

# Pharmacy Incentives and Competition with Parallel Trade

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## Abstract

We develop a model where retailers can alter the set of goods which the consumer can choose from, in response to differences in profitability across products. Using this model, we can quantify the importance of retailer incentives in facilitating sales, especially under market regulations as employed in European pharmaceutical markets. Estimating our model with rich data on a pharmaceutical market featuring parallel imports, we find that retailer incentives play a significant role for the observed outcome. Our counterfactual simulations imply that the presence of parallel imported drugs has small effects on average consumer welfare, while it has large implications for the distribution of industry profits. The effect on profit distribution is largely driven by pharmacy chains' incentives to strategically affect the choice set of consumers.

## 1 Introduction

In this paper, we develop a structural model to address questions concerning sales of parallel imported pharmaceutical drugs. Specifically, we address the incentives of retail pharmacies in facilitating sales of parallel imports amid regulatory policies towards parallel trade and price setting of pharmaceuticals. Our model allows us to explain how parallel imports can capture substantial market shares, even though savings afforded to consumers might be negligible or even non-existent. The mechanism of our model is that a retailer facing regulated prices might wish to restrict supply of less profitable products, which might reduce the number of consumers making their purchases with the retailer, as restrictions in the choice set generally decreases the expected utility of visiting the retailer. The problem of the retailer can thus be viewed as a variant of the classical trade-off between price-cost margin and quantity sold.

We estimate our model using a very rich data set on the Norwegian pharmaceutical market, where we are able to observe the purchases of individual consumers over time, the pharmacy chain at which a given purchase happened, and whether the specific drug dispensed was imported through the original producer (direct import) or by parallel traders. Since we also have data on the price

the pharmacy obtains for all purchases, as well as data on the wholesale prices paid by the pharmacy chain to the upstream firms for each product dispensed—i.e. specific drug packages—we can calculate the gross margin obtained by the chain on each product, which our model relates to retailers’ incentive to dispense parallel imports. We find that the inclusion of retailer incentives in our model plays an important role in explaining consumer choices, and also that restrictions on supply are prevalent and have important implications for the outcomes in the market we study.

Our counterfactual simulations imply that parallel imports have a very modest effect on consumer welfare. Further, we find that it allows the retail pharmacy chains to capture a much larger share of industry profits than would otherwise be the case, particularly at the expense of the original producer. This redistribution of profits is especially driven by the chains’ ability to shift sales as a response to differences in profitability, which also allows the chains to capture larger shares of profits due to parallel imports than would be the case without this strategic instrument.

Many industries rely on a downstream retailing sector to market goods. Vertical relationships between upstream producers and downstream retailers are determinant for market access of goods and consumer welfare. Actually, vertical relationships are not only determinant for price competition among substitute and differentiated goods, but intermediaries between producers and consumers—such as retailers—may also affect competition by engaging in other strategic actions affecting final consumers’ demand. Such strategic actions can be very diverse and also affect upstream producers’ behavior. Strategic behavior of retailers could include strategic choices regarding assortment of goods, introduction of store brands or private labels, advertising and promotion efforts. Equilibrium results of such structures can be analyzed thanks to game theoretic models and estimated through structural models. Typical sectors where retailers’ behavior has attracted attention of economists are the food retailing industry with large supermarket chains and internet platforms.

Pharmacy retailing is another sector that has been less studied, though for which the growth in health care expenses among developed countries raises many questions on which policies allow containment of pharmaceutical drugs’ costs while ensuring or improving access to patients. In many developed countries—the US being an exception—pricing of prescription drugs is regulated, and thus price competition was at first not perceived as an important aspect of pharmaceutical retailing. However, the growing market for OTC (over-the-counter) drugs is generally not price regulated, and competition among prescription drugs still exists and calls for other strategies such as detailing or direct to consumer advertising (especially in the US). In Europe, most countries regulate prices of prescription drugs, though other aspects of competitive behavior, such as strategic choice of entry across different markets, matter substantially. Within Europe, another element of competition is introduced by the possibility to trade drugs across countries. Parallel trade of drugs within Europe thus interacts with national regulatory pricing policies. With such parallel trade intermediaries, pharmaceutical retailers find an alternative upstream provider of drugs competing with national direct importers for the same branded or unbranded molecules. How pharmacists use those upstream providers strategically can rely on strategic contracting with upstream direct or parallel importers, and on pharmacists’ action affecting final demand. One strategy can be based on

strategic assortment choice of drugs, proposing one or two versions of the same drug which is either directly imported or imported by a parallel trader. This is similar to strategically choosing to stock out of some versions of drugs. Indeed, absent considerations of storage costs and logistics, retailers may find beneficial to stock out of a product to induce substitution towards other product, for which the retailer has higher margins. This behavior can be beneficial in other industries but it could especially be the case in tightly regulated markets where the price setting is constrained, such as is common in many European countries for pharmaceuticals.<sup>1</sup> What we have in mind is an endogenously set stock of each product, such that there is a chance that any given consumer entering the store will just face a subset of the products.

We will abstract from the decision on level of stocks and timing of consumer visit by letting the firm choose the probability of each product being available which will be independent across consumer visits for a suitable period of aggregation. The reason for having variety is that consumers obtain higher expected utility, while the reason for not having all products available at all times is to induce substitution towards more profitable products. Within the European Economic Area, drugs are allowed to be bought in one member state and resold in another, as long as the product is sufficiently similar to one already authorized for sale in the destination member state. This has made possible a large arbitrage trade between member states, where drugs are often bought in Southern European countries, such as Greece, Portugal and Spain and resold in Northern European countries, such as the UK, Netherlands and Sweden (Kyle, 2011). To a large extent, the price differences in the European Economic Area can be attributed to differences in price regulation, and—where such arrangements are in place—the aggressiveness of each member state’s authorities in negotiating with the manufacturers (Kyle, 2007).

Parallel traded drugs provide an interesting market in terms of studying retailer incentives. For many European countries, the prices of prescription drugs is regulated, while the consumers are covered by national health insurance, and will often face substantially lower costs than the full price. Often, this leads to very small or no price differences between direct and parallel imported drugs.<sup>2</sup> There are also large cross-country differences in the share of parallel import sales, which according to the findings of Kanavos, Costa-i Font, Merkur, and Gemmill (2004) seems to have a clear link to the regulation governing margins at the pharmacy and domestic supply level. As an example, German pharmacies are subject to regulations fixing their margins and have to a low extent supplied parallel trade before the national insurance authorities set a minimum quota of 5%, while British pharmacies have no direct caps on their margins and have large shares of parallel import (Kanavos, Costa-i Font, Merkur, and Gemmill, 2004). Even though studies of aggregate prices have not found evidence of any significant reduction in price dispersion across EU countries (Kanavos, Costa-i Font, Merkur, and Gemmill, 2004; Kyle, 2011), Ganslandt and Maskus (2004) report that parallel imports might have led to a reduction in drug prices on the order of 12–19% for relevant segments in Sweden. Using a structural model of demand estimated using data on the German market for oral anti-diabetic

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<sup>1</sup>For details on regulation in different countries, see, e.g., Kanavos, Costa-Font, and Seeley (2008).

<sup>2</sup>Direct imported drugs are the ones supplied by the manufacturers or their marketing agencies.

drugs, Duso, Herr, and Suppliet (2014) evaluate the welfare impact of parallel imports. Their estimates imply that parallel imports have reduced the prices of on-patent drugs by 11%, but that the impact on consumer surplus is modest. In contrast to this approach, we explicitly model and structurally estimate retailer incentives and contracting in the vertical chain.

Using the same source of data, Brekke and Holmås (2014) study the interaction between price regulation and parallel imports. Using data across a large number of drugs, they find evidence that original producers might benefit from tighter price regulation when there is competition from parallel trade. As we consider the market for a single, large drug, we do not touch upon this question. They also utilize a Nash bargaining model for the contracting between pharmacy chains and upstream producers to motivate their empirical analysis, though the channels they highlight are slightly different from ours. Novel features of our paper include the strategic decisions by the retailers on the drugs proposed to consumers, and structural estimation of the bargaining model.

There would be reason to suspect that some consumers would prefer the direct imported variety, even though the drugs are produced by the same company. The packaging will usually display the brand name of the parallel importer and the product can differ in visual appearance and inactive ingredients. This could be for instance tablets where the direct imported variety is round and white, while the parallel imported comes from a country where they are octagonal and red. This type of differentiation in appearance and specification across countries has been linked to attempts to reduce the scope for parallel trade (Kyle, 2011). In this sense, as we would suspect consumers to either be indifferent between direct and parallel import or skeptical towards parallel import and the price they pay are usually the same, it seems necessary to consider the incentives of the retail side of the market to explain why parallel imports are sold and the reason for the observed cross-country differences in dispensing practice for parallel imports.

We present the basic model in the following section. In Section 3, we present the market and data. In Section 4, we describe the empirical specification of our model and present the estimation results. In Section 5, we present the results from our counterfactual simulations, while Section 6 concludes.

## 2 Model

To explain the variation we see in the data, we aim at creating an estimable model that can be used for comparison and useful counterfactuals in terms of policy implications and cross-country differences.

### 2.1 Consumer Behavior

In the baseline model, we assume that the consumer has an exogenous need for a drug with a particular active ingredient and dosage of this active ingredient, i.e., we abstract from the issue of therapeutic substitution for now, to facilitate understanding of the fundamental mechanisms of the model.

The consumer makes a choice over which pharmacy chain  $c$  to visit, and—once in the pharmacy—a choice from the available choice set in the pharmacy. When the consumer chooses a pharmacy  $c$ , he does not know if parallel imported

(PI) or direct imported (DI) versions of the drug will be available, but forms an expectation of availability when he chooses which pharmacy chain to visit. Because pharmacies potentially have higher margins on drugs that the consumer do not strictly prefer, it may be optimal not to propose the lower margin drug with certainty in order to force consumers to buy the other option. It may also be optimal to propose consumers' preferred drug with a positive probability in order to attract them. In order for the model to be consistent with rational expectations, we assume that consumers' expectations about drug availability correspond to the probabilities of availability chosen by the pharmacy chains.

For a given active ingredient, the choice set at pharmacies can be  $\{PI\}$ ,  $\{DI\}$  or  $B = \{DI, PI\}$ . As will be clear from inspection of the pharmacy chains profit maximization objective, it is never optimal for them to be completely stock out of, and thus endogenously choose to propose patients an empty choice set with non-zero probability.<sup>3</sup> We let the origin of the drug be indexed by  $k \in \{0, 1\}$  where 0 denotes *PI* and 1 *DI*.

We denote  $\theta_{ct}^0$  and  $\theta_{ct}^1$  the probabilities that the choice sets are  $\{PI\}$  or  $\{DI\}$  respectively and thus  $1 - \theta_{ct}^0 - \theta_{ct}^1$  the probability of the choice set is  $B = \{DI, PI\}$ . We assume that the utility of consumer  $i$  is given by

$$u_{ikct} = \alpha_{ikct} + \epsilon_{ikct}$$

where  $\alpha_{ikct}$  is the deterministic utility consumer  $i$  obtains from choosing the drug of origin  $k$  in pharmacy chain  $c$  in market  $t$ , and  $\epsilon_{ikct}$  is an idiosyncratic i.i.d. random utility component, that we assume distributed independently across drugs and chains according to a Gumbel distribution. Note that the deterministic utility component could be a function of observable characteristics of drugs, chains, time, or the consumer.<sup>4</sup> However, even if the choice between parallel and direct imported versions of the prescribed active ingredient is driven by comparisons of utilities of the available versions to the consumer given his choice set, we assume that consumers cannot choose the pharmacy chain with perfect knowledge of drug availability.

