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The Price Effects of Competition from Parallel Imports and Therapeutic Alternatives: Using Dynamic Models to Estimate the Causal Effect on the Extensive and Intensive Margins

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Abstract
This paper studies responses to competition with the use of dynamic models that distinguish between short- and long-term price effects. The dynamic models also allow lagged numbers of competitors to become valid and strong instruments for the current numbers, which enables studying the causal effects using flexible specifications. A first parallel trader is found to decrease prices of exchangeable products by 7% in the long term. On the other hand, prices do not respond to the first competitor that sells therapeutic alternatives; but competition from four or more competitors that sell on-patent therapeutic alternatives decreases prices by about 10% in the long term.

Keywords Brand-name drugs · Dynamic model · Parallel trade · Pharmaceutical industry · Price competition · Therapeutic competition

JEL Classification D40 · I13 · L13 · L65

1 Introduction

This paper studies how the prices of on-patent pharmaceuticals react to competition from parallel imports and therapeutic alternatives. Because on-patent pharmaceuticals account for about three-quarters of costs for prescription pharmaceuticals, it is important to study the competition that affects these prices. Parallel imports are products that are sold by the producer at low prices in some countries and that are imported by "parallel traders" without the producer's permission. Therapeutic

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alternatives are other pharmaceutical substances that are intended for the same or similar medical diagnoses. The analyses are done using monthly data on prices for 1586 on-patent locally sourced products[1] that were sold in Sweden from October 2002 through October 2007.

I find that facing competition from one parallel trader that sells products with the same substance, but, for example, with a different strength, reduces prices by 3% in the long term. If the parallel trader instead sells a product with the same strength, form of administration, and nearly the same package size, the price reduction amounts to 7%. However, in most cases, competition from additional parallel traders causes no significant additional price reductions. I estimate that the long-term effect for an average product that faces competition from at least one parallel trader that sells an exchangeable product is a 9% price reduction.

The results also show that the first therapeutic competitor does not affect the price. On the other hand, the presence of four, or five or more, competitors that sell patent-protected substances are predicted to reduce prices in the long term by 9 and 10%, respectively. However, firms do not reduce prices in response to competition from therapeutic alternatives for which generics exist.

The paper contributes to the existing literature in four main ways: First, to my knowledge this paper is the first that estimates the causal price effects of the number of parallel traders. I am able to this by using reduced-form dynamic models that allow lags of the numbers of competitors to serve as valid instruments for their current values. This provides enough instruments to study also the causal effects on the intensive margins. Therefore, the paper presents estimates of how the number of parallel traders—as well as the number of therapeutic competitors—affects prices.

Second, the detailed data allow me to study how the effects of competition from parallel imports depend on the similarities across several variables between the locally sourced products and the parallel imports.

Third, the paper is to my knowledge also the first that distinguishes between short- and long-term effects and estimates the speed of adjustment for on-patent drugs. I find that prices react slowly to changes in competition: Fifteen months are required before half of the long-term effect is realized.

A fourth contribution is that the paper provides robust estimates of the effects of competition from parallel imports without making the assumptions that were made in previous studies in this field: for example, that exchange rates are valid instruments or that firms take competitors' prices as exogenous. As I describe in the following section, previous studies have either used potentially endogenous instruments or assumed that firms take competitors' prices as exogenous.

[1] Locally sourced products are sold directly to the country in which they are bought by consumers: products that are not parallel imported.

2 Related Literature

The theoretical literature on parallel trade in drugs includes Pecorino (2002), Ganslandt and Maskus (2004), Maskus and Chen (2004), Jelovac and Bordoy (2005), Chen and Maskus (2005), and Brekke et al. (2015). It shows, among other things, that parallel trade should create price competition and lead to lower prices in the importing country. Also, welfare effects of parallel trade are analyzed in this literature.

The empirical literature on the price effects of competition from parallel traders is limited to Ganslandt and Maskus (2004), Kanavos and Costa Font (2005), Kanavos and Vandoros (2010), Kyle (2011), Duso et al. (2014), Granlund and Köksal-Ayhan (2015, 2016), and Méndez (2018). Kanavos and Costa Font (2005) and Kanavos and Vandoros (2010) studied the effect of the market share of parallel imports but found no statistically significant price effects. Kyle (2011) focused on strategic responses to parallel trade and did not address the endogeneity problem. Still, Kyle reported that competition from parallel traders was associated with 3% lower prices for locally sourced drugs.[2]

Ganslandt and Maskus (2004) and Granlund and Köksal-Ayhan (2015, 2016) used exchange rates and the age of drugs as instruments and reported negative price effects for locally sourced drugs in Sweden that face competition from parallel imports with the same active substance, strength, and form of administration. The idea was that parallel imports should be more common when the Swedish currency (SEK) is stronger, because it reduces the purchase price of parallel traders measured in SEK, and when the drug is older, as parallel trade acts with a lag. The point estimates from the different specifications estimated range between 12–19% in Ganslandt and Maskus (2004) and between 15–17% and 17–21%, respectively, in Granlund and Köksal-Ayhan (2015, 2016).

The instruments that were used by Ganslandt and Maskus (2004) and Granlund and Köksal-Ayhan (2015, 2016) were too weak to study the causal effect of the number of parallel traders. Instead—in addition to reporting the average effect of competition from at least one parallel trader—these studies reported only OLS estimates with regard to the association between prices and the number of parallel traders. Another important problem is that the instruments that were used in these studies may affect the prices of locally sourced drugs in ways other than through the existence of parallel imports. For example, with a stronger Swedish currency, a producer can reduce the nominal price in Sweden without having to reduce the price in countries where the maximum prices that are allowed depend on the Swedish prices measured in Euros.[3]

[2] The empirical literature on parallel imports also includes studies such as Brekke et al. (2015), which shows that stricter price controls reduce competition from parallel imports; Granlund (2015), which shows how the pharmacies' ability to negotiate discounts reduces the market share of parallel imports; and Costa-Font (2016), which shows that parallel trade is partly driven by differences in distributors' margins between countries.

[3] Several countries use international reference pricing in which Swedish prices influence the highest price that the producers are allowed to charge. For example, the reference prices in Austria, Ireland, and

Duso et al. (2014) and Méndez (2018) estimated demand and supply equations and then used simulations to predict the effect of competition from parallel imports. Duso et al. found that parallel imports reduced the prices of locally sourced diabetic drugs in Germany by 11%, while Méndez predicted the price cuts for statins in Denmark to be 3%. Duso et al. reported the largest effect for patent-protected pharmaceuticals, while Méndez found the opposite pattern. Neither study discussed the importance of the number of parallel traders.

One important assumption in both Duso et al. (2014) and Méndez (2018) is that firms take competitors' prices as exogenous: The firms do not consider that their own price cuts can cause competitors to reduce their prices. This assumption may be one important reason why Duso et al. and Méndez estimated the marginal cost of the original drugs to be as high as 76% and 90%, respectively, of the price. Together with the relatively high prices in Germany and Denmark, this implies that drugs in many other countries are sold at prices well below marginal cost. These estimates also contradict Bernt et al. (1995), who stated that the marginal costs of most traditional pharmaceutical products are very small. However, it is hard to judge how this and other assumptions influence the predicted price effects of competition from parallel imports.

The empirical literature on therapeutic competition includes several demand analyses: Using U.S. data, Bernt et al. (1995), Baye et al. (1997), and Ellison et al. (1997) provided cross-price elasticities, which shows that different pharmaceutical substances within the same therapeutic group are substitutes. This is supported by results from: three Swedish markets (Rudholm, 2003); Norwegian markets (Brekke et al., 2009); the Indian pharmaceutical markets (Dutta et al., 2011); one German market (Duso et al., 2014); and one Danish market (Méndez, 2018). However, these cross-price elasticities are often small and sometimes not statistically different from zero.

However, knowledge of the cross-price elasticities is not enough for predicting how prices depend on the number of therapeutic alternatives, and only a few studies have analyzed this effect. For U.S. data, Lu and Comanor (1998) found that both the introductory price and the subsequent change in prices during the first four, six, and eight years are negatively affected by the number of brand-name substitutes. Ekelund and Persson (2003) estimated the same models with the use of Swedish data but found that the number of substitutes had no significant effect. To my knowledge, however, there has been no study for on-patent drugs that distinguishes between short- and long-term effects and accounts for the fact that changes in the number of therapeutic alternatives can be endogenous.

This paper relates to Bergman et al. (2017) and Granlund and Bergman (2018)—both of which used dynamic models to study competition effects. However, these papers studied prices for off-patent pharmaceuticals and focused on the effects of competition from generic substitutes.

Footnote 3 (continued)
Switzerland are the average of the prices in Sweden and in 26, 13, and 8 other countries, respectively (Aho et al., 2018).

