotiate better wholesale prices with the pharmacy chain, thus serving to identify bargaining weights.

4.4. *Estimation Results of the Structural Model*

As our data contain a very large amount of choices, we draw a random sample of 50,000 individuals from the full sample for estimating the individual choice model. We also restrict our attention to the markets for the 40 and 80 mg versions, as parallel imports only entered late in our period of analysis for the 10 and 20 mg strengths, so we do not have sufficient data for a careful estimation.

Demand Estimates. The maximum simulated likelihood estimates of the demand model are presented in Tables III and IV. Table III presents the preference parameters except all the mean parameters α_{jct}. The mean utility preferences of baseline group ($g = 0$) are normalized to zero. The statistical and economic significance of parameters governing preferences of unobserved discrete groups shows that the finite mixture of normal specification of preferences is better than a simple random coefficient distribution of preference. Moreover, it shows a pattern in which each group has a stronger relative preference for each of the pharmacy chains, which can be interpreted by the many unobserved factors—such as travel distance or chain-store preference—that would matter in consumers choices. All λ_c parameters are in the $(0, 1)$ interval as should be the case. With our estimates, we can simulate the average probability that an individual would choose direct imports versus parallel imports if free to choose. Figure 6 presents the distribution of this probability across markets (dosage-months), clearly showing the average preferences of consumers for direct imports.

Table IV presents the distribution of the estimates of the chain-market specific choice set probabilities θ. These estimates show that θ varies across markets and chains and are on average between 0.58 and 0.82 for the 40 mg market and between 0.39 and 0.67 for the 80 mg one. The estimates also show that there are many corner solutions for which θ is equal to one, meaning that both parallel imports and direct imports are always proposed by that chain in a given market (dosage-month combination). The median and 25% and 75% quantiles show that for some years, more than half of market-chains have $\theta_{ct} = 1$. Looking at chains' behavior, chain 1 performs significant foreclosure of direct imports in 2004, whereas chain 2 never does, and chain 3 does moderately for the market for

[14]The costs here are interpretable as both the total costs of parallel traders, for example, procurement and handling, sales value in the source country, and differences in import costs between Norway and the source country.

TABLE III

PARAMETER ESTIMATES FOR CONSUMER CHOICE MODEL WITH SUPPLY CONSTRAINTS[a]

Latent Groups	$g=0$	$g=1$	$g=2$	$g=3$
τ_g	0.07 –	0.26 (0.00)	0.29 (0.00)	0.38 (0.00)
Drug version specific taste $(\delta_j^g + \sigma_j^g \nu_i^j)$				
δ_0^g	0.00 –	0.53 (0.04)	−0.35 (0.04)	−0.39 (0.04)
σ_0^g	0.22 (0.13)	0.02 (0.83)	0.98 (0.01)	0.81 (0.02)
Chain specific taste $(\delta_c^g + \sigma_c^g \nu_i^c)$				
δ_2^g	0.00 –	4.09 (0.03)	1.94 (0.05)	−4.30 (0.11)
δ_3^g	0.00 –	−0.97 (0.12)	6.46 (0.07)	−3.80 (0.10)
σ_2^g	3.01 (0.13)	6.50 (0.23)	7.96 (0.10)	2.67 (0.13)
σ_3^g	2.75 (0.16)	3.27 (0.13)	3.59 (0.07)	2.52 (0.13)
$\lambda_1, \lambda_2, \lambda_3$		0.32, 0.54, 0.54 (0.01), (0.01), (0.01)		
$\ln \mathcal{L}(\hat{\beta})$		−168,093		
N		50,000		

[a]Note: one observation is a choice sequence of transactions by an individual. Standard errors in parentheses. The drug version specific taste is for parallel imports, and the reference is for direct imports. All α_{0ct}, α_{1ct} jointly estimated are not shown, whereas θ_{0ct}, θ_{1ct} are presented in Table IV.

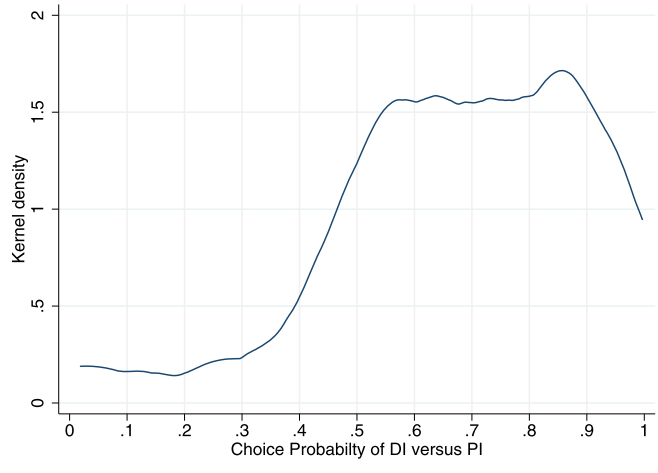

FIGURE 6.—Distribution across markets of probability to choose any DI versus any PI. Note: Probability to choose direct versus parallel imports if free to choose across the three chains and predicted from demand parameters estimates and averaged across latent groups.

TABLE IV

FORECLOSURE PARAMETER ESTIMATES θ_{ct}[a]

		Strength						
		40 mg			80 mg			
Chain	Year	2004	2005	2006	2004	2005	2006	2007
	Mean	0.008	0.522	0.404	0.037	0.041	0.016	0.358
	25% percentile	0.006	0.081	0.004	0.007	0.007	0.006	0.005
1	Median	0.007	0.632	0.012	0.020	0.010	0.011	0.106
	75% percentile	0.010	0.880	1.000	0.035	0.020	0.024	0.858
	Mean std. err.	(0.180)	(0.346)	(0.105)	(0.263)	(0.055)	(0.148)	(0.203)
	Mean	1.000	1.000	0.437	1.000	0.839	1.000	1.000
	25% percentile	1.000	1.000	0.018	1.000	0.979	1.000	1.000
2	Median	1.000	1.000	0.152	1.000	1.000	1.000	1.000
	75% percentile	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Mean std. err.	(0.234)	(0.052)	(0.182)	(0.111)	(0.143)	(0.041)	(0.042)
	Mean	0.756	0.962	1.000	1.000	0.302	0.847	0.502
	25% percentile	0.438	1.000	1.000	1.000	0.035	1.000	0.208
3	Median	1.000	1.000	1.000	1.000	0.055	1.000	0.308
	75% percentile	1.000	1.000	1.000	1.000	0.414	1.000	1.000
	Mean std. err.	(0.062)	(0.147)	(0.052)	(0.347)	(0.155)	(0.310)	(0.333)
	Mean	0.588	0.828	0.613	0.679	0.394	0.621	0.62
	25% percentile	0.010	0.835	0.015	0.042	0.016	0.029	0.20
All chains	Median	1.000	1.000	1.000	1.000	0.064	1.000	1.00
	75% percentile	1.000	1.000	1.000	1.000	1.000	1.000	1.00
	Mean std. err.	(0.159)	(0.182)	(0.113)	(0.240)	(0.118)	(0.166)	(0.193)