Thus, within the pharmacy, the probability that consumer  $i$  chooses  $k$  conditional on choice of pharmacy chain  $c$  when both products are available in the pharmacy is given by

$$s_{ikt|c,B} = \frac{e^{\alpha_{ikct}}}{e^{\alpha_{i0ct}} + e^{\alpha_{i1ct}}} = \frac{1}{1 + e^{\alpha_{ikct} - \alpha_{ik'ct}}} \text{ with } k' = 1 - k$$

Using the pharmacy specific random choice sets, assuming that the consumer always prefer the available drug than no drug, the choice probability of product  $k$  conditional on the choice of pharmacy  $c$  is

$$s_{ikt|c} = \theta_{ct}^k + s_{ikt|c,B}(1 - \theta_{ct}^0 - \theta_{ct}^1),$$

that is, the probability of drug  $k$  being the only available plus the probability that drug  $k$  is chosen when both are available times the probability that both are available.

<sup>3</sup>Note that this is absent of any considerations of storage costs.

<sup>4</sup>If we include an outside good, say, not going to a pharmacy, all utilities will be defined relative to this.

Then, the expected utility the consumer gets from any choice set  $S_{ct}$  in a pharmacy  $c$  is equal to the inclusive value of this choice set, which is given by the log-sum formula

$$I_{i|S_{ct}} = \ln \left( \sum_{k \in S_{ct}} e^{\alpha_{ikct}} \right),$$

where  $I_{i|S_{ct}}$  denotes the inclusive value of consumer  $i$  when faced with the choice set  $S_{ct}$  at chain  $c$  in market  $t$ . The inclusive value is equal to  $\alpha_{ikct}$ , i.e., the deterministic utility of drug  $k$ ,<sup>5</sup> when  $k$  is the only drug available. Note that the inclusive value when both are available is always larger than any of the  $\alpha_{ikct}$  alone.

The expected utility of visiting pharmacy chain  $c$  in market  $t$  is then given by the expected inclusive value, which we denote by  $I_{ict}$ , where the expectation is taken over the uncertain—from the consumer's point of view—choice set,

$$\begin{aligned} I_{ict} &= E_{S_{ct}} [I_{i|S_{ct}}] \\ &= \sum_k \theta_{ct}^k \alpha_{ikct} + (1 - \theta_{ct}^0 - \theta_{ct}^1) \ln \left( \sum_k e^{\alpha_{ikct}} \right). \end{aligned}$$

We assume that patient  $i$  chooses chain  $c$  in order to maximize his indirect utility  $I_{ict} + \varepsilon_{ict}$ , where  $\varepsilon_{ict}$  is extreme value Gumbel distributed independently across chains. The probability that consumer  $i$  visits chain  $c$  is then

$$s_{ict} = \frac{e^{I_{ict}}}{\sum_c e^{I_{ict}}}.$$

Then, denoting by  $F(\alpha_{it})$  the cumulative distribution function of consumer preferences  $\alpha_{it} = (\alpha_{i01t}, \dots, \alpha_{iC1t}, \alpha_{i11t}, \dots, \alpha_{i1Ct})$ , we can write the aggregate choice probability or market share of drug  $k$  sold by  $c$  at  $t$  as

$$s_{kct} = \int s_{ikct} dF(\alpha_{it}) = \int s_{ict} s_{ikt|c} dF(\alpha_{it}),$$

and the aggregate market share of drug  $k$  within the pharmacy chain  $c$  as

$$\begin{aligned} s_{kt|c} &= \int s_{ikt|c} dF(\alpha_{it}) \\ &= \int \left[ \theta_{ct}^k + s_{ikt|c,B} (1 - \theta_{ct}^0 - \theta_{ct}^1) \right] dF(\alpha_{it}) \\ &= \theta_{ct}^k + \left( 1 - \theta_{ct}^0 - \theta_{ct}^1 \right) \int s_{ikt|c,B} dF(\alpha_{it}). \end{aligned}$$

## 2.2 Pharmacy Chains Behavior

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

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

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<sup>5</sup>Note that we omit the means of all Gumbel distributed random utility terms,  $\varepsilon_{ijkt}$ , in the following. It is equal to the Euler-Mascheroni constant for all terms involving expectations of random utility terms, and will thus not affect choice.

where we will take  $p_{kct} = \bar{p}_t$ , that is, equal to a binding price ceiling chosen by the regulator for a given active ingredient-dosage combination, and where  $w_{kct}$  is the wholesale price of drug  $k$  in pharmacy  $c$  at  $t$ . We take the wholesale prices as given for now, and return to their determination when discussing the behavior of producers in the next section. We now denote by  $m_{kct} \equiv \bar{p}_t - w_{kct}$  the product price-cost margin, where  $w_{kct}$  allows wholesale price discrimination across pharmacy chains.

Remark that we implicitly assume that both margins are positive, such that pharmacy chains accept both procurement channels. Necessary first order conditions for an interior solution for the  $\theta$ 's are

$$0 = \frac{\partial \pi_{ct}}{\partial \theta_{ct}^0} = \frac{\partial \pi_{ct}}{\partial \theta_{ct}^1}. \quad (1)$$

For  $\theta_{ct}^0$ , this is

$$\begin{aligned} 0 &= \sum_k m_{kct} \frac{\partial s_{kct}}{\partial \theta_{ct}^0} = \sum_k m_{kct} \int \frac{\partial}{\partial \theta_{ct}^0} [s_{ict} s_{ikt|c}] dF(\alpha_{it}) \\ &= \int \sum_k m_{kct} \left[ \frac{\partial s_{ikt|c}}{\partial \theta_{ct}^0} s_{ict} + s_{ikt|c} \frac{\partial s_{ict}}{\partial \theta_{ct}^0} \right] dF(\alpha_{it}), \end{aligned}$$

which has the interpretation that a marginal increase in  $\theta_{ct}^0$  will have two effects: The first term shows the potential increase in profit through higher sales of the more profitable good 0 and lower sales of the less profitable good 1, due to good 0 more often being the only option of the consumer; while the second term is the profit loss from a loss in market share, due to chain  $c$ 's less attractive policy, from the consumer's point of view, that is, more often being stocked out of the other good.

As

$$\begin{aligned} \frac{\partial s_{ikt|c}}{\partial \theta_{ct}^{k'}} &= 1_{\{k=k'\}} - s_{ikt|c,B}, \text{ and} \\ \frac{\partial s_{ict}}{\partial \theta_{ct}^k} &= \left[ \alpha_{ikct} - \ln \left( \sum_k e^{\alpha_{ikct}} \right) \right] s_{ict} (1 - s_{ict}) \leq 0, \end{aligned}$$

using the fact that

$$\begin{aligned} &\frac{\partial s_{ikt|c}}{\partial \theta_{ct}^0} s_{ict} + s_{ikt|c} \frac{\partial s_{ict}}{\partial \theta_{ct}^0} \\ &= \left( 1_{\{k=0\}} - s_{ikt|c,B} \right) s_{ict} + s_{ikt|c} \left[ \alpha_{i0ct} - \ln \left( \sum_k e^{\alpha_{ikct}} \right) \right] (1 - s_{ict}) s_{ict}, \end{aligned}$$

we obtain that the first order condition for optimal  $\theta_{ct}^0$  implies

$$\frac{m_{0ct}}{m_{1ct}} = \frac{\int s_{i1t|c,B} s_{ict} + s_{i1t|c} \left[ \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i0ct} \right] (1 - s_{ict}) s_{ict} dF(\alpha_{it})}{\int s_{i1t|c,B} s_{ict} - s_{i0t|c} \left[ \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i0ct} \right] (1 - s_{ict}) s_{ict} dF(\alpha_{it})} \quad (2)$$

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  $\theta_{ct}^1$  can be written

$$\frac{m_{1ct}}{m_{0ct}} = \frac{\int s_{i0t|c,B} s_{ict} + s_{0t|c} \left[ \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i1ct} \right] (1 - s_{ict}) s_{ict} dF(\alpha_{it})}{\int s_{i0t|c,B} s_{ict} - s_{1t|c} \left[ \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i1ct} \right] (1 - s_{ict}) s_{ict} dF(\alpha_{it})}. \quad (3)$$

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

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

and similarly

$$\begin{aligned}
& s_{i0t|c,B} s_{ict} + s_{0t|c} \left[ \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i1ct} \right] (1 - s_{ict}) s_{ict} \\
> & s_{i0t|c,B} s_{ict} - s_{1t|c} \left[ \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i1ct} \right] (1 - s_{ict}) s_{ict}.
\end{aligned}$$

Thus, Equation (2) cannot be true if  $m_{1ct} > m_{0ct}$ , and Equation (3) cannot be true if  $m_{1ct} < m_{0ct}$ .

Considering the case where  $m_{1ct} < m_{0ct}$ , there is then no interior solution for  $\theta_{ct}^1$ , and thus we will have  $\theta_{ct}^1 = 0$ , meaning that the pharmacy chain never proposes only the drug with lower margin. Then  $\theta_{ct}^0$  is solution of Equation (2). 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 on average less variety.

Assuming for now that the margins are larger for parallel imports (good 0) for all chains, we can set the probability of proposing direct imports alone,  $\theta_{ct}^1$ , to zero for all  $c$  in the following exposition. Moreover, denote

$$(1 - \theta_{ct}^0) = \theta_{ct},$$

that is, the probability that both goods are available in pharmacy chain  $c$ . We can now express the expected inclusive value as

$$I_{ict} = (1 - \theta_{ct}) \alpha_{i0ct} + \theta_{ct} \ln \left( \sum_k e^{\alpha_{ikct}} \right) = \alpha_{i0ct} + \theta_{ct} \delta_{ict},$$

where

$$\delta_{ict} \equiv \ln \left( \sum_k e^{\alpha_{ikct}} \right) - \alpha_{i0ct} = \ln \left( 1 + e^{\Delta \alpha_{ict}} \right),$$

where  $\Delta \alpha_{ict} = \alpha_{i1ct} - \alpha_{i0ct}$ . Thus,  $\delta_{ict}$  is the incremental expected utility from having both drugs available to choose from, as opposed to only parallel import. Furthermore, let

$$\rho_{ict} \equiv s_{i1t|c,B},$$



that is, the probability that consumer  $i$  chooses the direct imported variety in chain  $c$  at  $t$  when both are available.<sup>6</sup> It will be helpful to note that  $\delta_{ict} = -\ln(1 - \rho_{ict})$ , 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 direct imported variety when both are available.

We can now rewrite

$$\begin{aligned} s_{i1t|c}(\theta_{ct}) &= \theta_{ct}\rho_{ict}, \\ s_{i0t|c}(\theta_{ct}) &= 1 - \theta_{ct}\rho_{ict}, \end{aligned}$$

and

$$s_{ct}(\boldsymbol{\theta}_t) = \int \frac{e^{\alpha_{i0ct} + \theta_{ct}\delta_{ict}}}{\sum_c e^{\alpha_{i0ct} + \theta_{ct}\delta_{ict}}} dF(\alpha_{it}) = \int s_{ict}(\boldsymbol{\theta}_t) dF(\alpha_{it}),$$

where  $\boldsymbol{\theta}_t = (\theta_{0t}, \dots, \theta_{Ct})'$ , the vector consisting of the probability that both goods are available for each chain.

The profit maximization problem for each chain  $c$  at  $t$  is now given by the program

$$\max_{0 \leq \theta_{ct} \leq 1} \pi_{ct},$$

where the optimality conditions are

$$\frac{\partial \pi_{ct}}{\partial \theta_{ct}} \begin{cases} \leq 0 & \text{if } \theta_{ct} = 0, \\ = 0 & \text{if } 0 < \theta_{ct} < 1, \\ \geq 0 & \text{if } \theta_{ct} = 1. \end{cases} \quad (4)$$

The derivative of profits with respect to the probability that both goods are available is

$$\frac{\partial \pi_{ct}}{\partial \theta_{ct}} = m_{0ct} \frac{\partial s_{0ct}}{\partial \theta_{ct}} + m_{1ct} \frac{\partial s_{1ct}}{\partial \theta_{ct}}, \quad (5)$$

where the derivatives of shares with respect to  $\theta_{ct}$  are

$$\begin{aligned} \frac{\partial s_{0ct}}{\partial \theta_{ct}} &= \int (-\rho_{ict}s_{ict} + (1 - \theta_{ct}\rho_{ict})\delta_{ict}s_{ict}(1 - s_{ict})) dF(\alpha_{it}), \text{ and} \\ \frac{\partial s_{1ct}}{\partial \theta_{ct}} &= \int (\rho_{ict}s_{ict} + \theta_{ct}\rho_{ict}\delta_{ict}s_{ict}(1 - s_{ict})) dF(\alpha_{it}). \end{aligned}$$

From these expressions, we see that there are basically two effects from increasing the probability that both products are available. To give a better sense of how the model works, we will discuss these effects first 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 where it is the only product available, while it is *positive* for the direct import, as it reduces the number of times that it is stocked out. The second effect is a change in the probability of choosing chain  $c$ , weighted by individual  $i$ 's conditional probability of choosing the product.