3 Institutional Setting and Theoretical Framework

3.1 Parallel Imports, the Pharmacy Monopoly, and the Benefit Scheme

The parallel importation of pharmaceuticals to Sweden became legal when Sweden joined the European Union in 1995, and in January 1997 the first package was sold in Sweden (Persson, Anell and Persson, 2001). Parallel traders buy drugs from wholesalers in another country within the European Economic Area (the EU member states and Iceland, Liechtenstein, and Norway), and then repackage them with Swedish labels and transport them to Sweden.

Just like locally sourced drugs, parallel imports need to be approved for sale either by the Swedish Medical Products Agency (SMPA) or by the European Medicines Agency (EMA). For a parallel import to be approved, it must be sufficiently similar to the locally sourced one: contain the same active ingredient and have the same therapeutic effect (LVFS 2004:8). However, parallel imports might differ from locally sourced drugs in color, taste, or shape—in which case the outer package should clearly inform the end-user about this.

During the study period, all pharmacies were operated by a government-owned monopoly and were staffed by government employees.[4] The pharmacies charged uniform prices across the country, and their margins were determined by the Pharmaceutical Benefits Agency (PBA), and were nearly identical for locally sourced and parallel-imported products.[5] Furthermore, a government-funded benefit scheme covered approximately 75% of the cost of prescription drugs for Swedish residents (National Board on Health & Welfare, 2013).

Substitution legislation that came into effect October 1, 2002, requires pharmacy personnel to inform consumers if cheaper exchangeable products are available. The SMPA defines a product as exchangeable if it has the same active substance, strength, and form of administration—e.g., delayed release capsules or oral fluid—as the prescribed product, and if its package sizes can approximately amount to the prescribed quantity.[6] For on-patent drugs, the rules imply that each group of

[4] A new law that allowed private pharmacies to be opened in Sweden came into effect July 1, 2009 (Ministry of Health and Social Affairs, 2009).

[5] From January 2006 through the end of this study-period the retail price in SEK (RP) depended on the purchase prices in SEK (PP) according to the formula: $RP = PP*1.20 + 31.24$ if $PP \leq 75$, $RP = PP*1.03 + 44.00$ if $75 < PP \leq 300$, $RP = PP*1.02 + 47.00$ if $300 < PP \leq 6000$, $RP = PP + 167.00$ if $PP > 6000$ (National Board on Health and Welfare, 2008). Before 2006, the pharmacies' margin per package was 2 SEK lower (Dental and Pharmaceutical Benefits Agency, 2005). The formula implies that the pharmacy's margin on locally-sourced products—which were usually more expensive—was on average 2%, or SEK 1.5 (approximately USD 0.20) higher than on parallel imported products.

[6] During the study period, packages that differed less than 12% in terms of the number of pills/capsules from the prescribed product were considered exchangeable. The exception is narcotic drugs, for which the dispensed quantity must equal exactly the prescribed quantity.

exchangeable products consists of the locally sourced brand-name product(s)[7] plus parallel imported versions that are sold in similar packet sizes.[8]

Consumers who buy the cheapest available exchangeable product pay a coinsurance rate that decreases according to the consumer's accumulated pharmaceutical expenditures and reaches zero for consumers with accumulated expenditures that exceed SEK 4300 (approximately EUR 470 or USD 570) during a 12-month period.[9] For parallel imports, available products are defined as those in stock at the pharmacy in question (Dental & Pharmaceutical Benefits Agency, 2009). If consumers oppose substitution or choose to switch to an exchangeable product other than the cheapest available, they are charged the entire incremental cost.

The pharmacy's obligation to inform the consumer about a cheaper substitute is waived if the physician has indicated on the prescription that no substitution should be allowed for medical reasons or if the pharmacist has reason to believe that the patient would be adversely affected: for example, if the low-cost alternative has a package that is difficult to open for the patient.[10] In these cases, the full cost of the prescribed product is included in the benefit scheme and is subject to the coinsurance rate described above.

Pharmaceutical firms were (and still are) free to set their own prices; but for a product to be included in the pharmaceutical benefit scheme its price must be approved by the PBA. When exchangeable products exist, the PBA approves prices that do not exceed the highest existing price of exchangeable products. This implies that parallel imports are always allowed to be priced as high as locally sourced products (Pharmaceutical Benefits Agency, 2003, 2006).

The PBA is restrictive in approving prices that exceed the highest existing price of exchangeable products. Therefore, the highest existing price of exchangeable products constitutes a price cap. The price cap is dynamic in the sense that it changes over time when the highest existing price changes over time. However, the PBA approves higher prices if the following two criteria are fulfilled: (i) there is a considerable risk that the drug will disappear from the Swedish market if the price is not approved; and (ii) the drug treats a serious condition that threatens the patient's life or health, and there are patients who risk being without similar treatment if the drug disappears from the market (LFNAR 2006:1).

For new products without medically-equivalent substitutes, the PBA's decisions about prices are determined by a cost-effectiveness analysis, and the agency does not approve prices that are too high relative to therapeutic alternatives. The agency does not alter submitted prices; instead, it only determines if a price is low enough for the

[7] Three percent of the groups of exchangeable products includes more than one locally sourced brand-name product. This can be because the producer sells both a 98-pill packet and a 100-pill packet or both blister packs and tins.

[8] The effects of the substitution reform on prices and costs have been studied by Andersson et al. (2005), Granlund (2010), Granlund and Rudholm (2011), and Granlund and Köksal-Ayhan (2015).

[9] Consumers paid 100% of the cost up to SEK 900; 50% of the cost from SEK 900 to 1700; 25% from SEK 1700 to 3300; 10% from SEK 3300 to 4300; and then 0%. On average during the study period, USD 1 = SEK 7.52 and EUR 1 = SEK 9.20.

[10] Physicians and pharmacists oppose substitution for only 2–3% of the observations each (Dental and Pharmaceutical Benefits Agency, 2016; Granlund, 2015).

product to be included in the benefit scheme or if the product should be excluded from the benefit scheme.

Firms must submit their prices for month t to the PBA two months in advance. On the sixth workday of month $t-1$, PBA announces all purchase and retail prices. Note that when the firms submit their bids in month $t-2$, the prices that apply in month $t-1$ have already been announced. Consequently, the number of active firms in that period is also known. During the study period, firms were forbidden from giving discounts to pharmacies. This implies that the transaction prices are identical to the bids that were submitted to the PBA.

3.2 Effects of the Numbers of Competitors on Prices

Ganslandt and Maskus (2004) is, to the best of my knowledge, the only study that theoretically analyzes the price effect of the number of parallel traders. Assuming that the quantity that a parallel trader can acquire in the source countries is limited, that parallel imports are perfect substitutes for locally sourced products, and that the producer maximizes its profit given the residual demand that it faces, they predicted that the equilibrium price of a locally sourced product would fall, at a decreasing rate, in the number of parallel traders.

Theoretical results with regard to the price-effect of generic entry is also relevant because parallel imports—like generics—are usually cheaper than locally sourced brand-name products and considered to be inferior by some consumers. Brekke et al. (2016) developed a model for price competition between sellers of heterogenous products. They predicted that the price of the brand-mane product would decrease in the number of generics producers because more generics producers result in lower prices of generics and reduces the distance in product space between the brand-name product and consumers' most preferred generic product.

However, according to the result of Frank and Salkever (1992), prices need not fall in response to entry of cheaper alternatives. The intuition is that if the most price-sensitive consumers buy generic, this can reduce the price sensitivity of the demand for the more expensive product—which increases the profit-maximizing price.

The model of Frank and Salkever (1992) might also be informative with regard to the effect of therapeutic competition. When the prices of therapeutic alternatives fall because of generic entry, the own-price elasticity of substances that do not face generic competition might become closer to zero, which can result in higher prices. On the other hand, the PBA takes into account the prices of therapeutic alternatives—which reduces the possibility to increase prices for producers who want their products to be included in the benefit scheme. Also, the county councils' drug and therapeutic committees take the relative prices of therapeutic alternatives into account when writing recommendations to physicians with regard to choices

of pharmaceuticals.[11] This can strengthen price competition between therapeutic alternatives.

3.3 Entry and Exit of Parallel Imports and Locally Sourced Drugs

Insights from Marshall's (1890) long-run perfect competition model tell us that a firm will enter a market only if its expected discounted revenue will cover its expected entry-, fixed-, and variable costs. However, a firm will exit when its (expected) revenues do not cover its (expected) variable costs, or exit before a new period starts (e.g., before a new yearly fee must be paid) if it expects that its revenue during this period will not cover fixed and variable costs. This difference between entry and exit conditions causes persistence in market participation for firms with entry- or fixed costs.

Parallel traders have variable costs that depend on the prices that are charged by the producer in the source country, the margin of the wholesaler in that country, and the cost of transportation and repacking. Parallel traders also have sunk entry costs—which include the cost of preparing the application to the SMPA or the EMA and the agency's fee for handling the application. In addition, parallel traders need to pay a small yearly fee to the SMPA and have some costs for contact with Swedish wholesalers. The cost of establishing these contacts constitutes a sunk entry cost.