[a]Note: The last row of each panel estimates lists the mean across markets of estimated standard errors of θ_{ct}. The standard errors of each θ_{ct} are obtained using their censored normal asymptotic distributions, as described in Appendix B.5.

the 40 mg dosage. In 2005, the picture is similar for the 40 mg market, with a bit less foreclosure of direct imports by chain 1, but on the 80 mg market, chains 2 and 3 start engaging in some foreclosure. In 2006, chain 2 starts performing foreclosure on the 40 mg market but still does not do so on the 80 mg market. Chain 1 continues quite substantial foreclosure in 2006 and 2007, whereas chain 3 does less in 2006 but a bit more in 2007. The fact that the chains have different strategies in θ_{ct} can be explained by the fact that they have different margins and possibly different tastes by consumers (α_{kct}) which are unrestricted and can depend on geographic location of stores (for example). In the case of 40 mg dosage, chain 1 indeed has wholesale margins for parallel imports, which are on average 0.39 NOK higher than for direct imports while for chain 2 it is 0.21 NOK and for chain 3 it is 0.16 NOK. For the 80 mg dosage, chain 1 indeed has wholesale margins for parallel imports that are on average 0.06 NOK higher than for direct imports while for chain 2 it is 0.04 NOK and for chain 3 it is 0.06 NOK. There is variation over time, but these averages are consistent with the fact that chains have different strategies. Of course, margins are endogenously determined, and our model also allows us to rationalize the margins determination with bargaining over wholesale price with the parallel traders and the manufacturer. The equilibrium margins depend on consumers' preferences (α_{kct}), the bargaining parameters and the shocks in source countries' wholesale prices. We also report the mean across chains and markets of the estimated standard errors of θ_{ct}, which show that they are precisely estimated.

TABLE V

BARGAINING PARAMETER ESTIMATES (GMM)[a]

	Manufacturer b_{1c}	Parallel Importer b_{0c}
Pharmacy Chain 1	0.95 (0.02)	0.50 (0.38)
Pharmacy Chain 2	0.55 (0.12)	0.26 (0.41)
Pharmacy Chain 3	0.67 (0.14)	0.32 (0.36)

[a]Note: Standard errors in parenthesis. Estimates of GMM equation (4.7), where X_t includes UK and Czech Republic Lipitor wholesale price interacted with indicator for parallel imports and excluded instruments in Z_t are exchange rates NOK/$US, NOK/€, NOK/CZK interacted with indicator for parallel trade and the inclusive value of the upstream supplier interacted with upstream supplier type (DI or PI).

Bargaining Model Estimates. The estimates of the bargaining parameters in Table V follow the method presented in Section 4.3.2, using the demand model estimates of Tables III and IV. Note that the constraint that bargaining parameters should be between 0 and 1 is not imposed in our estimation. The GMM estimates of equation (4.7) are obtained using the Lipitor wholesale price in the UK and the Czech Republic converted to NOK per DDD, both interacted with an indicator for parallel imports as explanatory variables X_t, and instruments Z_t that (in addition) include excluded variables such as indicators for chain identity and upstream firm type (parallel trader versus manufacturer), exchange rates NOK/$US, NOK/€, NOK/CZK, interactions of exchange rates with indicators for parallel trade and the inclusive value of the upstream firm interacted with upstream firm type.

From these estimates, we can see that (perhaps unsurprisingly) the parallel importers on average wield a smaller bargaining weight than the manufacturer. Pharmacy retailers, which are concentrated in Norway, constitute an important gatekeeper for parallel trade companies that want to export to Norway. Among the three pharmaceutical retailing chains, chain 2 is the international company Boots that retails drugs in a few other European countries such as the UK, Ireland, the Netherlands, but is absent in France and other Southern European countries that are typically source countries for parallel trade. It is thus unlikely that international retail pharmacists like Boots can influence parallel trade bargaining because of their presence in source countries. However, the fact that Boots also resells Pfizer products in the UK in addition to Norway can have some effect in their bargaining power with respect to the manufacturer. Taking this as given may explain why chain 2 (Boots) has the higher bargaining parameter with respect to the manufacturer while it does not have the highest market share in Norway.

We also use the Nash-bargaining equation (A.4) shown in Appendix A.2 for one of the main source countries (France) to identify the marginal cost of production c_t, instead of price constraints as in Dubois and Lasio (2018). Indeed, since aggregate demand (adding PI and DI) is constant in Norway, the cost of production is immaterial to the change in manufacturer profit in Norway and the marginal cost c_t is indeed absent from the Norwegian Nash-in-Nash equilibrium conditions. Details on demand estimates in France, which is an important source country for Lipitor in Norway, are provided in the online Appendix B.10.

5. COUNTERFACTUAL SIMULATIONS

Using our estimated model, we study several counterfactual policies. The first counterfactual of interest investigates the effect of parallel trade on firms' profits and consumer welfare by comparing the current situation with the counterfactual equilibrium where parallel trade is absent. Then we consider a hypothetical regulation of pharmacies that would remove their possibility to foreclose the choice of direct imports to consumers. Finally, we implement a counterfactual in which we also decrease the retail price of Lipitor by 20%. In the last two counterfactuals, we take into account nonnegative profit conditions for parallel traders, allowing exit but not entry as this is unlikely to happen given that we model counterfactuals where parallel traders are in general worse off. Both a ban on direct import foreclosure and a retail price decrease in Norway tend to reduce parallel trade. Entry of new parallel traders would be more likely if we were modeling the effects of a price increase in Norway or a policy change which would reduce the price in one of the source countries.