<sup>6</sup>Keep in mind that  $\rho$  could be a function of characteristics of the drugs through its dependence on the deterministic utility components  $\alpha_{ikct}$

This effect is *positive* for both products, since the incremental expected utility of having both drugs available,  $\delta_{ict}$ , is positive for all individuals, i.e., 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  $\theta_{ct}$  to induce more consumers to choose 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 direct imported variety on average, and even more so if this correlates positively with the probability of choosing chain  $c$  in the population. However, if people on average have a strong preference for the direct imported variety, the incremental utility  $\delta_{ict}$  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, we can see that the distribution of tastes in the population will be central in the decision of a pharmacy chain on how much to constrain supply.

From Equation (5), together with the previous discussion, we can see that an increase in  $m_{0ct}$ —the margin on parallel imports—will lead to decrease in  $\theta_{ct}$ , as  $\partial s_{0ct}/\partial \theta_{ct} < 0$ , while the opposite holds for an increase in  $m_{1ct}$ . We can also see that only the relative margin matters for the decision of the pharmacy chain, though the relative margin will depend on both the wholesale prices and the price ceiling.

We assume that each pharmacy chain  $c$  sets  $\theta_{ct}$  to maximize its profits conditional on the wholesale prices it faces, while taking the choices of all other pharmacy chains as given. The equilibrium in each market  $t$  will then be given by the vector  $\theta_t^*(\mathbf{w}_{0t}, \mathbf{w}_{1t})$ , which consist of the elements  $\theta_{ct}^*(\mathbf{w}_{0t}, \mathbf{w}_{1t})$ , that is, the vector of equilibrium  $\theta$  in  $t$  as a function of the wholesale prices of direct and parallel import in the market. Note that we have suppressed the dependence on  $\bar{p}_t$  for convenience. The vector  $\theta_t^*(\mathbf{w}_{0t}, \mathbf{w}_{1t})$  is defined such that Equation (4) is satisfied simultaneously for all pharmacy chains at  $t$ .

## 2.3 Upstream Producers and Importers

We now model the upstream behavior of both originator producers and of parallel importers. We assume that upstream firms and pharmacy chains bargain over wholesale prices, leading to the *Nash-in-Nash bargaining* model, first proposed by Horn and Wolinsky (1988). As documented by Brekke and Holmås (2014), the assumption that they bargain over a piece-rate price can be defended on the grounds of the prohibition against side-payments in contracts between producers and wholesalers in the Norwegian pharmaceutical market.

### 2.3.1 Producer Behavior

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

Thus, letting  $\theta_t^* \equiv \theta_t^*(\mathbf{w}_{0t}, \mathbf{w}_{1t})$  in the following for notational brevity, the profits of the producer are given by

$$\Pi_t(\mathbf{w}_{1t}) = \sum_{c \in \mathcal{C}} \left[ (w_{1ct} - c_t) s_{1ct}(\theta_t^*) + (p_t^I - c_t) s_{0ct}(\theta_t^*) \right],$$

where  $w_{1ct}$  is the wholesale price charged for direct imported drugs to chain  $c$  at time  $t$ ,  $w_{0ct}$  is the wholesale price for parallel imports,  $c_t$  is the marginal cost of production, and  $p_t^I$  is the price that the producer earns from sales in the exporting country to the parallel importer.

Remark that if the producer were to obtain wholesale prices equal to the price he obtains from exporting countries when parallel traders import the drug for market  $\mathcal{C}$ , that is  $w_{1ct} = p_t^I$  for all  $c \in \mathcal{C}$ , then the profit per unit demand (aggregate market size assumed exogenous and fixed for that market) is

$$\begin{aligned} \Pi_t(p_t^I, \dots, p_t^I) &= (p_t^I - c_t) \sum_{c \in \mathcal{C}} [s_{1ct}(\theta_t^*) + s_{0ct}(\theta_t^*)] \\ &= (p_t^I - c_t) > 0 \end{aligned}$$

Thus, the relevant range of the producer's wholesale price  $w_{1ct}$  is above the export price  $p_t^I$  but below the regulated retail price  $\bar{p}_t$ .

We assume that in each pairwise negotiation with the pharmacy chains, the producer and pharmacy chain  $c$  sets wholesale prices to maximize the Nash-product

$$N_{1ct} = (\Pi_t - \underline{\Pi}_{ct})^{b_{1c}} (\pi_{ct} - \underline{\pi}_{1ct})^{1-b_{1c}}, \quad (6)$$

where  $b_{1c}$  is the bargaining weight of the producer when negotiating with chain  $c$ ,  $\underline{\Pi}_{ct}$  is the producer's profit in absence of an agreement with pharmacy chain  $c$ , and  $\underline{\pi}_{1ct}$  is likewise pharmacy chain  $c$ 's profit in absence of an agreement with the producer. We make the relatively strong assumption that all contracts will remain the same if another negotiation fails.<sup>7</sup> The first order condition for a solution to Equation (6), is

$$b_{1c} \frac{\partial \Pi_t / \partial w_{1ct}}{\Pi_t - \underline{\Pi}_{ct}} + (1 - b_{1c}) \frac{\partial \pi_{ct} / \partial w_{1ct}}{\pi_{ct} - \underline{\pi}_{1ct}} = 0, \quad (7)$$

where  $\partial \pi_{ct} / \partial w_{1ct} = -s_{1ct}$ , since the pharmacy chain maximizes its profits given wholesale prices by setting  $\theta$  optimally, such that effects through  $\theta$  only have second order impact on the profits of the pharmacy chain.<sup>8</sup> Note that  $\Pi_t - \underline{\Pi}_{ct}$  and  $\pi_{ct} - \underline{\pi}_{1ct}$  are the net values of an agreement for the producer and chain  $c$  respectively. Letting  $s_{jrt \setminus 1c}$  denote the share of chain  $r$ 's product  $j$  in  $t$  when direct imports are not available at chain  $c$ , we can express the net value for the producer, suppressing the dependence of shares on  $\theta^*$ , as

$$\begin{aligned} \Pi_t - \underline{\Pi}_{ct} &= \sum_{r \in \mathcal{C}} [(w_{1rt} - c_t) s_{1rt} + (p_t^I - c_t) s_{0rt}] \\ &\quad - \sum_{r \in \mathcal{C}} [(w_{1rt} - c_t) s_{1rt \setminus 1c} + (p_t^I - c_t) s_{0rt \setminus 1c}] \\ &= \sum_{r \in \mathcal{C}} (w_{1rt} \Delta_{1c} s_{1rt} + p_t^I \Delta_{1c} s_{0rt}), \end{aligned}$$

<sup>7</sup>This assumption is commonplace in the literature estimating structural bargaining models. See e.g., Gowrisankaran, Nevo, and Town (Forthcoming) and Crawford and Yurukoglu (2012).

<sup>8</sup>This follows directly from the Envelope Theorem.

where we let  $s_{jct \setminus 1c} = 0$ , and  $\Delta_{1c}s_{jrt} \equiv s_{jrt} - s_{jrt \setminus 1c}$ , that is, the difference in share of product  $j$  in chain  $r$  between the case of agreement and disagreement in the negotiations between the producer and chain  $c$ . Since aggregate demand is assumed to be constant, particularly since consumer prices are fixed at  $\bar{p}_t$ , such that market shares sum to one both in the case of agreement and disagreement, the cost of production is immaterial to the change in producer profit. Similarly, the net value for the chain is

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

where the first term simply evaluates to  $(\bar{p}_t - w_{1ct})s_{1ct}$ . When the shape of demand is identified, it is possible to calculate the differences in shares,  $\Delta_{1c}s_{jrt}$ , using the estimated demand system. Note that this will also depend on the change in optimal  $\theta$  for each pharmacy chain.

We assume that the producer takes as given the margin  $(p_t^I - c_t)$  he obtains on sales in exporting countries from parallel imports in market  $\mathcal{C}$ . This is in line with the price in exporting countries being constrained by regulation in those countries. We also assume that each bargaining pair will observe the wholesale prices of parallel imports to each pharmacy chain  $\mathbf{w}_{0t} = (w_{01t}, w_{02t}, \dots, w_{0Ct})$ .

In maximizing the Nash-product, there will be an effect on the producer's profit from how changes in wholesale prices affects the equilibrium  $\theta_t^*$  in the next stage of the game. Let  $\mathbf{F}_{\theta,t}$  denote the vector of derivatives of pharmacy chain profit with respect to direct import availability at time  $t$ , i.e.

$$\mathbf{F}_{\theta,t} \equiv \left( \frac{\partial \pi_{1t}}{\partial \theta_{1t}}, \frac{\partial \pi_{2t}}{\partial \theta_{2t}}, \dots, \frac{\partial \pi_{Ct}}{\partial \theta_{Ct}} \right)'$$

The derivative of  $\theta_t^*(\mathbf{w}_{0t}, \mathbf{w}_{1t})$  with respect to its argument can be found by the implicit function theorem. Implicit differentiation of the system of first order conditions  $\mathbf{F}_{\theta,t} = \mathbf{0}$  yields

$$\frac{\partial \mathbf{F}_{\theta,t}}{\partial \theta_t'} \bigg|_{\theta_t = \theta_t^*} d\theta_t + \frac{\partial \mathbf{F}_{\theta,t}}{\partial \mathbf{w}_{1t}'} \bigg|_{\theta_t = \theta_t^*} d\mathbf{w}_{1t} = \mathbf{0}.$$

The Jacobian of  $\theta_t^*$  with respect to  $\mathbf{w}_{1t}$  is then

$$\frac{\partial \theta_t^*}{\partial \mathbf{w}_{1t}'} = - \left( \frac{\partial \mathbf{F}_{\theta,t}}{\partial \theta_t'} \bigg|_{\theta_t = \theta_t^*} \right)^{-1} \frac{\partial \mathbf{F}_{\theta,t}}{\partial \mathbf{w}_{1t}'} \bigg|_{\theta_t = \theta_t^*}.$$

Recalling that  $\frac{\partial \pi_{ct}}{\partial \theta_{ct}} = (\bar{p}_t - w_{0ct}) \frac{\partial s_{0ct}}{\partial \theta_{ct}}(\theta_t) + (\bar{p}_t - w_{1ct}) \frac{\partial s_{1ct}}{\partial \theta_{ct}}(\theta_t)$ , we have that

$$\frac{\partial \mathbf{F}_{\theta,t}}{\partial \mathbf{w}_{1t}'} = - \begin{pmatrix} \frac{\partial s_{11t}}{\partial \theta_{1t}} & 0 & \dots & 0 \\ 0 & \frac{\partial s_{12t}}{\partial \theta_{2t}} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \frac{\partial s_{1Ct}}{\partial \theta_{Ct}} \end{pmatrix},$$

while

$$\frac{\partial \mathbf{F}_{\theta,t}}{\partial \theta'_t} = \begin{pmatrix} \sum_k m_{k1t} \frac{\partial^2 s_{k1t}}{\partial \theta_{1t}^2} & \sum_k m_{k1t} \frac{\partial^2 s_{k1t}}{\partial \theta_{1t} \partial \theta_{2t}} & \cdots & \sum_k m_{k1t} \frac{\partial^2 s_{k1t}}{\partial \theta_{1t} \partial \theta_{Ct}} \\ \sum_k m_{k2t} \frac{\partial^2 s_{k2t}}{\partial \theta_{2t} \partial \theta_{1t}} & \sum_k m_{k2t} \frac{\partial^2 s_{k2t}}{\partial \theta_{2t}^2} & \cdots & \sum_k m_{k2t} \frac{\partial^2 s_{k2t}}{\partial \theta_{2t} \partial \theta_{Ct}} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_k m_{kCt} \frac{\partial^2 s_{kCt}}{\partial \theta_{Ct} \partial \theta_{1t}} & \sum_k m_{kCt} \frac{\partial^2 s_{kCt}}{\partial \theta_{Ct} \partial \theta_{2t}} & \cdots & \sum_k m_{kCt} \frac{\partial^2 s_{kCt}}{\partial \theta_{Ct}^2} \end{pmatrix}.$$