Because of entry costs and fixed costs, a parallel trader that is already selling a product in the Swedish market is more likely also to do so the next month. The trader may regret entering the market if prices that are charged by wholesalers in the source country rise unexpectedly, but if the price increases are moderate, the trader might still be able to cover its variable costs and therefore remain in the market. Besides changes in prices that are charged by the producer, prices that are charged by wholesalers in source countries depend on quantities that are available for parallel exports and demand for parallel imports across the European Economic Area. The latter is affected by exchange rate fluctuations.

There are two reasons that persistence in market participation is expected to be stronger for locally sourced drugs than for parallel imports: First, the entry costs for locally sourced products are higher. The fees that they need to pay to the SMPA or EMA are higher, and sellers of locally sourced products also need to document the cost-effectiveness of their products to be included in the pharmaceutical benefit scheme.[12] Second, compared to parallel traders, producers of locally sourced drugs face less uncertainty and variability in their variable costs.

[11] In Sweden, 21 county councils are responsible for providing health care; and, together with the central government, they finance the pharmaceutical benefit scheme. Each county has at least one drug and therapeutic committee—the purpose of which is to promote the safe and cost-effective use of pharmaceuticals.

[12] Parallel traders are not required to do this unless their price exceeds the price of the locally-sourced substitute.

3.4 Uncertainty, the Dynamic Price Cap, and Price Dynamics

Producers know the prices at which they sell in source countries and can easily observe exchange rates. However, they have less information about other variable costs of their parallel importing competitors. Therefore, they face uncertainty as to how low parallel traders are prepared to set their prices. In general, pharmaceutical producers are able to infer more information about a parallel trader's variable costs when the trader has been present in the market for a longer period. The reason is that the lowest price that is charged by the parallel trader—at least weakly—decreases in the time that the parallel trader is active in the market. This is one reason why a producer is better able to determine its optimal price in the presence of competition from a parallel trader when the parallel trader has been active in the market for a longer period.

When a new parallel-imported product or a new substance is first sold in the market, competitors might also be uncertain about how prescribers and consumers view the new product and hence how the demand for their products will be affected by the entry. This uncertainty can be expected to decrease with time: A producer is better able to determine the optimal price for the product in the new competitive environment when it has faced competition from a new seller for a longer period.

If prices could be adjusted freely and without cost, the sources of uncertainty that were described above would not lead to systematic price adjustment over time. However, the dynamic price cap that was described in subsection 3.1 may prevent the seller of a product that is already the most expensive among its substitutes from increasing the price if the seller wants its product to remain within the benefit scheme. Hence, for locally sourced products, a price cut that in retrospect is found to be too large cannot always be reversed, while a price cut that is too small can always be complemented with another price cut. This gives producers an incentive to reduce prices too little rather than too much when they face new competitors, and the decide whether to reduce the price further when they have inferred more information about the costs of their new competitors or about the behavior of prescribers and consumers.

Also, collusion can contribute to slow price adjustments. For example, a producer that has managed to coordinate prices tacitly with producers of therapeutic alternatives might be reluctant to reduce its prices directly in response to competition from parallel traders, since this might trigger price reductions by other producers and thereby make it hard to revert to the previous price if the competition from parallel trader ceases.[13]

[13] See, for example, Abrantes-Metz et al. (2004) and references therein for evidence on the effects of collusion on price stickiness.

Table 1 Variable definitions

P_{it}	The pharmacies' purchase price per defined daily dose (DDD)
$N\_PI\_Substance_{st}$	The number of parallel traders that sell products with the same substance
N_PI_{it}	The number of parallel traders that sell exchangeable products
$RelativepricePI_{it}$	Average price of exchangeable parallel imports divided by the price of product i
$SharePI_{it}$	Share of the number of DDDs that are sold by parallel traders
N_Th_{it}	The number of pharmaceutical substances with the same five-digit ATC code and with locally sourced drugs that are sold by other firms than firm i
N_ThGen_{st}	Number of substances with the same five-digit ATC code for which generic versions exist
DDD_{it}	The number of defined daily doses sold of product i in month t
DDD_{st}	The number of defined daily doses sold of products with substance s in month t

4 Data

This study is based on a panel dataset that was obtained by merging a dataset of pharmaceutical sales—that was compiled by IMS Sweden—with datasets that contain detailed information of each pharmaceutical product—that were provided by the county council of Västerbotten. The data cover all prescription drugs that were sold in Sweden from the introduction of the substitution legislation in October 2002 through October 2007. Newer data are not analyzed since pharmaceutical firms in July 2009 received the right to give discounts to pharmacies for pharmaceuticals that lack competition from generics, and firms in the fall of 2007 could have started to adjust their prices in anticipation of this reform. As is described in Appendix 3, I find no evidence that prices were adjusted in anticipation during this study period.

An observation in the dataset represents a product with a specific active ingredient, strength, administrative form, and package size, that is supplied by a certain firm, and is sold in a certain month. For each product, the dataset includes information about whether the product is brand-name or generic and whether it is locally sourced or parallel imported, and about the number of packages sold and the total value. That the observations are on the product level is an advantage since it means that composition effects that could be caused by, for example, changes in the distribution of package size or strength, do not bias the results.

The empirical analysis is restricted to locally sourced on-patent prescription drugs that are administered orally in the form of tablets or capsules. Off-patent and parallel imported drugs as well as products with other administrative forms were used to create the relevant variables for the analysis, but were excluded in the final dataset. Lacking information on patent expiration, I defined pharmaceuticals as off-patent starting the first time when any generics with the same active ingredient were sold in Sweden. Tablets and capsules for oral use account for about 55% in terms of values, number of packages, and observations.

The exclusions leave me with 66,628 observations of 1586 different products in 846 drugs and with 428 different active substances. A drug is here defined as a unique active substance-strength-administrative form combination. This means

Table 2 Descriptive statistics

	Mean	S.D	Min	0.25	Mdn	0.75	Max
P_{it}	32.87	96.48	0.00	4.20	9.70	34.45	1807.14
$N\_PI\_Substance_{st}$	0.87	1.56	0	0	0	1	7
N_PI_{it}	0.36	0.97	0	0	0	0	7
$RelativepricePI_{it}$ (if $N\_PI_{it} \geq 1$)	0.94	0.08	0.26	0.90	0.95	0.98	1.80
$SharePI_{it}$ (if $N\_PI_{it} \geq 1$)	0.49	0.30	0.00	0.23	0.51	0.75	1.00
N_Th_{it}	2.90	2.28	0	1	3	4	16
N_ThGen_{st}	0.89	1.03	0	0	1	1	6
DDD_{it} (in thousands)	241.27	7,521.46	0.00	1.93	9.94	41.22	1,087,500.00
DDD_{st} (in thousands)	876.90	16,394.62	0.00	26.96	123.24	438.94	1,573,205.00

The variables are defined in Table 1. Values of 0.00 and 1.00 indicate that the value is rounded to 0.00 and 1.00 respectively, but strictly different from 0 and 1. The descriptive statistics for $RelativepricePI_{it}$ and $SharePI_{it}$ (which are not used in the empirical analyses) are reported for the 10,997 observations for which $N\_PI_{st} \geq 1$. For the other variables, the number of observations is 66,628.

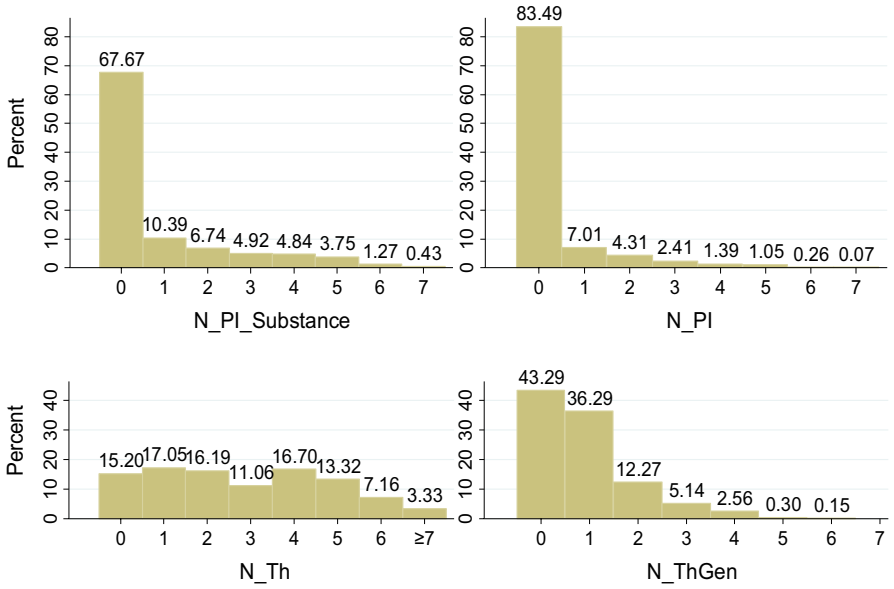

Fig. 1 Empirical distribution of $N\_PI\_Substance_{st}$, N_PI_{it}, N_Th_{it}, and N_ThGen_{st}. Seven to 16 competitors that sell therapeutic alternatives are grouped in the category ≥ 7 for N_Th_{it}

that products of a drug differ only in packet size and that different drugs with the same active substance either differ in strength or administrative form. 253 products with 54 different active substances were included only for part of the study-period because generics with the same active ingredient entered the Swedish market.