5.1. *The Impact of Parallel Trade*

We simulate a counterfactual situation in which parallel imports are banned, and direct imports therefore capture all demand. As observed retail prices are equal to the regulated price ceilings even when parallel imports are present, retail prices will necessarily be equal to the regulated price ceilings when only direct imports are allowed. Then consumers will simply choose their preferred pharmacy chain. In such a case, the aggregate counterfactual market share of direct imports sold by chain c is

$$s_{1ct_{\text{noPI}}} = \int \frac{e^{V_{i1ct}}}{\sum_{\tilde{c}} e^{V_{i1\tilde{c}t}}} dF(\boldsymbol{\nu}_i|\boldsymbol{\beta}), \tag{5.1}$$

which is equal to the market share of chain c in the absence of parallel imports. Once the counterfactual demand is known, we determine the counterfactual wholesale prices to compute profits. When parallel importers are absent, a pharmacy chain gets zero profits in case of disagreement with the manufacturer. In case of agreement, chain profits only depend on direct imports with $\pi_{ct_{\text{noPI}}} = (\bar{p}_t - w_{1ct})s_{1ct_{\text{noPI}}}$. For the manufacturer, profits are given by $\Pi_{t_{\text{noPI}}}(\boldsymbol{w}_{1t}) = \sum_c (w_{1ct} - c_t)s_{1ct_{\text{noPI}}}$.

Without parallel imports, if the manufacturer disagrees with a chain, consumers only options are direct imports sold by other chains. If all consumers still purchase the drug, the manufacturer will still obtain margins on all units demanded. The manufacturer has an incentive to set all wholesale prices equal to the retail price ceiling $w_{1ct} = \bar{p}_t$ because there is no loss from disagreeing with any chain, that is, $\Pi_{t_{\text{noPI}}} - \Pi_{-c,t_{\text{noPI}}} = 0$. In this case, the full market revenue is captured by the manufacturer, with pharmacy chains obtaining zero profits, as if there was vertical integration.

However, this main scenario can be thought of as an upper bound on what the manufacturer can obtain. If demand for direct imports in a chain is lost in the case of disagreement with the chain, then the Nash bargaining between the manufacturer and any chain c leads to the simple wholesale price

$$w_{1ct_{\text{noPI}}} = b_{1c}\bar{p}_t + (1 - b_{1c})c_t. \tag{5.2}$$

Though this scenario is unlikely, it provides a lower bound on the counterfactual profit of the manufacturer.

TABLE VI

IMPACT OF REMOVING PARALLEL IMPORTS OF ATORVASTATIN[a]

			Integration	Bargaining	
			$w_{1ct} = \bar{p}_t$	$w_{1ct} = b_{1c}\bar{p}t + (1 - b_{1c})c_t$	
	Δq_0	Δq_1	$\Delta\pi$	Δw_1	$\Delta\pi$
Pharmacy Chain 1	−12.56 −100%	14.68 435%	−13.75 −100%	0.35 17%	−5.51 −40%
Pharmacy Chain 2	−5.11 −100%	4.05 100%	−7.86 −100%	0.21 10%	−2.89 −37%
Pharmacy Chain 3	−6.32 −100%	5.25 217%	−7.58 −100%	0.26 13%	−3.19 −42%
			$\Delta\Pi$		$\Delta\Pi$
Manufacturer		23.99 243%	28.56 104%	0.27 13%	10.94 40%
Parallel	−23.99 −100%		−1.13 −100%	−1.13 −100%	
Manufacturer on French market			−2.72 −1.36%	−2.72 −1.36%	
Other statins profit on French market			−5.04 −1.31%	−5.04 −1.31%	

[a]Note: Quantities are in millions of DDD per year. Prices are in NOK, and profits are in millions of NOK per year.

Table VI presents the counterfactual changes in quantities (Δq), wholesale prices of direct imports (Δw_1), and profits ($\Delta\pi$ and $\Delta\Pi$) from the observed equilibrium to the counterfactual case without parallel trade. The demand changes when parallel imports are banned are identified using (5.1).

Removing parallel imports implies that aggregate demand switches to direct imports and is redistributed across the three chains so that chain 1 sells more Lipitor than before the ban while chains 2 and 3 sell less as there is less substitution toward direct imports than the initial parallel imports sold within these chains (the aggregate quantity sold by each chain, $\Delta q_1 + \Delta q_0$, being positive only for chain 1). The change in profits would favor the upstream manufacturer and penalize pharmacy chains. Pharmacy chains cannot use intrabrand competition between parallel and direct imports to extract part of manufacturers profits. The total profit of the manufacturer would increase by 28.56 million NOK per year if the manufacturer set wholesale price to the maximum reimbursement price and to a minimum of 10.94 NOK per year if the retailer keep some bargaining power. The parallel trader would disappear (losing their 1.13 million yearly profit) and pharmacy chains would lose significantly. Chain 1 loses much more than the others because they must accept a much higher increases in wholesale price. The differences across chains are due to the fact that they do not use the same amount of parallel imports, and thus, when banning parallel imports, the effect is more or less strong. Chain 1 had considerably stronger incentives to foreclose direct imports, leading to both higher share of parallel imports and lower bargained wholesale prices, such that the increase in the wholesale price of DI with a ban on PI is larger.

Table VI also shows the change in profit for the manufacturer and for other statin producers in the source country France. Solving for the bargaining outcome between the manufacturer and French regulator, we find that price would decrease leading to a reduction in profit of 2.72 million NOK per year, or less than 2% of the estimated profit on the French market. Other statins producers would lose approximately twice this amount due to tougher competition from Lipitor. This is small compared to the gain in Norway. The fact that the price decreases shows that the existence of parallel trade puts upward pressure on prices in France. The counterfactual outcome in France absent parallel trade does not depend on the wholesale prices in Norway, and is therefore the same when Norwegian wholesale prices are high—equal to the maximum retail reimbursement price—or low.

This counterfactual shows that banning parallel imports would benefit the manufacturer and substantially reduce the profit of retail chains. We report details on consumer welfare effects in online Appendix B.12. Although many consumers gain because they prefer direct imports, effects are mixed since there is also a negative effect from variety loss. However, we do not consider consumer welfare effects as very important given the problem at hand where both products offer truly similar medical benefits.