Then, the derivative of producer profits with respect to the wholesale price to chain  $\tilde{c}$  is

$$\begin{aligned} \frac{\partial \Pi_t}{\partial w_{1ct}} &= s_{1ct}(\theta_t^*) + \sum_{r \in \mathcal{C}} \left[ (w_{1rt} - c_t) \frac{\partial s_{1rt}}{\partial w_{1ct}}(\theta_t^*) + (p_t^I - c_t) \frac{\partial s_{0rt}}{\partial w_{1ct}}(\theta_t^*) \right] \\ &= s_{1ct}(\theta_t^*) + \sum_{r \in \mathcal{C}} \left[ w_{1rt} \frac{\partial s_{1rt}}{\partial w_{1ct}}(\theta_t^*) + p_t^I \frac{\partial s_{0rt}}{\partial w_{1ct}}(\theta_t^*) \right], \end{aligned}$$

where the second equality follows from the assumption of inelastic aggregate demand, such that  $\sum_{c \in \mathcal{C}} (\partial s_{1ct} / \partial w_{1ct} + \partial s_{0ct} / \partial w_{1ct}) = 0$ .

Now, rearrange and stack the first order conditions of Equation (7) for each  $c \in \mathcal{C}$ , to get

$$\mathbf{s}_{1t} + \left( \frac{\partial \mathbf{s}'_{1t}}{\partial \mathbf{w}_{1t}} - \mathbf{\Gamma}_{1t}^1 \right) \mathbf{w}_{1t} + \left( \frac{\partial \mathbf{s}'_{0t}}{\partial \mathbf{w}_{1t}} - \mathbf{\Gamma}_{0t}^1 \right) \mathbf{p}_t^I = 0, \quad (8)$$

where  $\mathbf{\Gamma}_{1t}^1$  is a  $\#(\mathcal{C}) \times \#(\mathcal{C})$  matrix with elements  $\mathbf{\Gamma}_{1t}^1(c, r) = \frac{1-b_{1c}}{b_{1c}} \frac{\Delta_{1c} s_{1rt}}{\Delta_{1c} \pi_{ct}} s_{1ct}$ , which relates to the relative bargaining weight of the producer and the chain  $c$ , their relative net value of agreement and the market share of the chain  $c$ .  $\mathbf{\Gamma}_{0t}^1$  is defined analogously, with  $\Delta_{1c} s_{0rt}$  replacing  $\Delta_{1c} s_{1rt}$ . The topscript 1 denotes that the terms relate to a bargaining situation involving the producer. Note that in the case where the producer has all the bargaining weight, that is,  $b_{1c} = 1$ , Equation (8) reduces to the first order condition for an optimal take-it-or-leave-it contract on  $w_{1ct}$  for the producer, while in the case of  $b_{1c} = 0$ , it can be rewritten as the condition for an optimal contract proposed by the chain.

Once the demand shape is identified, together with the optimal behavior of pharmacy chains, this is a system with one equation per molecule-pharmacy chain-period, with in principle two unknowns—the producer's cost  $c_t$  and the price earned in the foreign country  $p_t^I$ —though only the price in the foreign country can be identified in this setting. The reason is that, with the assumption of an exogenous, fixed market size, the producer will anyway expend the cost of supplying these drugs. More specifically, this assumption means that  $\sum_c (s_{0ct} + s_{1ct}) = 1$ , with the implication that the derivatives sum to zero. In such a market, and given the expression for producer profits above, the relevant opportunity cost for the producer is the price it obtains in exporting countries.

Remark that in case the producer does not internalize sales obtained through parallel trade (e.g., because of the organization of international companies), then the relevant profits are

$$\Pi_t = \sum_{c \in \mathcal{C}} (w_{1ct} - c_t) s_{1ct}(\theta_t^*),$$

and the system of first order conditions from Equation (7) becomes

$$\mathbf{s}_{1t} + \left( \frac{\partial \mathbf{s}'_{1t}}{\partial \mathbf{w}_{1t}} - \mathbf{\Gamma}_{1t}^1 \right) (\mathbf{w}_{1t} - \mathbf{c}_t) = 0$$

Note that if  $p_t^I - c_t = 0$ , such that parallel trade is not profitable for the producer, this will be identical to the profit maximization problem when internalizing sales from parallel trade. This could be the case if parallel traders import from sufficiently low price (low income) countries such that the regulated price in the exporting country is equal to the marginal cost of production.

### 2.3.2 Parallel Importers Behavior

We now consider the parallel importer's profits from its total sales of a drug in market  $\mathcal{C}$ . Of course, parallel importers can only make a profit if the imported drug price is lower than the maximum retail price set in market  $\mathcal{C}$ , that is if  $p_t^I < \bar{p}_t$ . This profit is given by

$$\Pi_t^{PI} = \sum_{c \in \mathcal{C}} (w_{0ct} - p_t^I) s_{0ct}(\boldsymbol{\theta}_t^*),$$

where  $w_{0ct}$  is the wholesale price paid for parallel imported drugs by chain  $c$  at time  $t$ , and  $p_t^I$  is the price that the importer has to pay for the drug in the exporting country. The wholesale price that parallel importers get from the pharmacy chains must be in the interval  $[p_t^I, \bar{p}_t]$ .

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 originator products to each pharmacy chain  $\mathbf{w}_{1t} = (w_{11t}, w_{12t}, \dots, w_{1Ct})$ . When bargaining over the wholesale prices charged to the chains,  $\mathbf{w}_{0t}$ , the parallel importer will also take into account how changes in these prices will affect the equilibrium  $\boldsymbol{\theta}_t^*$ . Similarly to Equation (7), the first order conditions for the solution to the Nash bargaining between each pharmacy chain  $\tilde{c}$  and the parallel importer is

$$b_{0c} \frac{\partial \Pi_t^{PI} / \partial w_{0ct}}{\Pi_t^{PI} - \underline{\Pi}_{ct}^{PI}} + (1 - b_{0c}) \frac{\partial \pi_{ct} / \partial w_{0ct}}{\pi_{ct} - \underline{\pi}_{0ct}} = 0, \quad (9)$$

which can be rearranged and stacked over the chains to get

$$\mathbf{s}_{0t} + \left( \frac{\partial \mathbf{s}'_{0t}}{\partial \mathbf{w}_{0t}} - \mathbf{\Gamma}_{0t}^0 \right) (\mathbf{w}_{0t} - \mathbf{p}_t^I) = 0, \quad (10)$$

where  $\mathbf{\Gamma}_{0t}^0$  is defined in the same fashion as  $\mathbf{\Gamma}_{1t}^1$ .

Since wholesale prices are observed, one can use these optimality conditions to identify the parallel importers cost, that is, the price at which imports are paid from the exporting country  $p_t^I$ . This will be conditional on estimates of demand and the bargaining parameters.

## 3 Market

We proceed by first describing the regulatory framework governing the market for prescription drugs in Norway. Due to the computational burden of estimat-

ing our model, we will focus on the market for a single drug, which we describe further below.

### 3.1 Regulation

The Norwegian market for drugs is subject to a wide array of regulations. The Norwegian Medicines Agency, a governmental organization under the Ministry of Health and Care Services, is the main regulatory body for drug affairs, in charge of marketing authorization, drug classification, vigilance, price regulation, reimbursement regulation, and providing information on drugs to prescribers and the public.

All drugs sold on the Norwegian market will be subject to a price cap, set by the Norwegian Medicines Agency. In most cases, this price cap is set as the average of the three lowest among market prices in a fixed group of European comparison countries, consisting of Sweden, Finland, Denmark, Germany, United Kingdom, Netherlands, Austria, Belgium and Ireland. The price caps should normally not change more than once every year. Reconsideration of the price caps will be initiated by the Norwegian Medicines Agency, where selection is based on sales volume over the past 12 months. The price caps are set according to the active ingredient in the drug and amount of active ingredient (dosage). Per unit price caps (unit being defined by Daily Defined Dose (DDD) for drugs where it exists) should generally be equal within the category of a given dosage for a given active ingredient, although the Norwegian Medicines Agency imposes package sizes to have lower per-pack price in some cases.

In cases where the patient has a long term ailment, defined as demanding treatment for at least three months, and the drug under question has been judged to have sufficient effect compared to the costs, government reimbursement is available. The prescribing physician is responsible for deciding if the patient satisfies the criteria for treatment length, while the Norwegian Medicines Agency decides if a drug is efficient and cheap enough to be put on the list of drugs approved for reimbursement. When patients get reimbursed, they face a co-payment of 38 % of the total price, capped at 520 NOK in 2013 (approximately 65 EUR) per three months. The co-payments for drugs and health care spending are capped at 2040 NOK yearly in 2013 (approximately 260 EUR). For drugs that are on patent, the government will reimburse the full cost of the drug to the patient, net of co-payments.

Parallel traded drugs will have to obtain a license for selling drugs in Norway from the Norwegian Medicines Agency, unless they already have obtained a license for sales in the European Economic Area through the centralized European Union procedure. Sales will be to one of the three large wholesalers, as only full-line wholesalers are allowed by law to supply pharmacies with drugs.<sup>9</sup> A license will be for a specific drug package, from a specific country, with the exception of licenses granted through the European Union procedure.

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<sup>9</sup>Whether this matters is an open question, as the market is almost fully vertically integrated at the wholesaler-pharmacy level, although the full-line supply regulation could be an explanation for the concentration and vertical integration observed in the market.

## 3.2 Description

We test our model on the Norwegian market for Atorvastatin, which is a member of the statins drug class, used for lowering blood cholesterol. It is marketed by Pfizer under the trade name *Lipitor*. The patent expired towards the end of 2011, so it is on patent the whole period of our data from 2004 to 2007. The drug comes in four distinct strengths in the Norwegian market: Tablets with 10, 20, 40 and 80 milligram of the active ingredient. The prescription will decide which of these strengths the consumer can obtain at the pharmacy, though the pharmacy can freely propose substitution to a parallel imported alternative given that it has the same strength. Atorvastatin was used by roughly 140,000 individuals in 2004 and 2005, but the number of users dropped to about 100,000 in 2006 and 85,000 in 2007.<sup>10</sup> The explanation for this can largely be attributed to a change in the regulation of statin prescriptions introduced in June 2005. The regulation required that Simvastatin was to be prescribed for all new cases requiring statin treatment, while present users were to be put on treatment with Simvastatin within a year, unless medical considerations dictate otherwise.<sup>11</sup> The motivation for the regulation was to reduce expenditure for the Norwegian National Insurance Administration.