Table 1 lists variable definitions, while Table 2 presents descriptive statistics. The first variable—P_{it}—is the pharmacies' purchase price per defined daily dose (DDD) of product i in month t. For daily doses, the definition of the World Health Organization is used for the 97% of the observations for which it has defined daily doses. For the remaining observations, the number of daily doses is defined to equal the number of pills per packet times the strength of the pills. Because I use natural logarithms of prices and control for product fixed effects in the estimation, identical estimation results are obtained if price per packet are used instead.

Data (that are not shown in the tables) reveal that 99% of the products that were sold in one month were also sold the previous month and that only 16% of the products have changed their prices during the study period. Still, non-stationarity of lnP_{it} is rejected at the 1% level.[14] Of the price changes, 58% are increases, and the mean price increase is 10%, while the mean price decrease is 11%.

The variables $N\_PI\_Substance_{st}$ and N_PI_{it} are the numbers of parallel traders that sell products with the same substance and exchangeable products, respectively. Figure 1 illustrates the distribution of these variables and of N_Th_{it} and N_ThGen_{st} which are described below. At most, producers faced competition from seven parallel traders. Data that are not shown in the tables reveal that 13 different parallel traders were active during the study period and that the locally sourced products were sold by 61 different firms. None of the firms sold both locally sourced and parallel-imported products. Parallel traders and producers on average sold 2.2 and 3.3 products with the same active substance per month.

The variable $RelativepricePI_{it}$ shows that, on average, prices of parallel imports are 6% lower than the price of an exchangeable locally sourced drugs. Data that are not shown in the tables reveal that parallel imports are more expensive than the locally sourced product in less than 5% of the cases where $RelativepricePI_{it}$ is defined. In more than half of these cases, the price of the locally sourced products had recently been reduced and a price that the locally sourced products had had within three months exceeded the current average price of the parallel imports. Data that are not shown in the tables also reveal that it is only for 96 observations that a locally sourced product has not been the most expensive product within the group of exchangeable products anytime the last six months.

$SharePI_{it}$ is the market share of parallel imports, in terms of DDDs, among product i and the products with which it is exchangeable. Table 2 reports descriptive statistics for this variable only for the 17% of the observations that face competition from at least one parallel trader that sells exchangeable products. For these, $SharePI_{it}$ range from 0.0001 to 0.9979 with a mean of 0.4901. A possible explanation for some of the highest values for $SharePI_{it}$, as well as for $RelativepricePI_{it}$, is that the locally sourced product was out of stock in Sweden for a few weeks.

In line with Brekke et al. (2009) and Pavcnik (2002), I consider substances that share five-digit ATC codes to be therapeutic alternatives. In line with this, N_Th_{it} is defined

[14] To be specific, non-stationarity of lnP_{it} is rejected at the 1% level according to nine of the ten tests that were executed using xtunitroot in STATA. The test results are available from the author upon request.

as the number of pharmaceutical substances with the same five-digit ATC code and with locally sourced drugs that are sold by firms other than firm i during month t. The variable N_ThGen_{st} is the number of therapeutic alternatives for which generic versions exist.

Last, DDD_{it} and DDD_{st} are the number of defined daily doses that were sold in month t of product i and substance s, respectively. As for P_{it}, the World Health Organization's definition (if it exists) is used for the substances; and for the remaining observations the number of daily doses of each product is defined as the product of the number of pills sold times the strength of each pill. This yield values that are proportional to other reasonable definitions of number of daily doses, which is all that is needed for using variations in the natural logarithms of DDD_{it} and DDD_{st} over time as proxies for changes in quantities.

5 Econometric Specifications

As discussed in Sect. 3.4, prices are expected to adjust gradually to new competitive environments. For this reason, I estimate dynamic models. The preferred specification IV 1 is written:

$$\begin{aligned} \ln P_{it} = \theta \ln P_{i,t-1} + \sum_{j=1}^{5} \alpha_j N\_PI\_Substance_{stj} + \sum_{k=1}^{5} \beta_k N\_PI_{itk} \\ + \sum_{l=1}^{5} \gamma_l N\_Th_{itl} + \sum_{m=1}^{4} \tau_j N\_ThGen_{stm} + \eta_t + \mu_i + \varepsilon_{it} \end{aligned} \tag{1}$$

where indices i, s, and t represent product, substance, and time in months, respectively. The dependent variable is the natural logarithm of the pharmacies' purchase price per DDD. I control for time using the specific monthly effects η_t, include product fixed effects μ_i, and allow the error terms to be clustered within substances.

The specification includes four sets of competition indicator variables. For the first three sets, indicator variables for 1, 2, 3, 4, and 5 or more competitors are included; but for N_ThGen, four or more therapeutic alternatives with generics versions are grouped together. The specification is chosen by first grouping categories together so no indicator variable takes the value 1 for less than 1% of the observations. This step resulted in four indicator variables for N_ThGen_{st} and five for N_PI_{it}. Then, I tested and found that the coefficients for the indicator variables for 5 and 6 or more $N\_PI\_Substance_{st}$, and for 5, 6, and 7 or more N_Th_{it}, respectively, were not significantly from each other. No further aggregation was done because it was not deemed needed to get fairly robust and precise estimates.

Specification IV 2 differs from specification IV 1 by also including $lnDDD_{it}$ as an explanatory variable. The advantage with specification IV 1 is that it provides estimates of the total price-effects of competition. Specification IV 2 contributes by

including an estimate of how changes in demand affect prices and provide estimates of the partial price effect of competition, holding quantity constant.[15]

In specification IV 1, the 19 indicator variables are all instrumented with their first lags and $lnDDD_{s,t-3}$. In specification IV 2, $lnDDD_{i,t-3}$ is included as an additional instrument. These instruments are chosen since producers can observe their values when at the end of $t-2$ they set their prices for month t. Recall that the prices of all products that can be sold within the benefit scheme in month $t-1$ are posted in the first half of month $t-2$. Hence, when the prices for month t are set, firms can observe how many potential competitors they will have in month $t-1$ and can, based on this, predict the competition they will face in month t. When prices from month t are set, IMS has also delivered sales data for month $t-3$ to its customers.

A requirement for these instruments to be valid is that they are uncorrelated with the error term ε_{it}. This might be reasonable, since a firm that wants to sell in $t-1$ must have submitted its price-bid already in $t-3$. In $t-3$, it is likely hard to predict ε_{it} since it depends only on the price shock in month t, while the lag of the dependent variable controls for a previous price shock. Appendix 1 contains a more thorough discussion of this—including the importance of no, or small, serial correlation. Appendix 2 explains that the potential bias that is caused by including the lag of the dependent variable together with fixed effects should be very small in this case.

In addition to specifications IV 1 and IV 2, I also use OLS to estimate a partial-adjustment specification (OLS P) and an error-correction specification (Error-C). The OLS P specification differs from specification IV 1 by including the first lags of the 19 endogenous variables instead of current values. By using lags instead of current values, the simultaneity bias can be avoided. Also, and as explained, when setting prices for month t, producers have good information about the number of competitors that they will face in month $t-1$, but lack this information for month t.

If producers have the naïve expectations that the values of the competition variables in month t will be the same as for month $t-1$, the OLS results can describe the data generating process better than can the IV results, given that the possible endogeneity problem is small or nonexistent. With rational expectations, the IV estimator can be preferable because an econometric prediction that uses the information that is available in month $t-2$ might be closer than the realizations in month $t-1$ to the predictions that the producers make in month $t-2$ when they set their prices.

Also in the error-correction specification, I use first-lags of the 19 endogenous variables instead of current values: Instead of estimating a specification of the form $\Delta Y_t = \beta_0 \Delta X_t - (1-\theta)\left[Y_{t-1} + \gamma X_{t-1}\right] + \varepsilon_t$, which is equivalent to $Y_t = \theta Y_{t-1} + \beta_0 X_t + \beta_1 X_{t-1} + \varepsilon_t$, I estimate one of the form $\Delta Y_t = \beta_0 \Delta X_{t-1} - (1-\theta)\left[Y_{t-1} + \gamma X_{t-2}\right] + \varepsilon_t$, which is equivalent to $Y_t = \theta Y_{t-1} + \beta_0 X_{t-1} + \beta_1 X_{t-2} + \varepsilon_t$.

The OLS P specification is a special case of the more flexible error-correction specification but is preferred both according to the Akaike information criterion and

[15] Including fixed effects controls for time-invariant differences in demand across products. No quantity variable is included in the first model because the variation over time in quantity sold is small—except for the variation that is caused by changes in the number of competitors.