5.2. *The Impact of Direct Imports Foreclosure by Pharmacy Chains*

We now consider a policy which, for example, through regulation, would prevent pharmacies from foreclosing access to directly imported versions of drugs to consumers. Under such a policy, parallel imports are allowed and used by pharmacy chains, but pharmacies are not allowed to exclusively offer parallel imports to consumers. Inspection of pharmacies' offerings to consumers would easily allow such a regulation to be implemented. Our estimates show that among the chain-market combinations featuring parallel imports, the estimated θ varies significantly between zero and one but is less than one for 45% of chain-markets, meaning that the consumer will face a restricted choice set in those instances. The quantitative effect of setting θ equal to one on the pharmacy chain demand will depend on the preferences of consumers. Moreover, when the pharmacy chains are required to always offer both varieties, it will also have an effect on the bargained wholesale prices between the upstream firms and the pharmacy chains. This implies that wholesale prices will generally increase, since there is no longer an incentive for the upstream firms to reduce wholesale prices to increase sales.

To simulate the counterfactual, we use the bargaining model of Section 3.3 with the estimated bargaining parameters, where counterfactual demand is obtained by requiring pharmacies to set $\theta_{ct} = 1$. When foreclosure is prevented, consumers can always choose between direct and parallel imports, and the pharmacist cannot affect demand. Therefore, the market share of each version and chain is exogenously given by preferences. To be more precise, when foreclosure is prevented, the counterfactual individual choice probabilities s_{ikct} are given by $s_{ikct} = s_{ict}s_{ikt|c}$, where the choice probability $s_{ikt|c}$ of version k of the drug conditional on pharmacy chain c is as before, but not the chain choice probability. The expected consumer utility of visiting pharmacy c is

$$E_{\epsilon_{ikct}}\left[\max_{k\in\{0,1\}}(V_{ikct} + \lambda_c \epsilon_{ikct})\right] = \lambda_c \ln\left(\sum_{k\in\{0,1\}} e^{V_{ikct}/\lambda_c}\right)$$

such that the individual choice probability is

$$s_{ikct} = \frac{\left(\sum_{k' \in \{0,1\}} e^{V_{ik'ct}/\lambda_c}\right)^{\lambda_c}}{\sum_{\tilde{c}} \left(\sum_{k' \in \{0,1\}} e^{V_{ik'\tilde{c}t}/\lambda_{\tilde{c}}}\right)^{\lambda_{\tilde{c}}}} \frac{e^{V_{ikct}/\lambda_c}}{e^{V_{i0ct}/\lambda_c} + e^{V_{i1ct}/\lambda_c}}. \tag{5.3}$$

Aggregate demand is obtained by integrating over the estimated distribution of preferences of consumers.

We then solve for the bargaining outcomes between the manufacturer or parallel importer and the pharmacy chains by taking into account bargaining in the source country France (details are provided in the online Appendix B.9).

Table VII shows the counterfactual results. First, preventing foreclosure of direct imports would raise total direct import sales by 9.27 million DDD per year (reducing sales of parallel imports by the same amount). The largest part of this substitution would occur at chain 1. Then, as wholesale prices increase, the three pharmacy chains lose profits, with losses from 6% at chain 2 to 11% at chain 1. We see that the manufacturer would gain from such a change, with an overall increase of revenue of 0.97 millions NOK per year. This increase occurs because there is no longer an element of competition for the upstream firm when bargaining over wholesale prices with the chains, such that the manufacturer wins both because of an increase in wholesale price of direct imports and substitution from parallel imports to direct imports. Pharmacy chains would lose more than the manufacturer earns because parallel importers would also slightly gain with this pol-

TABLE VII

IMPACT OF PREVENTING PARALLEL IMPORTS FORECLOSURE ($\theta_{ct} = 1$) OF ATORVASTATIN[a]

	Δq_0	Δq_1	Δw_0	Δw_1	$\Delta \pi$
Pharmacy Chain 1	−8.01 −64%	8.75 259%	0.09 5%	0.09 4%	−1.49 −11%
Pharmacy Chain 2	0.06 1%	−0.45 −11%	0.01 0%	0.02 1%	−0.50 −6%
Pharmacy Chain 3	−1.32 −21%	0.97 40%	0.02 1%	0.01 1%	−0.63 −8%
					$\Delta \Pi$
Manufacturer		9.26 94%		0.04 2%	0.97 4%
Parallel	−9.26 −39%		0.04 2%		0.50 44%
Manufacturer on French market					0.03 0.02%
Other statins profit on French market					0.08 0.02%

[a]Note: Quantities are in millions of DDD per year. Prices are in NOK, and profits are in millions of NOK per year.

icy. This experiment shows that it would reduce the part of profits obtained by pharmacy chains at the expense of the original manufacturer, in addition to shifting some profits from pharmacy chains to the parallel traders. Finally, the profit of the manufacturer and other statin producers in the source country France would barely change as indicated in Table VII.

5.3. *Decrease in the Price Ceiling*

We now consider a reduction of retail prices $\bar{p}_t$ by 20% under the assumption that foreclosure is also absent.[15] In this counterfactual, as new wholesale prices may decrease substantially and parallel importers profits decrease, it is likely that participation constraints requiring positive profits may bind for parallel importers, leading them to exit from some markets.

Table VIII shows that the 20% reimbursement price reduction that decreases total drug expenses by the government by 20% has a much lower effect on the manufacturer than pharmacy chains. The 20% retail price decrease leads to a wholesale price decrease of direct imports of only 1% in chain 1, 9% in chain 2, and 4% in chain 3. The sales of direct imports increase substantially in chain 1, while total profits of the manufacturer decrease by 7% or an average of 2.03 million NOK per year. At the same time, total expenses decrease by 19.47 million NOK per year (20% of the total expenses in these markets).