We combine data from several sources: Transaction data from the *Norwegian Directorate of Health* covering all purchases of reimbursable drugs by individuals in Norway, wholesaler registry data from the *Norwegian Institute of Public Health* on monthly wholesale prices of drug wholesalers in Norway, data on price regulation, substitutability and parallel marketing licenses from the *Norwegian Medicines Agency*, and data on aggregate wholesale prices in several countries from *IMS Health*. We thus have data on all purchases of Atorvastatin in Norway for the period 2004–2007, which amounts to about 1,4 million transactions. The transactions are performed by around 170,000 individuals, where a pseudo-ID for each individual allows us to use information on repeated choices. The demographic information on individuals is otherwise limited to age and gender. For each transaction, we know the price the pharmacy charges for the drug, the copayment paid, the specific pharmacy at which the transaction happened, the number of packages bought, and the specific drug package.<sup>12</sup>

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 wholesaler. The three largest chains, Apotek 1, Boots and Vitus, covers 85 % of all pharmacies, while public hospital pharmacies (6 %), a smaller retail chain (5 %), and independent pharmacies (4 %) make up the rest.<sup>13</sup>

Table 1 shows the yearly size of the Atorvastatin market in Norway in millions of *Daily Defined Doses* (DDD), segmented by the amount of active ingredient.<sup>14</sup> We have also calculated the share of DDD which are parallel imports

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<sup>10</sup>The population of Norway was roughly 4.6 million in this period.

<sup>11</sup>More details on this regulatory change can be found in Sakshaug, Furu, Karlstad, Rønning, and Skurtveit (2007).

<sup>12</sup>An example of a specific drug package is *Lipitor* with 40 mg of the active ingredient, containing 98 tablets, and imported by Farmagon from France.

<sup>13</sup>The shares are calculated from our own data and checked against data obtained from the Norwegian Medicines Agency. The numbers correspond exactly to official statistics reported by the Norwegian Medicines agency and the Norwegian Pharmacy Association.

<sup>14</sup>Our definition of the market includes direct purchases in pharmacies by individuals exclusively. Though 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



**Table 1:** Market size in million DDD, share of parallel imports, and price to consumers (Price) and wholesale prices (Wholesale) in NOK/DDD

		2004	2005	2006	2007
10 mg	DDD (mill.)	16.36	15.10	9.13	4.61
	Share parallel	0.00	0.00	0.00	0.13
	Price	8.78	8.84	8.39	8.43
	Wholesale direct	6.21	6.20	5.86	5.86
	Wholesale parallel	-	-	-	4.42
20 mg	DDD (mill.)	34.15	34.99	22.14	12.07
	Share parallel	0.00	0.00	0.00	0.10
	Price	6.62	6.67	6.37	6.42
	Wholesale direct	4.74	4.74	4.52	4.53
	Wholesale parallel	-	-	-	3.15
40 mg	DDD (mill.)	23.78	31.22	26.42	29.32
	Share parallel	0.79	0.48	0.07	0.17
	Price	4.16	4.21	3.82	3.90
	Wholesale direct	3.00	3.01	2.71	2.76
	Wholesale parallel	2.91	2.93	2.87	2.03
80 mg	DDD (mill.)	12.03	20.12	27.38	35.69
	Share parallel	0.93	0.86	0.96	0.63
	Price	2.15	2.23	1.98	1.97
	Wholesale direct	1.55	1.60	1.40	1.39
	Wholesale parallel	1.52	1.50	1.38	1.35

within each segment. We see that for 10 and 20 mg, parallel imports were not present before 2007. For 40 and 80 mg, parallel imports often covers a substantial share of the market, covering around 90% of the 80 mg segment in 2004-2006. The reason for the differences in parallel import shares are likely due to a combination of differences parallel export opportunities, differences in profitability across parallel import locations and differences in the relative price in the exporting country and Norway. Due to the lack of data on parallel trader behavior outside of Norway and the difficulty of determining the reason for why parallel imports are absent in some markets, we will focus solely on the markets where they are present for the part of our estimation regarding upstream producer and importer behavior.<sup>15</sup> There is also substantial variation between some of these years. The market size for 10 and 20 mg decreases substantially over the sample period, while it stays at roughly the same level for 40 mg and increases substantially for 80 mg. It seems likely that the large changes in the number of consumers underlying these figures will have an impact on the distribution of preferences in the market. We will maintain the somewhat strong assumption that the distribution of preferences due to unobserved factors stays constant, both across segments and time, though we do allow the average taste for each available drug to change across segments and time, which we return to when discussing the specification of the consumer choice model.<sup>16</sup> 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 almost all cases, except for 40 mg in 2006, which also corresponds to a large drop in sales of parallel imports (see Figure 1 below).

Table 2 shows information about the specific packages sold in the Norwegian market for Atorvastatin in the sample period. The active upstream firms are Pfizer, Farmagon and Orifarm, where Pfizer holds the patent and is responsible for the direct imports, and Farmagon and Orifarm are parallel importers. The parallel importers have licenses to import from the United Kingdom, France, Czech Republic and Poland, where typically the licenses from the Eastern European countries are acquired in 2006. The underlying sales patterns in the data shows that the packages imported from Eastern Europe are only sold in 2007. Where several source countries are listed, the packages imported from the different countries are given the same ID in the national drug classification system, which means that they are identical.<sup>17</sup> In several of the cases, the par-

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to official statistics (gathered to monitor drug utilization in Norway) on aggregate usage of Atorvastatin, which makes us conclude that this would represent a negligible share of sales.

<sup>15</sup>As we are mostly interested in the behavior of retailers, and how this feeds into the behavior of the upstream firms, this is not a large problem. In the markets where parallel imports are absent, there is no scope for strategic behavior by the pharmacy chains. We do, however, include this part of the sample when estimating the consumer choice model, as it gives us more variation in the choice sets of the consumers over time to identify preference heterogeneity.

<sup>16</sup>To see the consequence of this assumption, imagine the case where, after a large reduction in the number of consumers, the remaining consumers have a very similar tastes. This will affect the incentives of pharmacy chains when setting  $\theta$ , since any change will now have a less dispersed (more “concentrated”) effect than before, in the sense that each consumer reacts more similarly.

<sup>17</sup>The parallel import process is such that the drugs will be repackaged by the parallel importer to be in accordance with nation specific guidelines on package labels, language and

**Table 2:** Drug packages and parallel import licensing

Dose	Company	#Tablets	Source country	License Year
10 mg	Pfizer	100	-	-
	Farmagon	100	Czech Rep.	2006
	Orifarm	100	Poland	2006
20 mg	Pfizer	100	-	-
	Farmagon	100	Czech Rep.	2006
	Orifarm	100	Poland	2006
40 mg	Pfizer	100	-	-
	Farmagon	98	UK, France	2002, 2004
	Farmagon	100	Poland, Czech Rep.	2004, 2006
	Orifarm	98	UK	2002
80 mg	Pfizer	100	-	-
	Farmagon	98	UK, France	2002, 2004
	Farmagon	100	Czech Rep.	2006

allel importers have license to import the package from two countries. In Figure 1, we show sales of each upstream company by month in 1000 DDD, displayed separately for each segment (amount of active ingredient) and pharmacy chain. Inspection of the data underlying this figure shows that parallel imports are exclusively from the Eastern European countries for 10 and 20 mg, where parallel imports enter in the second half of 2007. For 40 mg, parallel imports are from the Western European countries until 2007, when it switches to Eastern European imports after a large drop in parallel imports in 2006. For 80 mg, parallel imports are exclusively from Western Europe until 2007, when about 10% of the parallel traded drugs are imported from Eastern Europe.

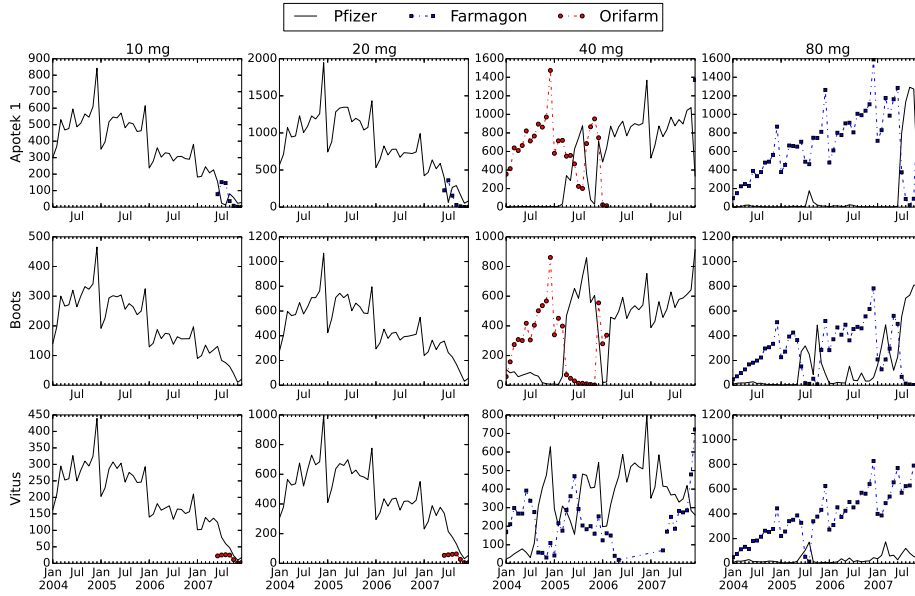
In Figure 2, we show consumer prices and wholesale prices for each upstream company by month, separately for each segment and pharmacy chain. Note that the consumer price is entirely decided by the price cap, which is binding for both the direct and parallel imported varieties. The wholesale prices of parallel importers are consistently lower than the direct import wholesale price—except in one instance—and often substantially so.

## 4 Econometric Estimation

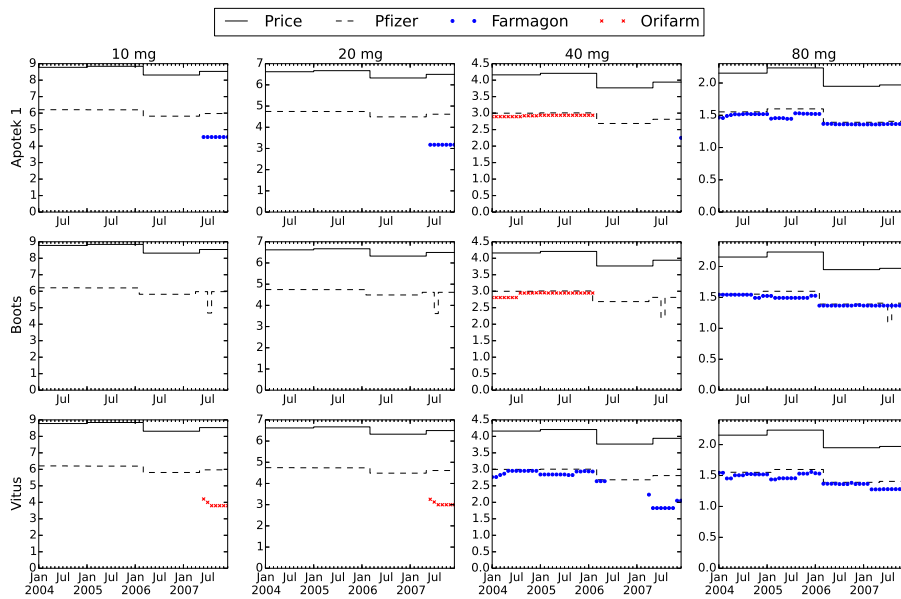
Since we have a panel of repeated choices for individuals, we estimate a mixed parameters logit model of individual choice by maximum likelihood. The connection between the strategic probabilities chosen by the pharmacy chain and consumer choice probabilities makes it impossible to separate the estimation of the two. Thus, the estimation of parameters governing individual choice also includes estimation of the probabilities that both goods are available in any given pharmacy chain in any given market. We return to the discussion of the details of this estimation below. In a second step, we use the estimated parameters and probabilities of both goods being available to identify the opportunity and

warnings, so the correct interpretation is that the packages are indiscernible after repackaging.

**Figure 1:** Monthly sales in 1000 DDD of direct imports (Pfizer) and parallel imports (Farmagon or Orifarm) for each chain and dosage (mg)



**Figure 2:** Monthly price to consumers (Price), wholesale price of direct imports (Pfizer) and wholesale price of parallel imports (Farmagon or Orifarm) in NOK/DDD for each chain and dosage (mg)



marginal costs for both direct and parallel importers, given by  $p_t^I$ .

We first discuss the specification and estimation of the individual choice model, and then the identification of the bargaining model and marginal costs, before we present of our results.