Table 3 Estimation results for lnP_{it} and ΔlnP_{it}

	IV 1 (lnP_{it})		IV 2 (lnP_{it})		OLS P (lnP_{it})		Error-C (ΔlnP_{it})		Error-C cont.	
	Coeff	Std.err	Coeff	Std.err	Coeff	Std.err	Coeff	Std.err	Lagged first differences	
$lnP_{i,t-1}$	0.9567***	(0.0066)	0.9568***	(0.0066)	0.9491***	(0.0107)	−0.0415***	(0.0060)		
$N\_PI\_Substance_s$									Coeff	Std.er
1	−0.0012*	(0.0006)	−0.0012**	(0.0006)	−0.0011**	(0.0005)	−0.0010*	(0.0005)	−0.0005	(0.0004)
2	−0.0012*	(0.0007)	−0.0013*	(0.0007)	−0.0011*	(0.0007)	−0.0010	(0.0006)	−0.0003	(0.0004)
3	−0.0013	(0.0008)	−0.0013	(0.0008)	−0.0013	(0.0008)	−0.0012	(0.0007)	−0.0001	(0.0005)
4	−0.0020**	(0.0010)	−0.0020**	(0.0010)	−0.0019**	(0.0008)	−0.0018**	(0.0008)	−0.0006	(0.0010)
≥ 5	−0.0017**	(0.0007)	−0.0017**	(0.0007)	−0.0017**	(0.0007)	−0.0016***	(0.0006)	− 0.0003	(0.0010)
N_PI_i										
1	−0.0020**	(0.0009)	−0.0019**	(0.0008)	−0.0019***	(0.0006)	− 0.0017**	(0.0007)	− 0.0013**	(0.0006)
2	−0.0024*	(0.0012)	−0.0022*	(0.0012)	−0.0021**	(0.0008)	−0.0020**	(0.0010)	−0.0016**	(0.0007)
3	−0.0020	(0.0019)	−0.0017	(0.0019)	−0.0025*	(0.0013)	−0.0029*	(0.0015)	−0.0011	(0.0008)
4	−0.0067***	(0.0023)	−0.0064***	(0.0023)	− 0.0055***	(0.0016)	− 0.0042***	(0.0014)	− 0.0046**	(0.0022)
≥ 5	−0.0015	(0.0013)	−0.0011	(0.0013)	−0.0017	(0.0012)	−0.0022**	(0.0010)	−0.0003	(0.0025)
N_Th_i										
1	0.0000	(0.0004)	0.0000	(0.0004)	−0.0001	(0.0006)	0.0001	(0.0005)	−0.0003	(0.0014)
2	−0.0016*	(0.0009)	−0.0016*	(0.0009)	−0.0015	(0.0009)	−0.0013	(0.0009)	−0.0011	(0.0015)
3	−0.0004	(0.0010)	−0.0005	(0.0010)	−0.0003	(0.0010)	−0.0002	(0.0010)	−0.0008	(0.0017)
4	−0.0040**	(0.0019)	−0.0040**	(0.0019)	−0.0032*	(0.0017)	−0.0027*	(0.0015)	−0.0045	(0.0030)
≥ 5	−0.0048**	(0.0021)	−0.0048**	(0.0021)	−0.0036**	(0.0017)	−0.0031**	(0.0016)	−0.0050*	(0.0030)
N_ThGen_s										
1	0.0004	(0.0007)	0.0004	(0.0007)	0.0005	(0.0006)	−0.0000	(0.0004)	0.0041	(0.0039)
2	0.0019**	(0.0010)	0.0019*	(0.0010)	0.0016*	(0.0009)	0.0013	(0.0008)	0.0045	(0.0039)
3	0.0016	(0.0011)	0.0015	(0.0011)	0.0013	(0.0010)	0.0009	(0.0008)	0.0046	(0.0040)
≥ 4	0.0031**	(0.0014)	0.0031**	(0.0014)	0.0027**	(0.0013)	0.0022*	(0.0012)	0.0057	(0.0041)

Table 3 (continued)

	IV 1 (lnP_{it})		IV 2 (lnP_{it})		OLS P (lnP_{it})		Error-C (ΔlnP_{it})		Error-C cont.
	Coeff	Std.err	Coeff	Std.err	Coeff	Std.err	Coeff	Std.err	Lagged first differences
$lnDDD_{it}$			0.0003	(0.0003)					
$dlnP_i^*/dPI_i^*$	−0.0905***	(0.0299)	−0.0861***	(0.0287)	−0.0728***	(0.0273)	− 0.0844***	(0.0279)	
$dlnP_i^*/dThG_s^*$	−0.0413	(0.0333)	−0.0445	(0. 0333)	− 0.0264	(0. 0272)	−0.0349	(0.0283)	
Observations	61.093		61.093		64,493		62,598		
Products	1505		1505		1537		1515		
Log-likelihood	171,956		171,938		178,425		176,571		
AIC	−343,759		−343,7209		−356,692		−352,949		
S. corr. 1, p–v	0.5041		0.5064		0.8522		0.5001		
S. corr. 2, p–v	0.1326		0.1337		0.0712		0.1352		
S. corr. 3, p–v	0.7786		0.7815		0.2348		0.7078		

The variables are defined in Table 1. For the 19 indicator variables: Current values are used for the IV specifications; first lags are used for OLS P; and for Error-C second lags are reported in the first two columns and lagged first-differences are reported in the last two columns. All specifications include time- and product-specific fixed effects. Except for time for OLS P, both groups of fixed effects are jointly significant at the 5% level. In the IV 1 specification, first lags of the 19 endogenous variables and $lnDDD_{s,t-3}$ are used as instruments. $lnDDD_{i,t-3}$ is added as an additional instrument for specification IV 2. The differentials $dlnP_i^*/dPI_i^*$ and $dlnP_i^*/dThG_s^*$ capture the mean long-term effect of competition from parallel imports and from therapeutic alternatives for products for which $N\_PI_i > 0$ and $N\_ThGen_s > 0$. For the IV 2 specification, the differentials show the partial effects conditioned on quantity. For both IV-specifications, the null hypothesis that the model is under-identified is rejected at the 1% significance level, and the null hypothesis for the Hansen J test that the instruments are valid—uncorrelated with the error term—is not rejected at conventual levels. The last three rows report the p-value for the serial correlation test that was proposed by Cumby and Huizinga (1992). The null hypotheses are no serial correlation of the first-, second- and third-order, respectively. Standard errors that are robust to correlations within substances are given in parentheses. ***, **, and * indicate that the coefficient is statistically significant different from zero at the 1, 5, and 10% significance levels

the Bayesian information criterion. This is one reason why the preferred specification is a partial adjustment rather than an error-correction specification. The other reason is that I am unable simultaneously to find strong instruments for both the first difference and the lags of the endogenous variables and hence cannot provide reliable IV-results for an error-correction specification.

6 Results

The results that are presented in Table 3 show that the prices adjust slowly to changes in competition. The speed of adjustment—which for the three partial-adjustment specifications is one minus the coefficient for $lnP_{i,t-1}$ and for the error-correction specification is the coefficient for $lnP_{i,t-1}$ with reversed sign—is estimated to be 0.05 for the OLS P specification and slightly above 0.04 for all specifications. This implies that the long-term effects are 20–24 times the coefficients for the 19 indicator variables in levels. The slow adjustment implies it takes about six months before a fourth of the long-term effects are realized and about 15 months before half are realized.

Note that the specifications do not assume that the previous month's price affect the current price. On the contrary, the estimated specifications include static models as special cases: e.g., that the coefficient for $lnP_{i,t-1}$ equals zero in the first three specifications and equals minus one in the fourth specification. The results clearly show that these static models can be rejected.

The differential $dlnP_i^*/dPI_i^*$ shows the long-term effect of facing competition from parallel imported products for an average product that faces such competition: It shows that, for a product for which N_PI_i is strictly positive and the values of indicator variables for $N\_PI\_Substance_s$ and N_PI_i equal the within-sample means for products for which $N\_PI_i \geq 1$, the price in the long term will be 7–9% lower than it would have been if the product never faced competition from parallel imports.[16] Considering that pharmaceuticals that lack generic competition account for about 80% of the costs for prescription pharmaceuticals, this is an economically important effect. The effect is also significantly different from zero at the 1% level in all specifications. Still, the effect is smaller than most previous estimates that have been reported in the literature—even though previous studies have reported estimates that are somewhere between short- and long-term effects.

The point estimates for the differential $dlnP_i^*/dPI_i^*$ are most negative for specification IV 1. That the point estimates for the OLS P and error-correction specifications are closer to zero is expected because they are estimated with OLS. It is also expected that the point estimate is closer to zero for the IV 2 specification, because for this specification $dlnP_i^*/dPI_i^*$ (and the individual parameter estimates) shows the

[16] The exact percentage effect of the differential can be calculated using the formula $100 * [\exp(dlnP_i^*/dPI_i^*) - 1]$.