TABLE VIII

IMPACT OF REDUCING THE PRICE CEILING BY 20% FOR ATORVASTATIN[a]

	Δq_0	Δq_1	Δw_0	Δw_1	$\Delta \pi$
Pharmacy Chain 1	−7.93 −63%	8.78 260%	−0.04 −2%	−0.02 −1%	−9.50 −69%
Pharmacy Chain 2	−0.27 −5%	−0.21 −5%	−0.46 −23%	−0.18 −9%	−3.70 −47%
Pharmacy Chain 3	−1.47 −23%	1.09 45%	−0.17 −8%	−0.08 −4%	−4.68 −62%
					$\Delta \Pi$
Manufacturer		9.67 98%		−0.09 −5%	−2.03 −7%
Parallel	−9.67 −40%		−0.22 −11%		−0.44 −39%
Manufacturer on French market					−0.16 −0.08%
Other statins profit on French market					−0.26 −0.07%

[a]Note: quantities are in millions of DDD per year. Prices are in NOK, and profits are in millions of NOK per year.

[15]Preventing foreclosure in the counterfactuals where the retail price ceiling is lower simplifies simulations, although allowing pharmacists to use a foreclosure strategy does not change the results in any important way.

This shows that if the manufacturer ex ante negotiates the retail price ceiling $\bar{p}_t$ for reimbursement with the Norwegian government, it could accept a 20% lower retail price with a lump sum transfer above 2.03 millions NOK per year from the government that would make both the manufacturer and the government (tax payers) better off. Moreover, the lower reimbursement price of Lipitor in Norway leads to a reduction in the price of Lipitor in the source country (France) of only 0.25% on average and a profit decrease of 0.16 million NOK (0.08% of the profit on the French market) for the manufacturer and a decrease of 0.26 million NOK per year for all other statin producers in France. Other statin prices in France are also reduced, but only by roughly one tenth of the price reduction of Lipitor in France.

Robustness Checks. Dubois and Sæthre (2018) showed the results when the reaction in France is not taken into account. In that case, parallel imports would decrease slightly more (in chain 1 and almost same in others) at the benefit of direct imports, and the manufacturer's profits would decrease by 1.92 million instead of 2.03 million. It shows that taking into account the price reaction in source countries when the Norwegian government sets a lower reimbursement price matters somewhat when evaluating the loss to the manufacturer.

With other retail price reduction amounts, the effects are qualitatively similar. With a 10% retail price reduction, for example, the effect on the manufacturer profit is even smaller, while most of the reduction in expenses is attributed to a reduction in pharmacy chain profits. Table IX shows the changes in profits for different retail price reductions

TABLE IX

IMPACT OF REDUCING THE PRICE CEILING OF ATORVASTATIN (AND PREVENTING PARALLEL IMPORTS FORECLOSURE)[a]

Δp_t		−10%	−15%	−20%	−25%	−30%
$\Delta \pi_t$						
	Pharmacy Chain 1	−5.38 −39%	−7.33 −53%	−9.50 −69%	−11.41 −83%	−13.22 −96%
	Pharmacy Chain 2	−2.64 −34%	−3.35 −43%	−3.70 −47%	−4.32 −55%	−5.00 −64%
	Pharmacy Chain 3	−2.70 −36%	−3.73 −49%	−4.67 −62%	−5.60 −74%	−6.48 −85%
$\Delta \Pi$						
	Manufacturer	−0.19 −1%	−1.06 −4%	−2.04 −7%	−2.95 −11%	−4.15 −15%
	Parallel	0.01 1%	−0.21 −19%	−0.44 −39%	−0.65 −58%	−0.85 −75%
Number of chain-market exits		2	8	20	32	43
Government spending change ($\Delta(p_t q_t)$)		−9.73	−14.60	−19.47	−24.33	−29.20
$\Delta(p_t q_t) - \Delta \Pi$		−9.55	−13.54	−17.42	−21.38	−25.05
Manufacturer on French market		−0.01	−0.08	−0.16	−0.18	−0.26
Other statins profit on French market		−0.02	−0.10	−0.26	−0.32	−0.50

[a]Notes: The profits changes are in millions of NOK per year. Percentage are indicated below absolute changes. There are 77 markets (strength-month combinations), and thus 231 chain-market observations.

from 10 to 30%. As mentioned earlier, when performing these counterfactuals, we must also check that the price reduction still allows parallel importers to remain in the market. When the retail price is too small, some parallel importers will exit the market because their source cost corresponding to some wholesale price in a source country is too high compared to the maximum price allowed in Norway. In the case of a 20% price reduction, there are approximately 10% of chains-month combinations (20 cases) where the parallel importer exits. Of course, when some parallel trader stops working with a chain in a given market, it both reduces competition between chains and (marginally) benefits the manufacturer.

6. CONCLUSION

By investigating the incentives of pharmacy chains in selling parallel-traded drugs, we show that foreclosure of directly imported drugs is plausibly used by pharmacy chains to increase profits and bargaining position relative to the manufacturer. Pharmacy chains procure parallel imports at lower prices than direct imports and attempt to steer demand toward the parallel-imported versions of drugs. With retail prices constrained by regulation, pharmacy chains effectively introduce competition between upstream suppliers by distorting assortment. In our counterfactual simulations, we find that a lower retail price may not be very detrimental to the manufacturer, as it can reduce the presence of parallel imports, thus reducing opportunities for pharmacies to extract rents by using parallel imports.

The specific random foreclosure mechanism that we highlight—in which pharmacies can distort availability of drugs for which they have differing margins—has not been formalized in the previous literature, although pharmacists' incentives have been mentioned as a plausible factor impacting sales of drugs for which substitution at the pharmacy level is available (see, e.g., Caves, Whinston, Hurwitz, Pakes, and Temin (1991)). The incentives to distort availability seem particularly important in many European countries, where price regulation is prevalent.

Furthermore, we show how to identify and estimate the consumer demand model with choice sets unobserved to the econometrician by modeling retailer incentives to choose the optimal set of product varieties. In our case, this is achieved by using rich data regarding retail pharmacies' margins, in a setting where the retailer has clear incentives to partially foreclose access to less profitable products, even though it might reduce the retailer's attractiveness to consumers. The method can be useful for many other settings where strategic supply-side choice of product offerings can be modeled and taken into account when estimating demand.