#### 4.1 Consumer and chain behavior

Take as the point of departure our previously described model, i.e.

$$\begin{aligned}
\rho_{ict} &= \frac{e^{\alpha_{i1ct}}}{e^{\alpha_{i0ct}} + e^{\alpha_{i1ct}}} \\
s_{i1t|c} &= \theta_{ct}\rho_{ict} \quad s_{i0t|c} = 1 - \theta_{ct}\rho_{ict} \\
s_{ict} &= \frac{e^{\alpha_{i0ct} + \theta_{ct}\delta_{ict}}}{\sum_k e^{\alpha_{i0kt} + \theta_{kt}\delta_{ikt}}} \\
s_{ijtc} &= s_{ijt|c}s_{ict} \\
\pi_{ct}(\boldsymbol{\theta}_t) &= m_{0ct} \int s_{i0ct}(\boldsymbol{\theta}_t) dF + m_{1ct} \int s_{i1ct}(\boldsymbol{\theta}_t) dF \\
\boldsymbol{\theta}_t^* &= \left\{ \arg \max_{0 \leq \theta_{ct} \leq 1} \pi_{ct}(\boldsymbol{\theta}_t) \right\}_{c \in \mathcal{C}},
\end{aligned} \tag{11}$$

where  $\alpha_{ijct}$  is individual  $i$ 's deterministic utility from product type  $j$  bought at pharmacy chain  $c$  in market  $t$ . For the estimates presented below, the specification of individual utility is

$$\alpha_{ijct} = \alpha_{jct} + \sigma_j \nu_i^j + \sigma_c \nu_i^c + \gamma_j \mathbf{1}_{\{age_i > age_{0.5}\}} + \delta_c^{g_i} + \sigma_c^{g_i} \nu_i^c, \tag{12}$$

where  $\alpha_{jct}$  is the average utility in market  $t$  for product  $j$  at chain  $c$ , common to all individuals and thus capturing any market fixed effects for each product.  $\nu_i^k$  is individual  $i$ 's taste characteristic for product characteristic  $k$ , here taken to be either product type  $j$  or a specific chain  $c$ . We assume that these taste characteristics are standard normal distributed, such that  $\sigma_k$  is a parameter measuring the scale of individual utility in deviations from the mean. Demographics enter by an indicator for whether individual  $i$  is above the median age in the sample ( $age_{0.5}$ ), which is allowed to affect the relative taste for product type  $j$  with utility  $\gamma_j$ . More specifically, we only allow a difference in the mean utility for parallel imports, such that  $\gamma_1 = 0$ . Finally,  $\delta_c^{g_i}$  is a chain specific utility term and  $\sigma_c^{g_i}$  is a chain specific utility dispersion term, both conditional on individual  $i$ 's group  $g_i \in \mathcal{G}^u$ , where  $\mathcal{G}^u$  is the set of groups in the population. The group of individual  $i$  is unobserved, and is thus treated as a latent class during estimation. Note that  $\sigma_c^{g_i}$  is interacted with individual  $i$ 's unobserved taste characteristic for chain  $c$ ,  $\nu_i^c$ , which allows each group in  $\mathcal{G}^u$  to have a different scale for the unobserved chain specific taste characteristics.

Additional restrictions on the parameters are that  $\sigma_j$  is the same for both direct and parallel imports, and  $\sigma_c^{g_i}$  is the same for all chains, such that  $\sigma_j = \sigma_J$ ,  $j \in \{0, 1\}$  and  $\sigma_c^{g_i} = \sigma_C^{g_i}$ ,  $\forall c \in \mathcal{C}$ , though we do allow the baseline scale of individual taste for chain  $c$ ,  $\sigma_c$ , to differ across chains.<sup>18</sup> We allow there to be four latent classes, where one is arbitrarily chosen as the base group,  $g = 0$  with

<sup>18</sup>Initial attempts at different specifications did not seem to indicate large gains from more complex parameterizations.

$\delta_c^0 = 0$  and  $\sigma_C^0 = 0$ . Each group,  $g$ , has a population share  $\tau_g$ , assumed to be the same across markets, which is introduced into the likelihood as a probability to be estimated. The population share corresponds to the probability that a random individual will be a member of the group, and is parametrized as

$$\tau_g(\boldsymbol{\eta}) = \frac{e^{\eta_g}}{\sum_{g \in \mathcal{G}^u} e^{\eta_g}},$$

where  $\boldsymbol{\eta} \in \mathbb{R}^{\#\mathcal{G}^u}$  is a vector of parameters describing the group probabilities through the parametrization in (4.1). This ensures that  $0 < \tau_g < 1$  for all groups. Without loss of generality, we fix  $\eta_0 = 0$  to ensure that there is a unique vector of population shares,  $\boldsymbol{\tau}$ , for all values of  $\boldsymbol{\eta}$ , such that the likelihood—which we will describe shortly—is well defined.

The expressions for aggregate shares, used in the solution of the simultaneous market contraction and equilibrium calculation, is now given by

$$s_{jct} = \theta_{ct} \sum_{g \in \mathcal{G}^u} \tau_g \sum_{g^o \in \mathcal{G}^o} \tau_{g^o,t} \int s_{ijt|c}(g^o, \nu_i) s_{ict}(g, g^o, \nu_i) dF(\nu_i), \quad (13)$$

where  $g^o$  now denotes the observed demographic group (age above or below median)—to separate it from the unobserved group  $g$ —which has known shares in the population in each market given by  $\tau_{g^o,t}$ . Note that the unobserved group of the individual only enters the probability of the individual choosing a given chain,  $s_{ict}$ , which is purely a feature of our assumption that the unobserved group only governs chain specific utility.

First, recognize that the estimates of the mean market parameters  $\alpha_{0ct}$ ,  $\alpha_{1ct}$  and  $\theta_{ct}$  will be functions of the parameters governing individual heterogeneity and the data. Using this, let  $\beta = (\sigma_J, \sigma_C, \gamma_0)$ , i.e., the full vector of parameters to estimate by maximum likelihood. The probability that an individual  $i$  chooses product  $j$  at chain  $c$  in market  $t$  as a function of the parameter vector  $\beta$  conditional on  $\nu_i$ , is then  $s_{ijct}(\beta; \nu_i)$ . The likelihood of individual  $i$ 's choice sequence can be written

$$L_i(\beta) = \sum_{g \in \mathcal{G}^u} \tau_g \int \left( \prod_{p \in \mathcal{P}_i} s_{i, y_{ip}, t_p}(\beta; g, g^o, \nu_i) \right) dF(\nu_i), \quad (14)$$

where  $\mathcal{P}_i$  is the set of purchase events in which consumer  $i$  is involved,  $y_{ip}$  denotes consumer  $i$ 's choice of product and chain under purchase event  $p$  and  $t_p$  is the market in which purchase event  $p$  happens.<sup>19</sup> The log likelihood to be maximized with respect to the parameters of the model is then

$$\ln \mathcal{L}(\beta) = \sum_i \ln L_i(\beta) \quad (15)$$

Note that if a person is observed to choose the direct import in the data, the probability of the conditional choice, given observed and unobserved individual taste shifters, is actually

$$s_{i1t|c}(\beta; g^o, \nu_i) = \rho_{ict}(\beta; g^o, \nu_i),$$

<sup>19</sup>There is no summation over the observed groups,  $g^o$ , as these are known for all individuals.

i.e. not including the  $\theta_{ct}$ , since we know that direct import was available, such that her choice was not affected by any stock-out.<sup>20</sup> If we see a person choosing parallel import, we do not observe the choice set she had available. The pharmacy chains' incentives—described by the first order condition given in Equation (4)—allow us to identify the model even though  $\theta_{ct}$  is unobserved.

The profits of pharmacy chain  $c$  in market  $t$  is given by

$$\pi_{ct} = m_{0ct}s_{0ct} + m_{1ct}s_{1ct},$$

where  $m_{jct}$  is the margin on product variety  $j$ , where  $m_{1ct} < m_{0ct}$ . The chain thus maximizes profits by setting the probability of the least profitable product being available,  $\theta_{ct}$ . Let  $\boldsymbol{\theta}_t$  denote the vector of such probabilities for all chains in market  $t$ . Assuming that each chain sets  $\theta_{ct}$  competitively, the equilibrium in the market is given by the vector  $\boldsymbol{\theta}_t^*$  such that the Nash equilibrium condition

$$\left. \frac{\partial \pi_{ct}}{\partial \theta_{ct}} \right|_{\boldsymbol{\theta}_t = \boldsymbol{\theta}_t^*} \begin{cases} = 0 & \text{if } 0 < \theta_{ct}^* < 1 \\ \leq 0 & \text{if } \theta_{ct}^* = 0 \\ \geq 0 & \text{if } \theta_{ct}^* = 1 \end{cases},$$

holds for all  $c$ . The probabilities  $\theta_{ct}$  are unobserved, but since we observed the profit margins of the pharmacy chains we can calculate the value of  $\boldsymbol{\theta}$  that satisfies the equilibrium condition conditional on the parameters of demand.

There is a challenge in estimating the model, due to  $\vec{\alpha}_0, \vec{\alpha}_1$  and  $\vec{\theta}$  consisting of constants for each chain-market combination, implying a significant number of parameters to be estimated by maximum likelihood. Utilizing the fact that these parameters are common across consumers within each market, they can be solved for by a simpler root-finding algorithm, conditional on the parameter vector  $\beta$ . The intuition is that, within each market  $t$ , these parameters can be set such that observed aggregate shares are equal to predicted aggregate shares both within and across chains, and such that the market equilibrium condition holds. We can thus use a non-linear system of equations for each market  $t$ , where we search for the parameters  $\alpha_{0t} = \hat{\alpha}_{0t}(\beta)$ ,  $\alpha_{1t} = \hat{\alpha}_{1t}(\beta)$  and  $\boldsymbol{\theta}_t = \hat{\boldsymbol{\theta}}_t(\beta)$  such that

$$\begin{aligned} \check{s}_{jct} - s_{jct}(\hat{\boldsymbol{\theta}}_t, \hat{\alpha}_{0t}, \hat{\alpha}_{1t}; \beta) &= 0, \quad j \in \{0, 1\}, \quad \forall c \in \mathcal{C} \\ \left. \frac{\partial \pi_{ct}}{\partial \theta_{ct}}(\hat{\boldsymbol{\theta}}_t, \hat{\alpha}_{0t}, \hat{\alpha}_{1t}; \beta) \right\} &\begin{cases} = 0 & \text{if } 0 < \hat{\theta}_{ct} < 1 \\ \leq 0 & \text{if } \hat{\theta}_{ct} = 0 \\ \geq 0 & \text{if } \hat{\theta}_{ct} = 1 \end{cases} \quad \forall c \in \mathcal{C}, \end{aligned}$$

where  $\check{s}_{jct}$  is the observed market share.

The estimation routine then becomes a nested fixed point algorithm, where we solve for the parameters  $\vec{\alpha}_0(\beta)$ ,  $\vec{\alpha}_1(\beta)$  and  $\vec{\theta}(\beta)$  conditional on the current value of  $\beta$  in the inner loop, while searching for the parameter vector  $\hat{\beta}$  that maximizes the log likelihood in the outer loop.

<sup>20</sup>We assume that the pharmacy does not stock out of the most profitable product—virtually always the parallel imported variety—at least not in a systematic way.

## 4.2 Bargaining

To estimate the bargaining game, it is necessary to know the outcomes that would arise in case of a disagreement in the bargaining between each upstream firm and each pharmacy chain. Under the assumption that all other contracts will remain unchanged in the case of a disagreement in the negotiation between one pair, we can use the estimated demand model to solve for the market equilibrium that would arise for each pairwise disagreement in terms of stock-out probabilities,  $\theta$ , and market shares. This allows us to calculate the changes in market shares,  $\Delta_{jc}s_{jrt}$ ,  $j \in \{0, 1\}$ ,  $c, r \in \mathcal{C}$ , and net values of agreement for the pharmacy chains,  $\Delta_{jc}\pi_{ct}$ , which enter the  $\Gamma$ -matrices relating to the relative bargaining power and net value of agreement between the relevant upstream firm and pharmacy chain.