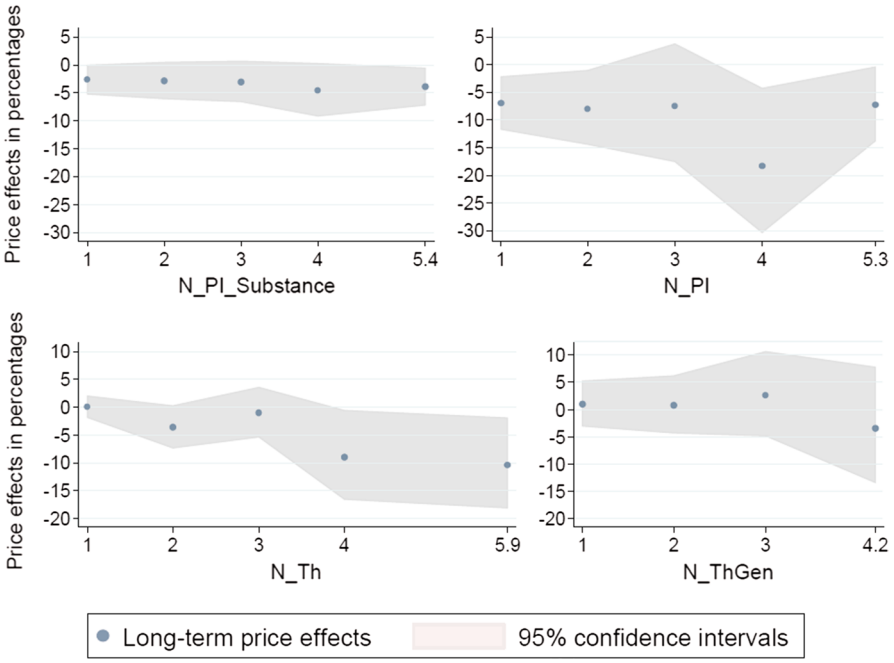

Fig. 2 Estimated long-term price effects (in percentages) of the number of parallel traders that sell products with the same active substance ($N\_PI\_Substance_{it}$) and exchangeable products N_PI_{it}, respectively, in the upper panels, and of the number of competitors that sell therapeutic alternatives (N_Th_{it}) and the number of therapeutic alternatives with generics (N_ThGen_{st}) in the lower panels. The predictions are from specification IV 1, and the dots illustrate the point estimates. The effects are plotted holding N_PI_{it} and N_ThGen_{st} at zero in the left panels and holding $N\_PI\_Substance_{it} = N\_PI_{it}$ and $N\_Th_{it} = N\_ThGen_{st}$ in the right panels. The estimates for the indicator for five or more parallel traders are plotted at $N\_PI\_Substance_{it} = 5.4$ and $N\_PI_{it} = 5.3$, since these are the averages of $N\_PI\_Substance_{it}$ and N_PI_{it} conditional on $N\_PI\_Substance_{it} \geq 5$ and $N\_PI_{it} \geq 5$, respectively. Likewise, the estimates for the indicator for five or more N_Th_{it} and for four or more N_ThGen_{st} are plotted at $N\_Th_{it} = 5.9$ and $N\_ThGen_{st} = 4.2$, since these are the averages of N_Th_{it} and N_ThGen_{st} conditional on $N\_Th_{it} \geq 5$ and $N\_ThGen_{st} \geq 4$, respectively

partial price-effects of competition from parallel imports conditioned on the quantity variable $lnDDD_{it}$.[17]

[17] The effect of $lnDDD_{it}$ on lnP_{it} is statistically not significantly different from zero, but according to the point estimates, the long-term effect of $lnDDD_{it}$ on lnP_{it} is 0.0003/(1–0.9568) = 0.0069. Therefore, for the indirect price-effects of competition from parallel imports through quantity to account exactly for the difference of −0.0044 between the estimates of $dlnP_i^*/dPI_i^*$ across the two IV-specifications, $lnDDD_{it}/dPI_{it}^*$ must equal −0.64 as 0.0069 × (−0.64) = −0044. Because 100 × [exp(−0.64)− 1] = −47, this means that the quantity that is sold on average must fall by 47% in response to facing competition from exchangeable substitutes. This can be compared with the average market share of parallel imports among exchangeable products which is 49%, but entry of parallel imports might in some cases also affect the size of markets.

Together with the estimate that the short-term effects are just 4–5% of the long-term effect for the partial-adjustment specification, the differential $dlnP_i^*/dPI_i^*$ also reveals that the average short-term price effect of competition from parallel imports according to these specifications is −0.4% For the error-correction specification, the short-term price effect of competition from parallel imports is estimated to be −0.2% (std. err. 0.1%) with the use of the estimates that are reported in the last two columns of Table 3. Note that even though the relative difference across specifications with regard to the short-term effects can appear large, the absolute difference is economically small.

Let us now interpret the individual parameter estimates for the variables that measure competition from parallel imports. For the IV 1 specification, the coefficient for the indicator variable for $N\_PI\_Substance_{st}=1$ shows that if only one parallel trader sells products with the same active substance—but not an exchangeable product to product *i*—the price is reduced by 0.12% in the short-term. Tests that are not reported in the tables show that additional parallel traders that sell products that are not exchangeable to product *i*, but that have the same active substance, will not cause any significant further price reduction. If the first parallel trader sells an exchangeable product, so that both $N\_PI\_Substance_{st}$ and N_PI_{it} equal one, the predicted price reduction is 0.31% (due to rounding) in the short-term and 7.0% in the long-term. The price reduction is not significantly larger if a second or third firm starts importing exchangeable products, but with $N\_PI\_Substance_{st}=4$ the price falls another 11% in the long term. The predicted long-term price effects are illustrated in Fig. 2.

It is interesting to note that the results, in general, suggest that it is more important whether sellers face competition from parallel imports than the number of competitors that they face. As was mentioned, competition from one parallel trader that sells exchangeable products reduces prices by 7% in the long term, but facing competition from *at least* one such parallel trader only reduces prices by 2% more, on average, according to the results from the preferred specification IV 1. The exception is that the results suggest that the fourth parallel trader that sells exchangeable products has larger effects on the prices than does the first; but because relatively few sellers face competition from four traders, it only has a small effect on the differential $dlnP_i^*/dPI_i^*$.

Because parallel imports in most cases are cheaper than locally sourced products, the reference price that affects the out-of-pocket cost of buying product *i* usually falls when a parallel trader starts selling an exchangeable product. However, if the parallel trader sells a product with the same active substance, but with a different strength, administrative form, or too different packet size, the reference price is not affected. Also, consumers are informed if cheaper exchangeable alternatives are available at the pharmacy and are free to choose among them; but to buy a product with different strength or administrative form they need a new prescription from their physician. Therefore, it is not surprising that the prices of locally sourced products are affected more by the number of parallel traders that sell exchangeable products than by the number that sells other products with the same active substance.

Other results (that are not presented here) indicate that the prices of products that are sold by a firm that sells multiple products with the same active substance,

strength, and administrative form are reduced slightly less in response to competition from exchangeable parallel imports. This difference in price response between single- and multi-product firm is, however, not statistically significant. Nor is there any significant effect of additional parallel traders that sell products that are not exchangeable simply because their package sizes differ too much from that of product *i*.

As was mentioned in the literature section, because of a lack of instruments, previous research has not analyzed the causal effect of the number of parallel traders. Instead, Ganslandt and Maskus (2004) reported estimates from a static OLS regression with indicator variables for the number of parallel traders; they show that the first and second trader were associated with no, or a marginal, price reduction, while a sizable price effect— −4%—came with the third trader. This is quite opposite to the result presented above. I get similar results to theirs when I estimate a specification that is similar to theirs with my data. Therefore, I interpret the difference between the IV estimates presented above and the OLS estimates of Ganslandt and Maskus as not being explained by different datasets but instead by a large endogeneity bias for the first parallel trader in their study.

Turning to the effects of competition from one therapeutic alternative, we see that the estimates for $N\_Th_{st} = 1$ and $N\_ThGen_{st} = 1$ are non-significant and quite precisely estimated. This indicates that competition from one therapeutic alternative has no or small price effects, irrespective of whether the therapeutic alternative is on or off patent. Other results that are not presented in the tables show that the effect of $N\_Th_{st} = 1$ is substantially more negative during the second half of the study-period, compared to the first half. Still, the effect of $N\_Th_{st} = 1$ is not significantly different from zero in either half.

On the other hand, the coefficients for N_Th_{it} equaling 2, 4, and 5 or more, respectively, are all negative and significantly different from zero at either the 5 or 10% significance level. Because I control for the number of therapeutic alternatives for which generic versions exist, these coefficients indicate that prices are reduced when there are more competitors that sell substances for which generics do not exist. The estimates for N_ThGen_{st} equaling 2 and 4 or more, respectively, show that the price reductions are significantly smaller when the competitors sell substances for which generics also exist.