We estimate our structural model for the atorvastatin market, showing that the original manufacturer could be better off accepting a lower reimbursement price combined with a lump sum transfer from the government when marketing in Norway. This transfer would be much less expensive than the additional reimbursement that the government spends under the higher observed prices. This finding shows that lower price discrimination across countries can make both the tax payer and private patent holder better off if accompanied by lump sum compensation to the original manufacturer who owns the patent. However, we do not model the optimal reimbursement price setting by the Norwegian government, which should take into account not only the consequences on international price setting given the possibility of parallel trade, but also the existence of substitute drugs on the market. Moreover, we also do not account for quantity constraints. Quantity shortages are unlikely to happen for an important statin product such

as atorvastatin, and the European competition law prevents restriction of quantities for trade. However, European competition authorities started becoming less strict on this point, as they understood the problem of parallel imports, such that quantity restrictions on imports may become important in the future.

Our results also show that we should consider vertical relationships and market structure of pharmacy retailing in the debate on impact of parallel trade on long-term welfare. In fact, parallel trade can be considered a threat to third-degree price discrimination, which could result in a manufacturer only serving high-demand markets (Malueg and Schwartz (1994)). Danzon, Wang, and Wang (2005) already showed that launch delays are correlated with price regulation. However, Grossman and Lai (2008) also showed that parallel trade limits the ability of poorer countries to free ride on innovation incentives created in richer countries, which benefits everyone in the long run, even if free riding may benefit them in the short run. While free trade of goods remains a principle of the European Economic Area, it seems regulators are starting to understand the potential harm to exporting countries because of recent and possibly related drug shortages.[16]

The ability of regulators to trade off static and dynamic efficiency by responding optimally to the presence of parallel trade and determining price regulation, hinges on the ability of each country's regulator to fully incorporate the effect of price ceilings on innovation and politically trade off price levels and innovation in an optimal manner. Our results show that it may be important to also consider the structure and regulation of pharmaceutical retailing, as intermediate retailers may manage to extract a large part of the reward to innovators. We leave for future research the study of optimal price regulation across countries when parallel trade and strategic pharmacies interact with pharmaceutical industry manufacturers.

APPENDIX A

A.1. *Pharmacy Chains Behavior Proofs*

When the pharmacy chain procures the drug from both direct and parallel imports, both margins m_{0ct} and m_{1ct} must be positive and necessary first-order conditions for an interior solution of θ's are

$$0 = \frac{\partial \pi_{ct}}{\partial \theta^0_{ct}} = \frac{\partial \pi_{ct}}{\partial \theta^1_{ct}}.$$

For θ^0_{ct}, the first-order condition is (the equivalent condition for θ^1_{ct} is not shown):

$$\begin{aligned} 0 &= \sum_k m_{kct} \frac{\partial s_{kct}}{\partial \theta^0_{ct}} \\ &= \int \sum_k m_{kct} \Bigg[\underbrace{\frac{\partial s_{ikt|c}}{\partial \theta^0_{ct}}}_{\substack{\text{change in probability} \\ \text{to choose } k \text{ in } c}} \underbrace{s_{ict}}_{\substack{\text{probability to} \\ \text{choose chain } c}} + \underbrace{s_{ikt|c}}_{\substack{\text{probability to} \\ \text{choose } k \text{ in chain } c}} \underbrace{\frac{\partial s_{ict}}{\partial \theta^0_{ct}}}_{\substack{\text{change in probability} \\ \text{to choose chain } c}} \Bigg] dF(\mathbf{V}_{it}|\boldsymbol{\beta}), \end{aligned}$$

which shows that θ^0_{ct} has substitution effects within and across chains for both versions of the drug.

[16] "The EU Commission acknowledges that parallel trade in medicines may be one of the reasons for the occurrence of shortages of a number of medicinal products for human use." Press release, May 2018.

Developing the first-order conditions using the effects of θ's on the demand, we show below that it must be that $\theta^k_{ct} = 0$ if m_{kct} is the lowest of the two margins. As

$$\frac{\partial s_{ikt|c}}{\partial \theta^{k'}_{ct}} = 1_{\{k=k'\}} - s_{ikt|c,B} \quad \text{and} \quad \frac{\partial s_{ict}}{\partial \theta^{k'}_{ct}} = \left[V_{ik'ct} - \lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) \right] s_{ict}(1 - s_{ict}) \leq 0,$$

using the fact that

$$\frac{\partial s_{ik't|c}}{\partial \theta^0_{ct}} s_{ict} + s_{ik't|c} \frac{\partial s_{ict}}{\partial \theta^0_{ct}} = (1_{\{k'=0\}} - s_{ik't|c,B}) s_{ict} + s_{ik't|c} \left[V_{i0ct} - \lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) \right] (1 - s_{ict}) s_{ict},$$

we obtain that the first-order condition for optimal θ^0_{ct} implies

$$\frac{m_{0ct}}{m_{1ct}} = \frac{\int s_{i1t|c,B} s_{ict} + s_{i1t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i0ct} \right] (1 - s_{ict}) s_{ict} \, dF(\mathbf{V}_{it})}{\int s_{i1t|c,B} s_{ict} - s_{i0t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i0ct} \right] (1 - s_{ict}) s_{ict} \, dF(\mathbf{V}_{it})} \tag{A.1}$$

because $1 - s_{i0t|c,B} = s_{i1t|c,B}$ and $1 - s_{i0t|c} = s_{i1t|c}$.

Similarly, the first-order condition with respect to θ^1_{ct} (for an interior solution) can be written

$$\frac{m_{1ct}}{m_{0ct}} = \frac{\int s_{i0t|c,B} s_{ict} + s_{0t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i1ct} \right] (1 - s_{ict}) s_{ict} \, dF(\mathbf{V}_{it}|\boldsymbol{\beta})}{\int s_{i0t|c,B} s_{ict} - s_{1t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i1ct} \right] (1 - s_{ict}) s_{ict} \, dF(\mathbf{V}_{it}|\boldsymbol{\beta})}. \tag{A.2}$$

We can see that only one of the first-order conditions will be satisfied. Indeed, as $1 - s_{i0t|c} = s_{i1t|c}$,

$$\begin{aligned}
&s_{i1t|c,B} s_{ict} + s_{i1t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i0ct} \right] (1 - s_{ict}) s_{ict} \\
&\quad = s_{i1t|c,B} s_{ict} - s_{i0t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i0ct} \right] (1 - s_{ict}) s_{ict} \\
&\qquad + \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i0ct} \right] (1 - s_{ict}) s_{ict} \\
&\quad > s_{i1t|c,B} s_{ict} - s_{i0t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i0ct} \right] (1 - s_{ict}) s_{ict},
\end{aligned}$$

and similarly,

$$\begin{aligned}
&s_{i0t|c,B} s_{ict} + s_{i0t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i1ct} \right] (1 - s_{ict}) s_{ict} \\
&\quad > s_{i0t|c,B} s_{ict} - s_{i1t|c} \left[\lambda_c \ln\left(\sum_k e^{V_{ikct}/\lambda_c} \right) - V_{i1ct} \right] (1 - s_{ict}) s_{ict}.
\end{aligned}$$

Thus, equation (A.1) cannot be true if $m_{1ct} > m_{0ct}$, and equation (A.2) cannot be true if $m_{1ct} < m_{0ct}$.