We assume that the specific parallel import firm used by a given pharmacy chain is given. The implication of this assumption is that the pharmacy chain does not have the option of buying from another parallel importer, if the negotiations with the one it currently utilizes breaks down. This assumption is mostly for convenience, as the alternative would require to solve for the wholesale prices and sales under alternative contracts between different firms. The presence of two parallel traders in the market we study may lead us to believe that competition will be fierce, in the sense that a pharmacy chain will choose the one giving the most opportune offer. In the bargaining game, this would imply that the net value of agreement for the pharmacy chain becomes very small or zero. However, we do believe that the bargaining model might provide a good approximation to the true process determining the contracts, taking into consideration that the parallel traders might be differentiated in terms of the value they generate for each pharmacy chain and that their supply of drugs might be limited to some extent.<sup>21</sup> Another concern is that parallel traders might have more alternatives than we incorporate in our net value calculations. One could consider the case where a parallel trader can find possible outlets for a given drug it carries in several countries with several retail pharmacies, such that they in effect make decisions according to what can be considered a demand correspondence for Europe as a whole. In this case, we would likely overstate the net value of agreement for the parallel importer.

Note that the optimality conditions for the bargaining game gives us the parallel importers cost of supplying, as well as the price the direct importer earns on each parallel traded unit. In Section 2.3, we assumed these to be the same to simplify the exposition. However, there are reasons to believe the gain to the producer and cost of the parallel trader to differ, due to e.g., costs related to packaging and extra logistics. We assume that parallel importers' costs, denoted  $p_{0t}^I$ , are a function of the wholesale prices in the source countries and a company fixed effect for the parallel importer. We also make a similar assumption for the opportunity costs of Pfizer, denoted  $p_{1t}^I$ , letting it be a function of wholesale prices in the source countries and a company fixed effect. With  $p_{1t}^I$  and  $p_{0t}^I$  calculated from Equations (8) and (10), stacked in the vector  $p_t^I = (p_{0t}^I, p_{1t}^I)'$

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<sup>21</sup>This would replicate our model, if the total net value is positive for all pairs for which we observe trade, while it is negative for all alternative pairs for which we do not. If this does not hold, our calculated net values of agreement will to some extent be off, compared to their true values.



for each market  $t$ , we specify

$$p_t^I(\mathbf{b}) = X_t\eta + \epsilon_t, \quad (16)$$

where  $X_t$  is a matrix with columns consisting of wholesale prices in several countries from the IMS Health data, an indicator for parallel import, their interaction, and an indicator for the identity of the parallel importing firm. The countries for which we include the wholesale prices are Germany, Italy, Spain, Turkey, France, UK and US, where we take it that these will be informative about the price at which parallel traders acquire the drugs and what the direct importer earns on parallel trade—especially for France and UK, which are sources of parallel imports in our data.  $p_t^I(\mathbf{b})$  is a function of the vector of bargaining parameters  $\mathbf{b} = (b_{00}, \dots, b_{0C}, b_{10}, \dots, b_{1C})'$ . The parameter vector  $(\eta, \mathbf{b})'$  is estimated by GMM, assuming that the conditional moments  $E[\epsilon(\eta, \mathbf{b})|Z] = 0$  hold for instruments  $Z$ . Both the variables included in  $X$ , as well as the price ceiling, indicators for pharmacy chain identity, and their interaction are assumed to satisfy this condition. The specific moment conditions we use are the sample means  $Z'\epsilon(\eta, \mathbf{b}) = 0$ , such that our GMM objective becomes

$$O(\eta, \mathbf{b}) = \epsilon(\eta, \mathbf{b})'ZWZ'\epsilon(\eta, \mathbf{b}),$$

where  $W$  is a weighting matrix for the moments. The estimator is thus given by

$$(\hat{\eta}, \hat{\mathbf{b}}) = \arg \min_{\eta, \mathbf{b}} O(\eta, \mathbf{b}).$$

The intuition for identification of 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.<sup>22</sup> In addition, the price ceiling affects sales revenues of a given product. This implies that it has an effect on the net values of agreement in each pairwise bargain, through the effect on the total value of the agreement for both parties, as the price ceiling determines sales revenues. It is reasonable to expect that the price ceiling will have differential impact on total value of agreement in the different pharmacy chains. Moreover, we expect the price ceiling to impact the relative net value of agreement between the upstream firm and pharmacy chain differently across chains, due to differences in the response of demand and the other chains' strategies ( $\theta_{ct}$ ) in the event of a disagreement. Thus, we believe that the interactions between pharmacy chain indicators and the price ceiling will help identifying the bargaining parameters, due to the equilibrium effect of changes in net values of agreement being dependent on the bargaining parameters.

The necessary assumption for the price ceiling—and thus the interactions with pharmacy chain indicators—to be valid instruments, is that the price ceiling is uncorrelated with  $\epsilon_t$ , conditional on the wholesale prices in other countries included in  $X_t$ . It is possible that the price ceiling—being a function of prices

<sup>22</sup>The costs here interpretable as both the total costs of parallel traders, e.g., procurement and handling, and opportunity costs of the direct importer, e.g., sales value in source country and differences in import costs between Norway and the source country.

in several other countries, as described in Section 3.1—is correlated with the unobserved determinants of parallel trade costs. Seeing that we include the wholesale prices in the UK, which is the only exporting country in our sample that is also in the reference countries for regulatory price ceilings, we believe this to be less of a concern. Nonetheless, it is difficult to completely rule out correlation, e.g., correlation between prices in reference countries for Norwegian price ceilings and prices in the Eastern European exporting countries, or prices in the reference countries being informative about parallel trade costs, other than the procurement of the drugs themselves. However, the inclusion of prices in several countries in  $X_t$  should help in capturing general movements in trade costs, exchange rates and relative prices between different locations, alleviating this concern to some extent.<sup>23</sup>

### 4.3 Results

As our data contain a very large amount of choices, we draw a random sample of 50,000 persons from the full sample of about 170,000 for estimating the individual choice model. The maximum likelihood estimates of the individual heterogeneity parameters are shown in Column *Full model* of Table 3 and 4. Table 3 shows the baseline parameters, common across all unobserved groups and specific to group 0, while Table 4 shows the parameters for the unobserved groups with differing values from the baseline.<sup>24</sup> With these estimates, over 80% of the 95 markets that feature parallel imports have rationing to some extent, where 127 of the 345 chain-market combinations with parallel imports are estimated to feature rationing. Given that the chain is estimated to perform rationing, it is often substantial, with an average  $\theta$  of about 0.3, i.e., a 70% probability of being stocked out of the less profitable product. We find that the largest chain, *Apotek 1*, sets  $\theta < 1$  about twice as often as the other two chains and has an average  $\theta$  of 0.4, while it is about 0.8 for the other chains.

We also estimate the model excluding the possibility of pharmacies affecting consumers by changing availability for comparison. The results of this specification are shown in Column *Reduced* of Table 3 and 4. The difference in likelihood of over 15,000 log points tells us that our proposed model has a substantially better fit than the alternative where  $\theta$  is restricted to be equal to one. It should be noted that  $\theta$  are not free parameters, but are set according to restrictions from optimizing behavior and the additional data afforded by observing wholesale prices. The results here imply that the extra information and the way the model puts it to use has a positive contribution towards explaining the choices we see in our data.

From the estimates of parameters governing preferences according to unobserved, discrete groups in the population in Table 4, there are two striking features: The first is that the statistical and economic significance of these parameters imply that the specification is appropriate, compared to a more usual mixed parameters logit specification with a single distribution on each

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<sup>23</sup>In this discussion, the variables in  $X_t$  are only taken to be good predictors for the elements of  $p_t^I$ . The determination of  $p_t^I$  is not important for the analysis we perform later on, so we are not reliant on  $\eta$  having a causal interpretation. In this sense, when we refer to the *unobserved determinants* of parallel trade costs, it is taken to be the *prediction error*.

<sup>24</sup>Note that the group given by  $g = 0$  is defined by having  $\delta_c^g = 0, \forall c$  and  $\sigma_C^g = 0$ , such that the preferences of this group is represented by the baseline utility parameters.

**Table 3:** Choice model estimates: utility parameters common across all consumers

	Full model	Reduced
$\sigma_J$	0.50 (0.01)	0.53 (0.01)
$\gamma_1$	0.00 (0.02)	-0.23 (0.02)
$\sigma_1$	13.07 (0.19)	6.94 (0.29)
$\sigma_2$	14.45 (0.18)	15.56 (0.41)
$\sigma_3$	5.38 (0.13)	6.93 (0.29)
$\ln \mathcal{L}(\hat{\beta})$	-243,244	-258,477
$N$	50,000	

Standard errors in parenthesis.

coefficient.<sup>25</sup> The second is a pattern where each group has a stronger relative preference for each of the pharmacy chains. This seems reasonable, as one would suspect that many unobserved factors, such as travel distance or chain store preference, would contribute to exactly such a pattern.

The results from the estimation of the bargaining parameters, following our discussion in Section 4.2, are shown in Table 5. Keep in mind that the bargaining parameters are the bargaining weights of the upstream firms. From these estimates, we can see that, perhaps surprisingly, the parallel importers wield a larger bargaining weight on average, compared to the originator. The difference in bargaining weights between the direct importer and parallel importers could partly reflect the fact that the original producer likely also makes profits on sales of parallel imports, albeit in other countries. In addition, if the originator would come to a disagreement with a given chain, some of the lost sales will be captured by increased sales of its direct imported variety in other chains, while the rest will be captured by parallel imports, both of which will generate profits for the direct importer. For the parallel importer, all sales going to the direct imported product is irrevocably lost profits. Besides such practical considerations, there are no theoretical reasons to believe that the bargaining weights should take any particular value.<sup>26</sup>

## 5 Counterfactuals

With our estimated model, it is possible to answer two interesting questions: The first regards the impact on consumer welfare from having parallel imports

<sup>25</sup>Note that the specification here is a finite mixture of normal distributions. The economic significance is based on comparisons of behavioral implications under a simpler distributional specification not reported here.

<sup>26</sup>Except for between zero and one, which is satisfied in our estimates.

**Table 4:** Choice model estimates: Shares and utility parameters of unobserved groups

	Full model			Reduced		
	$g = 1$	$g = 2$	$g = 3$	$g = 1$	$g = 2$	$g = 3$
$\tau_g(\boldsymbol{\eta})$	0.33 (0.005)	0.28 (0.007)	0.18 (0.004)	0.51 (0.010)	0.12 (0.006)	0.09 (0.008)
$\eta_g$	0.5 (0.05)	0.34 (0.06)	-0.13 (0.04)	1.61 (0.06)	0.2 (0.11)	-0.12 (0.07)
$\delta_1^g$	9.07 (0.16)	-0.08 (0.19)	-0.42 (0.16)	-1.08 (0.22)	5.55 (0.29)	2.27 (0.23)
$\delta_2^g$	0.16 (0.19)	6.51 (0.00)	-0.1 (0.13)	-1.64 (0.28)	10.71 (0.40)	0.26 (0.42)
$\delta_3^g$	2.94 (0.38)	-0.11 (0.49)	6.17 (0.31)	-4.01 (0.24)	1.14 (0.36)	3.55 (0.23)
$\sigma_C^g$	5.16 (0.32)	1.84 (0.26)	64.82 (0.79)	2.35 (0.35)	3.06 (0.59)	0.76 (0.42)

Standard errors in parenthesis.

Standard errors of  $\tau_g$  calculated by the delta method.

Group 0 constitutes 0.21 for *Full model* and 0.28 for *Reduced*.