The lower-right panel of Fig. 2 shows that there is no significant effect of the number of competitors that sell substances with generics. In econometric terms, the main explanation is that the significantly negative estimate for the indicator variables for N_Th_{it} are nearly offset by the positive estimate for those for N_ThGen_{st}. In economics terms, one possible explanation is that producers of on-patent pharmaceuticals refrain from engaging in price competition with therapeutic alternatives that because of generic alternatives are priced too low. The price cut that is required for a substance to be the one that physicians are recommended to try first might simply be so large that firms prefer to sell at high prices even if this means that their products are prescribed only to patients who are already using them or for which the therapeutic alternatives gives less positive effect or more side effects.

In terms of the relative importance of competition on the extensive and intensive margins, the results for therapeutic alternatives are quite different from those

for competition from parallel imports. This is not especially surprising given that the two types of competition are quite different. Competition between a producer and a parallel trader is asymmetric competition between two very different firms, in which the parallel trader usually is forced to set a lower price than the producer to sell anything. On the other hand, competition between two producers that sell substances within a therapeutic class can be competition between two similar firms.

Previous studies suggest that symmetry facilitates tacit collusion, and tacit collusion is considered most likely when there are only two interacting firms (Davies et al., 2011; Fonseca & Normann, 2012). Hence, one possible explanation for the lack of effect of the first therapeutic competitor can be tacit collusion. As was mentioned above, the large effect of the first parallel trader that sells an exchangeable product can be because of the effect that this has on the reference price, which affects consumers' cost of buying the locally sourced product.

7 Conclusions

This paper studies the price effects of competition from parallel imports and therapeutic alternatives to branded, patented pharmaceuticals. Unlike previous research in this field, I use dynamic models that make lags of number of competitors into valid and strong instruments for current values. This, in turn, provides enough instruments to allow a study of the effects of the number of competitors and to do this with the use of indicator variables, and to distinguish between competition from parallel traders at different levels.

The results show that competition from one parallel trader that sells a product with the same active substance, strength, form of administration, and nearly identical package size reduces the price by 7% in the long term. However, prices adjust slowly, and it takes 15 months before half of the long-term price reduction is realized.

The results also show that it is mainly competition at this fine-grained level that matters. Policy-makers who are interested in low pharmaceutical costs might therefore want to incentivize parallel traders to sell products with more strength-form-package size combinations: for example, by abolishing extra fees for parallel traders that sell additional products with different strengths or forms of administration.

On average, the price of a product that faces competition from at least one parallel imported exchangeable product is predicted to be 9% lower in the long term, compared to if the product faces no competition from parallel imports. This effect is smaller than has been reported by previous studies, except those reported by Méndez (2018) for statins in Denmark. This is despite the fact that previous studies have reported something in between short- and long-term effects and have not accounted for the fact that competition from products with similar package sizes has larger effects on prices than does competition from less close substitutes. One possible explanation of the difference in results is that the results of this paper rest neither on the assumption that exchange rates or the age of pharmaceuticals are valid instruments, nor on the assumption that firms behave as if their prices do not affect their competitors' future prices.

With regard to competition from other producers that sell pharmaceuticals that are intended for the same or similar medical diagnoses, I find no price effect from a first therapeutic alternative. Conversely, four and five or more firms that sell therapeutic alternatives without generic versions have significant negative effects one prices.

This paper demonstrates that using dynamic models—when the price setting is in fact dynamic and prices are set in advance—has several advantages: Most important, it resolves the simultaneity problem by allowing lags to be used as strong instruments for the current number of competitors. The dynamic price cap has likely contributed to slow adjustments in the prices that are studied in this paper, and the detailed rules with regard to price setting has facilitated the use of lags as instruments. Still, in many other markets prices are set in advance and gradually adjust towards new equilibria. Hence, I hope that this paper inspires researchers who are studying the effects of measures of competition on prices in such markets to consider using dynamic specifications to estimate the causal effects.

Appendix 1: Validity of instruments

Even if a firm cannot predict the error term ε_{it} when it must submit a price in month $t-3$ for month $t-1$, a firm can choose not to sell a product with a set price. A problem occurs if such a choice is affected by ε_{it}: for example, if a parallel trader has not sold its product in the beginning of month $t-1$ and if its choice of whether or not to sell at all in month $t-1$ is affected by the value of P_{it}, which is announced around the ninth day of month $t-1$. The choice could be affected, since a higher P_{it} likely means that the parallel trader can sell more of its product for the price it has set, which can make it more worthwhile to start selling in Sweden.

Still, for two reasons, I find it unlikely that this causes a problem for the validity of the instruments: First, a parallel trader that has a product in Swedish packages already at the beginning of month $t-1$ is likely to start selling before the value of P_{it} is announced—instead of waiting and facing the risk of having to repackage the product and sell it in another country. Second, a trader that does not have a product in Swedish packages before it observed P_{it} is unlikely to get products ready to sell in Sweden before the end on month $t-1$. Still, because of this potential problem, I also estimate specification IV 3 in which I instrument the endogenous variables with their second lags and $lnDDD_{s,t-3}$. The results of this specification are presented in Table 4 in Appendix 3.

A potential problem for all specifications is that serially-correlated error terms could bias the estimators for the lag of the dependent variable. Therefore, I tested for serial correlation of up to three months by using the test that was proposed by Cumby and Huizinga (1992), as has been implemented in STATA by Baum and Schaffer (2013). Cumby and Huizinga showed how a consistent estimate of the covariance matrix can be used to test for serial correlation in the true regression error also in models in which some regressors—e.g., the lag of the dependent variable—are only weakly exogenous.

The results show no evidence of serial correlation for either of the IV specifications or for the error-correction specification. Of course, this does not rule out

that serial correlation exists; but it does show that if such correlation exists, it is too weak to be detected. In addition, given the large number of observations, the test by Cumby and Huizinga (1992) rejects the null hypothesis of no serial correlation also when the estimated correlation is quite close to zero.

For specification OLS P, I can reject the null hypothesis of no second-order serial correlation at the 10% significance level. Still, the serial correlation is small: The estimated correlation between $\varepsilon_{i,t}$ and $\varepsilon_{i,t-1}$ is -0.009, while it is -0.049 for ε_{it} and $\varepsilon_{i,t-2}$ and 0.001 for ε_{it} and $\varepsilon_{i,t-3}$. Since the serial correlation is small, the bias caused by this is likely negligible; based on Monte Carlo simulations, Keele and Kelly (2006) report biases of less than 1% for both the short- and long-term effect when using OLS with a lagged dependent variable when the correlation coefficient is 0.1. Because of this, and the relatively low variance of the OLS estimator, I presented the estimates for OLS P in the results section; but in Appendix 3, I show that GLM regressions, allowing for first- and second-order serial correlation, give nearly identical results.

Appendix 2: Nickell bias

Including lags of the dependent variable in a fixed effects model can also yield bias. According to Nickell (1981), the limit of the bias for the parameter θ as N approaches infinity can be approximated by $-(1+\theta)/(\mathrm{T}-1)$, where N and T are the number of fixed effects and time periods, respectively. Nickell notes that for low values of θ, his more exact formula for the bias—and hence also this approximation—corresponds well to the Monte Carlo results of Nerlove (1967). On the other hand, for $\theta = 0.9$, $T = 10$, and when 95% (99%) of the total variance are due to the fixed effects, Nerlove finds a bias that is just 26% (6%) of the bias that is suggested by the approximation that was written above.

The latter result of Nerlove (1967) is interesting, since the fixed effects account for 95% of the total variance in the preferred specification IV 1. If the same relationship between Nickell's approximation and Monte Carlo simulations holds for T = 41 (which is the average in this study), one would expect a bias of about -0.01 if $\theta = 0.9$. Furthermore, since Nerlove's simulations indicate that the bias is decreasing in θ for $\theta > 0.5$ if at least 70% of the total variance is due to the fixed effects, the bias is expected to be even closer to zero because θ is estimated to about 0.96. Because the bias can be expected to be less than 0.01 in absolute value, I present results from estimations in which I have not accounted for this small bias.

Appendix 3: Robustness Analyses

Table 4 presents the results from six robustness analyses. To facilitate comparison, the results from the IV 1 specification are also presented in column 1 of Table 4.