In the case in which $m_{1ct} < m_{0ct}$, there is no interior solution for θ^1_{ct}, and thus we will have $\theta^1_{ct} = 0$, meaning that the pharmacy chain never proposes the drug with the lowest margin alone. Then θ^0_{ct} is a solution of equation (A.1). Thus if $m_{1ct} < m_{0ct}$ then $\theta^1_{ct} = 0$ and if $m_{1ct} > m_{0ct}$ then $\theta^0_{ct} = 0$. The intuitive explanation is that when the chain increases the probability of only having the lower margin product available, profits are hurt both due to the opportunity cost of consumers who would otherwise have bought the high margin product when both were available and the loss of market share due to offering less variety on average.

A.2. *Counterfactuals Taking Into Account Reaction in Source Countries*

The bargaining surplus for the manufacturer with respect to another country I that is not a source country for any chain c ($I \neq I(c)$ for any c) is irrelevant for our concern, since prices in countries that are not exporting to Norway should not be affected by the changes in the Norwegian market regulation, provided these other countries do not export to source countries of Norway.[17]

Method Taking Into Account Price Reactions in Source Countries. The bargaining surplus for the manufacturer with respect to a source country $I(c)$ (for a given c) is

$$
\begin{aligned}
&(\Pi_t - \Pi_{-I(c),t}) \\
&\quad = \sum_{\tilde{c}} \left[(w_{1\tilde{c}t} - c_t) s_{1\tilde{c}t} + \left(p^{I(\tilde{c})}_{1\tilde{c}t} - c_t \right) s_{0\tilde{c}t} \right] M_N + \sum_I \left(p^I_{1t} - c_t \right) q_{It}\left(p^I_{1t} \right) \\
&\qquad - \sum_{\tilde{c}} \left[(w_{1\tilde{c}t} - c_t) s_{1\tilde{c}t\setminus I(c)} + \left(p^{I(\tilde{c})}_{1\tilde{c}t} - c_t \right) s_{0\tilde{c}t\setminus I(c)} \right] M_N + \sum_{I \neq I(c)} \left(p^I_{1t} - c_t \right) q_{It}\left(p^I_{1t} \right) \\
&\quad = \sum_{\tilde{c}} \left(w_{1\tilde{c}t} \Delta_{I(c)} s_{1\tilde{c}t} + p^{I(\tilde{c})}_{1\tilde{c}t} \Delta_{I(c)} s_{0\tilde{c}t} \right) M_N + \left(p^{I(c)}_{1t} - c_t \right) q_{I(c)t}\left(p^{I(c)}_{1t} \right), \qquad \text{(A.3)}
\end{aligned}
$$

with $\Delta_I s_{1\tilde{c}t} = s_{1\tilde{c}t} - s_{1\tilde{c}t\setminus I}$, $\Delta_I s_{0\tilde{c}t} = s_{0\tilde{c}t} - s_{0\tilde{c}t\setminus I}$, and $I(c)$ is the source country of chain c, where $s_{1\tilde{c}t\setminus I}$ is the demand of direct imports in chain $\tilde{c}$ when there is no parallel imports from source country I, and $s_{0\tilde{c}t\setminus I}$ is the demand of parallel imports in chain $\tilde{c}$ when there is no parallel imports from source country $I(c)$ (implying that $s_{0ct\setminus I(c)} = 0$ and $s_{0\tilde{c}t\setminus I(c)} = 0$ if $I(c) = I(\tilde{c})$), and M_N is the market size of Norway.

Then Nash bargaining in source country $I(c)$ amounts to

$$
\max_{p^{I(c)}_{1t}} (\Pi_t - \Pi_{-I(c),t})^{b_{I(c)}} \left(\Delta W_{I(c)}\left(p^{I(c)}_{1t} \right) \right)^{1 - b_{I(c)}},
$$

where $\Delta W_I(p^I_{1t})$ is the welfare gain provided by the drug in country I and b_I is the bargaining parameter of the manufacturer with respect to country I ($I(c)$ being the country I used as source of imports by chain c).

[17] We do not explore the possible effects of changes in negotiation in other countries who do not export to Norway but who export to countries that export to Norway. As our counterfactuals tend to reduce parallel trade, parallel trade from new countries is unlikely. We thus assume that no country would start exporting to Norway if they are not already doing it.

We allow the wholesale price p^I_{1ct} obtained by the manufacturer for a unit of drug sold in country I and reexported to the chain c in Norway to be different from the wholesale price p^I_{1t} obtained by the manufacturer for the domestic market of country I. If there is no intermediary and no transaction cost born by the manufacturer, both prices should be the same, but can otherwise be different. While allowing this flexibility, we impose that when the negotiated wholesale price p^I_{1t} in country I changes, the price paid by the parallel trader p^I_{0ct} changes by the same amount. We thus assume both that $\frac{\partial p^I_{1ct}}{\partial p^I_{1t}} = 1$ and $\frac{\partial p^I_{0ct}}{\partial p^I_{1t}} = 1$, which encompasses the case where we would impose $p^I_{1ct} = p^I_{1t}$ and $p^I_{0ct} = p^I_{1t}$.