**Table 5:** Bargaining model estimates

	Direct import	Parallel import
Chain 1	0.47 (0.02)	0.83 (0.02)
Chain 2	0.06 (0.01)	0.64 (0.09)
Chain 3	0.77 (0.12)	0.57 (0.11)

available, while the second regards the impact of pharmacy chains' strategic utilization of availability in facilitating sales of parallel imports and deciding the distribution of industry profits. For expositional purposes, we frame the question of consumer welfare effect as one regarding a possible ban on parallel imports, though it just as well be read as the effect of actually having parallel imports (with reversed signs). The question of pharmacy chains' behavior is framed as a possible ban on opportunistic restrictions of availability, which—even though it might be a contrived example which is difficult to imagine how to enact in practice—is especially interesting as a quantitative assessment of the importance of this strategic instrument.

## 5.1 Consumer welfare

From our estimates, it is possible to assess the impact of parallel imports on consumer welfare. From our model, we have that expected utility for a given consumer  $i$  in market  $t$ , conditional on the consumer's unobserved taste characteristic  $\nu_i$ , is given by

$$EU_{it}(\nu_i) = E \left[ \max_{jc} \{u_{ijct}\} \middle| \nu_i \right] = \ln \left( \sum_{c \in \mathcal{C}} e^{\alpha_{i0ct} + \theta_{ct} \delta_{ict}} \right), \quad (17)$$

which—remembering the definition of  $\delta_{ict}$  as the incremental expected utility from having both products available—collapses to the traditional logit log-sum  $\ln \left( \sum_c \sum_j e^{\alpha_{ijct}} \right)$  when all  $\theta_{ct} = 1$ . Thus, we obtain the unconditional expected utility for each consumer in market  $t$  by integrating over the estimated distribution law of the taste characteristics, which yields

$$EU_t = \int \ln \left( \sum_{c \in \mathcal{C}} e^{\alpha_{i0ct} + \theta_{ct} \delta_{ict}} \right) dF(\nu_i).$$

The thing we can note is that there are two possible effects at play from parallel imports. First, there is a *positive* effect of more diversity, which is partially due to the inclusion of an idiosyncratic random utility component for each additional product, and partially due to preference heterogeneity, where some consumers will gain due to higher valuation of the new products.<sup>27</sup> Second, there is an *ambiguous* effect stemming from  $\theta_{ct}$ . Compared to the case where parallel imports are available and all  $\theta_{ct} = 1$ , it has a negative impact. Compared to the case where only direct imports are available, it is more likely negative when  $\Delta\alpha_{ict}$ , i.e., the difference in deterministic utility between direct imports and parallel imports in chain  $c$ , is larger and  $\theta_{ct}$  is lower. The intuitive interpretation of the last point is that pharmacies might force consumers over to a lower valued product on average, thus reducing consumer welfare.

<sup>27</sup>The dependence of welfare on the number of idiosyncratic random utility components can potentially be a cause for concern, as discussed by Akerberg and Rysman (2005) and Petrin (2002). It really depends on what exactly is defined as an option and is assumed to have an idiosyncratic component (think about a store shelf with several of the same product). The inclusion of other unobserved taste characteristics, which captures correlation in utility over alternatives (i.e., the source of preference heterogeneity effects), will to some extent alleviate this effect, depending on the scale and correlation pattern (if one  $\alpha_{ijct}$  increases vis-à-vis the other  $\alpha$ 's, the expression for expected utility will approach  $\alpha_{ijct}$ ).

**Table 6:** Change in consumer welfare from removal of parallel imports

	All markets	Any $\theta_{ct} < 1$
$\% \Delta EU_t$	-1.7%	-0.9%
$E[\Delta EU_{it} > 0]$	34.8%	41.9%
$N$	95	79

Consumer welfare in market  $t$  if parallel imports were removed can readily be calculated from our estimates as

$$EU_t^R = \int \ln \left( \sum_{c \in \mathcal{C}} e^{\alpha_{i1ct}} \right) dF(\nu_i),$$

such that the change in per person expected utility if parallel imports were forbidden is  $EU_t^R - EU_t$ . Since we do not have an estimate of the marginal utility of income, we cannot transform this into a monetary welfare measure. Instead, we can consider the relative change in welfare, which we calculate as the percentage difference from the situation with parallel imports,

$$\% \Delta EU_t = \frac{EU_t^R - EU_t}{EU_t} \cdot 100\%.$$

We also consider the proportion of consumers who would be better off without parallel imports,

$$E[\Delta EU_{it} > 0] = \int \mathbf{1}_{\{EU_{it}^R - EU_{it} > 0\}} dF(\nu_i),$$

to assess the importance and role of preference heterogeneity.

The estimated changes in welfare are calculated in Table 6. It is clear that the loss of diversity would be the dominant effect, reducing consumer welfare on average by almost two percent. We interpret this as a modest loss to consumer welfare if parallel imports were to be removed from this market. For 16 out of these 95 markets, there is no estimated supply restriction, and considering only the markets featuring supply restriction (i.e., some  $\theta_{ct} < 1$ ), the reduction in consumer welfare is only about 1%. We also see that a large proportion of consumers have strong enough preferences for the direct imports that they would benefit from such a ban. In 34 of the 95 markets the change in consumer surplus would actually be positive on average, which corresponds to markets where the market mean valuation for direct imports is relatively high compared to parallel imports and where the pharmacy chains use supply restrictions to a large degree.

## 5.2 Pharmacy chain strategy and distribution of profits

With our estimates of the bargaining model, parallel importer costs and direct importer opportunity cost, it is possible to assess the impact of the pharmacy chains' strategy of optimally choosing the probability with which a drug will be proposed to the consumer. We will consider the case where each pharmacy

**Table 7:** Impact of a requirement to carry all varieties ( $\theta_c = 1, \forall c \in \mathcal{C}$ )

	$\Delta q$	$\Delta p \cdot q$	$\Delta w$	$\Delta w \cdot q$	$\Delta \pi$	$\Delta \Pi$
Apotek 1						
Direct	22.8	72.6	0.19	62.7	9.9	15.6
	26.7%	14.0%	5.0%	17.0%	46.7%	9.3%
Parallel	-21.4	-67.4	0.35	-39.2	-28.2	2.3
	-41.0%	-44.8%	15.8%	-38.4%	-55.5%	40.3%
Boots						
Direct	2.2	4.2	0.16	7.9	-3.7	1.3
	4.3%	1.3%	4.2%	3.4%	-9.7%	1.3%
Parallel	-3.9	-10.2	0.05	-4.8	-5.5	1.2
	-15.9%	-17.8%	2.6%	-12.1%	-23.1%	87.4%
Vitus						
Direct	8.1	24.5	0.16	21.6	2.9	6.5
	17.1%	8.3%	4.3%	10.3%	25.0%	6.8%
Parallel	-7.8	-23.8	0.31	-9.8	-14.0	2.4
	-26.5%	-30.6%	14.4%	-19.4%	-46.1%	72.9%
Total Direct						
	33.1	101.6	0.17	92.2	9.1	23.4
	14.4%	7.5%	4.5%	11.4%	20.2%	6.5%
Total Parallel						
	-33.1	-101.6	0.25	-53.8	-47.7	5.9
	-27.9%	-29.8%	11.8%	-28.0%	-46.7%	56.9%

Quantities ( $q$ ) in million DDD, wholesale prices ( $w$ ) in NOK/DDD and monetary sums in million NOK.

chain  $c$  sets  $\theta_c = 1$ . This could be due to the regulator enforcing an obligation to supply all varieties, or if the producer could make a take-it-or-leave-it requirement to always propose its product in the contract with each pharmacy chain. This will have an effect on the composition of goods sold, where it is clear that the amount of direct imports sold will increase at the expense of parallel imports, though it is difficult to say by how much. Among the chain-market combinations featuring parallel imports, the average  $\theta$  is roughly three quarters, meaning that the consumer will face a restricted choice set one in four times. The quantitative effect of setting  $\theta$  below unity depends on the preferences of the consumers in the cases where  $\theta_c < 1$ , since some will likely buy the parallel imported variety also in the case where both are available. When the pharmacy chains are required to always keep both varieties, it will also have an effect on the bargained wholesale prices between the upstream firms—the direct and parallel importers—and the pharmacy chains. This can be seen directly from Equations (8) and (10) governing the bargaining solution, where terms corresponding to derivatives of shares with respect to wholesale prices are zero when  $\theta$  is constrained at one. This implies that the wholesale prices in general will increase, since there is no longer an incentive for the upstream firms to reduce wholesale prices to increase sales. The distribution and size of this increase is not in general possible to decide up front.

To get a sense of the quantitative impact of the chains' strategies, we calcu-

late the market equilibrium that would arise if the chains always had available the varieties which they are observed to sell in the data.<sup>28</sup> For these calculations, we take consumer preferences, marginal costs of the parallel importer, the direct importer’s gain on each parallel traded unit and bargaining weights as given, and solve for demand and the bargaining outcomes. In Table 7 we show the changes from the current situation in terms of quantities ( $\Delta q$ ), sales revenues ( $\Delta p \cdot q$ ), wholesale prices ( $\Delta w$ ), wholesale expenditure ( $\Delta w \cdot q$ ), profits of the pharmacy chains ( $\Delta \pi$ ) and profits of the upstream firms ( $\Delta \Pi$ ), broken down by pharmacy chain and type of upstream firm both in units and percentages. We see that such a regulatory change would have large impacts on both sales and distribution of profits in the market, where sales of parallel imports would drop by about 33 million DDD and 100 million NOK (roughly 12.5 million EUR). This change is very unevenly distributed between the chains, where the largest chain, *Apotek 1*, would experience the largest changes both in absolute numbers and relative to the status quo, which to a large extent mirrors the aggressive policies of this chain in stocking out of the direct imports. Note that sales, both in quantity and value, after the regulation will be absent any strategic behavior by the firms, less the decision to be present in the market which we take as given. Thus, sales will be given only by consumer preferences. Overall, the wholesale prices of the parallel importers increases the most, which reflects that the parallel importers especially were in a position to increase their sales by reducing prices to the pharmacy chains, thus giving the pharmacy chains incentives to distort supply. We see that both the direct importer and parallel importers would gain from such a change, especially the parallel importers in relative terms. This is due to the fact that there is no longer an element of competition between the upstream firms when bargaining over wholesale prices with the chains, in the sense that there is no longer any opportunity to affect pharmacy chains’ choice of  $\theta$ . Since the parallel importers earlier had very small margins, the increased wholesale prices would have a large enough impact on profits to more than offset the reduction in volume.

## 6 Conclusion

In this paper, we have investigated the incentives of pharmacy chains in selling parallel traded drugs. Our estimates show that the availability of direct imported drugs are plausibly reduced to a large extent in the specific market we study. This is driven by the two factors of constrained pricing and parallel importers generally giving the pharmacy chains lower wholesale prices than the direct importer. Our counterfactual estimates indicate that the gains to consumers from parallel imports in our market of study is small, mostly due to reduced availability of direct imports resulting in lower utility for a large portion of consumers with preference for the direct imported variety. In countries where pharmaceutical prices are less regulated, this could very well be overturned. Further, we find that the possibility of reducing availability benefits

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<sup>28</sup>The implication of the last point is that a chain is not set up to carry parallel imports in a given market in our counterfactual simulation if we didn’t observe any sales in our data. This might seem like a strange artefact, though this is due to our goal of quantifying the importance of the optimal stock-out probabilities, and thus avoiding contamination with elements of assortment choice and parallel export opportunities.



the pharmacy chains at the expense of both the direct importer and parallel importers. In this market, where prices are constrained by regulation, being able to distort supply between the varieties introduces competition between the upstream firms through the pharmacy chains.

The specific mechanism we highlight—where pharmacies can distort availability of drugs for which they have differing margins—have not been formalized in the previous literature, though 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 seems particularly important in many European countries, where price regulation is prevalent. Furthermore, to the best of our knowledge, the addition of consumer expectations over available choices to the choice model we utilize have not been studied in the previous literature using discrete choice models.

For future studies, it would be interesting to know how prevalent the kind of behavior that we have studied here are in other pharmaceutical markets, both where prices are tightly and less tightly regulated.

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