As mentioned in the data section, the current study uses prices from October 2002 to October 2009. In July 2009, pharmaceutical firms were granted the right to give

Table 4 Estimation results for lnP_{it}, robustness analyses

	IV 1	Anticipation	IV 3	AR 2	Review	2 lags	3 lags
$lnP_{i,t-1}$	0.9567***	0.9532***	0.9567***	0.9437***	0.9567***	0.9504***	0.9507***
$lnP_{i,t-2}$						0.0065	0.0423*
$lnP_{i,t-3}$							−0.0377*
$N\_PI\_Substance_s$							
1	−0.0012*	−0.0011*	−0.0013*	−0.0011***	−0.0012*	−0.0011*	−0.0011*
2	−0.0012*	−0.0011	−0.0013	−0.0011**	−0.0012*	−0.0012*	−0.0012*
3	−0.0013	−0.0015*	−0.0019	−0.0012**	−0.0013	−0.0013	−0.0013
4	−0.0020**	−0.0022**	−0.0021	−0.0019***	−0.0020**	−0.0020**	−0.0019**
≥ 5	−0.0017**	−0.0016*	−0.0023***	−0.0017***	−0.0017**	−0.0017**	−0.0017**
N_PI_i							
1	−0.0020**	−0.0020**	−0.0018**	−0.0018***	−0.0020**	−0.0020**	−0.0019**
2	−0.0024*	−0.0023	−0.0022*	−0.0020***	−0.0024*	−0.0024*	−0.0022*
3	−0.0020	−0.0020	−0.0017	−0.0022*	−0.0020	−0.0021	−0.0018
4	−0.0067***	−0.0059**	−0.0066***	−0.0054***	−0.0067***	−0.0068***	−0.0065***
≥ 5	−0.0015	−0.0017	−0.0012	−0.0013	−0.0015	−0.0016	−0.0013
N_Th_s							
1	0.0000	0.0001	−0.0003	−0.0001	−0.0000	0.0000	0.0000
2	−0.0016*	−0.0013*	−0.0021**	−0.0015**	−0.0016*	−0.0016*	−0.0016*
3	−0.0004	−0.0013*	−0.0009	−0.0003	−0.0005	−0.0004	−0.0004
4	−0.0040**	−0.0039**	−0.0034**	−0.0033***	−0.0041**	−0.0041**	−0.0040**
≥ 5	−0.0048**	−0.0047**	−0.0038**	−0.0037***	−0.0048**	−0.0048**	−0.0047**
N_ThGen_s							
1	0.0004	0.0004	−0.0005	0.0005	0.0005	0.0004	0.0004
2	0.0019**	0.0010	0.0011	0.0015***	0.0020**	0.0020**	0.0018*
3	0.0016	0.0009	0.0006	0.0013*	0.0016	0.0016	0.0015
≥ 4	0.0031**	0.0022	0.0022	0.0026***	0.0030**	0.0031**	0.0029**

Table 4 (continued)

	IV 1	Anticipation	IV 3	AR 2	Review	2 lags	3 lags
$Review_{st}$					−0.0012		
$Review_{s,t-1}$					0.0007		
$dlnP_i^*/dPI_i^*$	− 0.0905***	−0.0819***	−0.0931***	−0.0638***	−0.0899***	−0.0917***	−0.0829***
$dlnP_i^*/dThG_s^*$	−0.0413	−0.0465	−0.0578*	−0.0248	−0.0438	−0.0431	−0.0423
Observations	61,093	54,096	60,821	64,459	61,093	60,821	60,821
Products	1505	1465	1499	1520	1,505	1499	1499
Log-likelihood	171,956	151,602	171,056		171,958	171,061	171,112
AIC	−343,759	−303,065	−341,958		−343,758	−341,966	−342,066

***, **, and * indicate that the coefficient is statistically significant different from zero at the 1, 5, and 10% significance levels, respectively. Unlike in the other specifications, the standard errors in the AR2 specification are not robust to arbitrary serial correlation within substances. Standard errors, which are omitted to save space, are available on request

$Review_{st}$ equals one for therapeutic groups for which the PBA has completed a cost−effectiveness evaluation. The other variables are defined in Table 1. For the 19 variables that lack time indices, first lags are used for the AR 2 specification, estimated with a generalized linear model accounting for first− and second−order serial correlation, while current values are used for the other specifications—all of which are estimated with 2SLS. All specifications include time and product−specific fixed effects. In the specifications that are estimated with 2SLS, first lags of the 19 endogenous variables and $lnDDD_{s,t-3}$ are used as instruments. The differentials $dlnP_i^*/dPI_i^*$ and $dlnP_i^*/dThG_s^*$ capture the mean long−term effect of competition from parallel imports and from therapeutic alternatives for a product for which $N\_PI_i > 0$ and $N\_ThGen_s > 0$. For all IV−specifications, the null hypothesis that the model is under−identified is rejected at the 1% significance level; and the null hypothesis for the Hansen J test that the instruments are valid—uncorrelated with the error term—are not rejected at conventual levels

discounts to pharmacies. Results in Granlund (2015) are consistent with producers after July 2009 giving pharmacies discounts to incentivize them to sell locally sourced products instead of parallel imports. It is also possible that producers, due to the possibility of giving discounts, stopped decreasing list prices in response to facing competition from parallel imports. Because price increases can imply that a pharmaceutical no longer is included in the benefit scheme, firms could have stopped decreasing list prices already when they started anticipating the reform.

In column 2 Table 4, I of investigate this by excluding the prices that were set after February 2007, when the government inquiry—which eventually resulted in the changed rules—began. Comparing the results in column 2 with those in column 1, I find no evidence that the price effects of competition were larger before February 2007 than during the whole study period.

The possibility of giving pharmacies discounts should not have any important direct effect on the price responses to therapeutic competition, since pharmacies have limited possibilities to affect the prescribers' choices among therapeutic alternatives. Possible explanations as to why the effect of competition from parallel imports were not larger before February 2007 include that the inquiry did not leak any suggestions to change the rules during its first months of work and that producers did not believe that the suggestions of the inquiry would become law. In April 2009, the parliament voted to give firms the right to give pharmacies discounts; but unlike the suggestion from the inquiry, this right was given only for on-patent pharmaceuticals.

Column 3 of Table 4 presents the specification IV 3, which I mentioned in Appendix 1, in which the endogenous variables are instrumented with their second lags and $lnDDD_{s,t-3}$. A comparison of the results in column 3 with those in column 1 shows that using the second lags instead of the first lags as instrument has small effects on the results.

In the results section, I reported that the null hypothesis of no serial correlation of order two could be rejected at the 10% level for the specification OLS P, while I found no evidence of serial correlation for the other specifications. To investigate the importance of potential serial correlation, column 4 of Table 4 presents results from a generalized linear model that accounts for first- and second-order serial correlation. In this specification, called AR 2, the first lags of the 19 competition variables are included as exogenous variables. Hence, the results from this specification should primarily be compared to the results of specification OLS P.

Table 4 shows that the estimates for parallel traders that sell exchangeable products (N_PI_i) is slightly smaller in the AR 2 specification as compared with the estimate for OLS P. As a result, the estimate of the average long-term effect of competition from parallel imports changes from −7 (according to specification OLS P) to −6% (according to specification AR 2). However, this change is less than a half standard error. This indicates that the consequence of not accounting for small serial correlation (the estimated correlation between $\varepsilon_{i,t}$ and $\varepsilon_{i,t-1}$ is −0.009, while it is −0.049 for ε_{it} and $\varepsilon_{i,t-2}$) is small, which is consistent with the Monte Carlo simulations that are presented by Keele and Kelly (2006).

At the end of 2003, the (PBA) initiated cost-effectiveness evaluation of 49 therapeutic groups, but only three therapeutic groups (migraine; diseases caused by

excess stomach acid; and asthma, chronic obstructive pulmonary disease (COPD), and coughs) were completed during the study period. These reviews could affect prices since the PBA might directly recommend a reduction in the price of a drug and since producers might follow the recommendation so as to retain the drug's reimbursement status.

In the fifth column of Table 4, I control for the reviews by including the indicator variable $Review_{st}$ (with parameter β_6), which takes the value of one for a therapeutic group for which the review had been completed by the PBA. Unlike the competition variables, it is reasonable to expect the short-term effect of the review to equal its long-term effect. To allow for this possibility, I also include $Review_{s,t-1}$ (with parameter β_7). If $\beta_7 = -\theta\beta_6$ (where θ is the parameter for $lnP_{i,t-1}$), the short-term effect of $Review_{st}$ equals its long-term effect.[18] I cannot reject that this is true, nor can I reject that both the short- and long-term effects of $Review_{st}$ equal zero. The results that are presented in Table 4 further show that including $Review_{st}$ and $Review_{s,t-1}$, at most, has very small effects on the estimates for other parameters.

The specifications that are presented in columns 6 and 7 differ from specification IV 1 only by including two and three lags of the dependent variable instead of one lag. The results show that adding a second lag has negligible effects on the results. The sum of the coefficients for the two lags in this specification is nearly identical to the coefficient for $lnP_{i,t-1}$ in specification IV 1, and the estimates for the 19 competition variables differ by less than 0.0001. When a third lag is added, the sum of the coefficients for the lags of the dependent variable becomes 0.9552, which is slightly less than the estimates for $lnP_{i,t-1}$ in specification IV 1. As a consequence of this and small changes in the coefficients for some of the indicator variables, the estimate of the average long-term effect of competition from parallel imports changes from -9 to -8%.

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[18] To see this, note that the short-term effect equals β_6, while the long-term effect is given by $(\beta_6 + \beta_7)/(1-\theta)$. Hence, if $\beta_7 = -\theta\beta_6$, the long-term effect becomes $(\beta_6 - \theta\beta_6)/(1-\theta) = \beta_6$.

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