This implies the following first-order condition for a Nash-bargaining equilibrium:

$$b_{I(c)} \frac{1}{(\Pi_t - \Pi_{-I(c),t})} \frac{\partial(\Pi_t - \Pi_{-I(c),t})}{\partial p^{I(c)}_{1t}} + (1 - b_{I(c)}) \frac{\partial \ln \Delta W_{I(c)}(p^{I(c)}_{1t})}{\partial p^{I(c)}_{1t}} = 0, \tag{A.4}$$

where

$$\frac{\partial(\Pi_t - \Pi_{-I(c),t})}{\partial p^{I(c)}_{1t}} = \Delta_{I(c)} s_{0ct} M_N + q_{I(c)t}(p^{I(c)}_{1t}) + (p^{I(c)}_{1t} - c_t) \frac{\partial q_{I(c)t}(p^{I(c)}_{1t})}{\partial p^{I(c)}_{1t}}$$

and $\Pi_t - \Pi_{-I(c),t}$ comes from (A.3). Using this first-order condition, one can account for the equilibrium change in wholesale price $p^{I(c)}_{1t}$ in the source country $I(c)$ in each counterfactual. We can also use this first order condition to identify the marginal cost c_t and bargaining parameter $b_{I(c)}$.

In our application, we assess the effects of Norwegian counterfactual policies on the wholesale price in France p^I_{1t}, and thus on the relevant importing prices from France $p^{I(c)}_{1t}$, in addition to the effects in Norway. We also account for equilibrium effects on prices of other statins in France, meaning that $q_{It}(p^I_{1t})$ and $W_I(p^I_{1t})$ depend implicitly on prices of all statins in France, denoted by the vector $\overrightarrow{p}^I_t$.

Demand Model and Price Setting in France. We estimate a random coefficient logit demand model à la Berry, Levinsohn, and Pakes (1995) for the statin market in France, and use it to predict demand for and welfare gain from atorvastatin in France. The details of the demand estimation together with the regulatory environment in France are described in Appendix B.10. We use the demand estimates to identify the welfare gain function $\Delta W_I(p^{\mathrm{FR}}_{1t})$ in the source country France for atorvastatin at price p^{FR}_{1t} as $\Delta W_I(p^I_{1t}) \equiv \Delta W_a(\overrightarrow{p}^I_t)$ for $a = atorvastatin$ where $\overrightarrow{p}^I_t$ is the price vector of all statins in the source country I (France). Given the demand model, the welfare gain $\Delta W_a(\overrightarrow{p}^I_t)$ is

$$\Delta W_a(\overrightarrow{p}^I_t) = M_F \Bigg[\int \frac{1}{\beta^i_p} \ln\Bigg(1 + \sum_{\tilde{a}} \exp(\beta^i_p p_{\tilde{a}t} + \beta_g g_{\tilde{a}t} + \beta_{\tilde{a}} + \beta_t + \xi_{\tilde{a}t})\Bigg) dF(\beta^i_p)$$
$$- \int \frac{1}{\beta^i_p} \ln\Bigg(1 + \sum_{\tilde{a} \neq a} \exp(\beta^i_p p_{\tilde{a}t} + \beta_g g_{\tilde{a}t} + \beta_{\tilde{a}} + \beta_t + \xi_{\tilde{a}t})\Bigg) dF(\beta^i_p) \Bigg],$$

where M_F is the French market size.

We then use the bargaining first-order condition for atorvastatin (A.4) and the analogous conditions for other statins to simulate the counterfactual price equilibrium in the French statin market as a whole. As other statins are not exported to Norway, the first-order conditions for other statins are simpler, and depend on the Norwegian policy only through its effect on the price of atorvastatin (Lipitor).

As the results also depend on the bargaining parameter b_{FR} of pharmaceutical companies with respect to the French regulator, we first identify this bargaining parameter using the observed equilibrium prices and the Nash bargaining first-order condition for drugs that are not subject to parallel trade. Indeed, the Nash bargaining necessary first-order condition for any statin a that is on patent and not exported to Norway can be written to express marginal cost as

$$c_{at} = p_{at} + \frac{1}{\frac{\partial \ln q_{at}(\overrightarrow{p}_t^I)}{\partial p_{at}} + \frac{1 - b_{\text{FR}}}{b_{\text{FR}}} \frac{\partial \ln \Delta_a W_{\text{FR}}(\overrightarrow{p}_t^I)}{\partial p_{at}}} \tag{A.5}$$

for $a \neq$ *atorvastatin*, where $\Delta_a W_{\text{FR}}$ is the welfare gain in France provided by statin a, $q_{at}(\overrightarrow{p}_t^I)$ is the demand of statin a, c_{at} the marginal cost and $\overrightarrow{p}_t^I = (p_{at})_{a=1,\ldots,A}$ the vector of all statin prices in source country I (France). We show in Appendix B.10 how we account for price setting of generics, which is not subject to the same regulatory rule. We estimate the bargaining parameter b_{FR} using a set of restrictions on marginal costs, assuming that they are the sum of a molecule fixed effect, a strength fixed effect, a quarter fixed effect and a mean independent deviation. We obtain an $\hat{b}_{\text{FR}} = 0.49$, which is in the same range of values obtained by Tuncel (2020) for other drug markets in France.

Then we can use the bargaining first-order conditions for all statins together with bargaining first-order conditions for parallel and direct imported atorvastatin with chains in Norway to find the new counterfactual equilibrium.

A.3. *Effects of Parallel Imports Entry on Margins and Profits of Pharmacist Chains*

TABLE X

REDUCED FORM EVIDENCE OF PARALLEL IMPORTS ENTRY ON PHARMACIST PROFITS AND MARGINS[a]

	$\ln \frac{q_{j0ct} m_{j0ct} + q_{j1ct} m_{j1ct}}{q_{j0ct} + q_{j1ct}}$			$\ln(q_{j0ct} m_{j0ct} + q_{j1ct} m_{j1ct})$		
Dependent Variable	(OLS) (1)	(OLS) (2)	(2SLS) (3)	(OLS) (4)	(OLS) (5)	(2SLS) (6)
Presence PI of j in chain c at t	−0.498 (0.025)	0.019 (0.004)	0.585 (0.215)	1.476 (0.029)	0.033 (0.015)	1.267 (0.544)
Chain-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Chain-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Products fixed effects		Yes	Yes		Yes	Yes
N	35,756	35,756	35,756	35,756	35,756	35,756

[a]Notes: Product j is defined by ATC code level 5 (molecule)-strength. In the case of Two Stage Least Squares estimates (2SLS), the variable "Presence of PI" is instrumented using the wholesale price in Czech Republic, France, Poland, Spain, United Kingdom, as well as exchange rates between NOK and euros, US dollars, GBP, Czech crown, Swiss franc interacted with pharmacy chain dummies.

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