Center for European, Governance and Economic Development Research
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Discussion Papers

Number 362 – January 2019

REFERENCE PRICING AND PARALLEL IMPORTS: EVIDENCE FROM GERMANY

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ISSN: 1439-2305

Reference Pricing and Parallel Imports: Evidence from Germany

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January 2019

Abstract

I study the effect of reference pricing on competition by parallel imports, in particular the market share of parallel imports and the number of parallel traders. First, I analyze the effect of reference pricing on competition by parallel imports in a vertical differentiation model with a locally sourced version and a parallel import offered by n identical parallel traders. Second, I explore the effect of reference pricing on competition by parallel imports using a dataset with prescription drugs with competition from parallel imports. Both model and estimation results suggest that the introduction of reference pricing inreases the market share of the parallel import and the number of parallel traders, while a decrease in the reference price decreases the market share of the parallel import and the number of parallel traders.

JEL Classification: F12, I11, I18

Keywords: reference pricing, parallel imports, pharmaceutical regulation

1 Introduction

In this paper, I study the effect of reference pricing on competition by parallel imports, in particular the market share of parallel imports and the number of parallel traders.

Pharmaceutical parallel trade and reference pricing are both prevalent phenomena in the European Union[1]. The combination of regional exhaustion of intellectual property rights and

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[1] In the destination countries of parallel trade, the share of parallel imports in pharmacy market sales ranged between 7.9% in the United Kingdom, 10.3% in Germany, 10.6% in the Netherlands, 18.7% in Sweden, and 25.2 % in Denmark (EFPIA, 2016).

the free movement of goods in the EU internal market enable parallel trade, implying that goods that were placed on the market in one country can be exported to another country without the authorization of the manufacturer (Maskus, 2000). Considerable price difference for pharmaceuticals between EU member states, which may be as high as 300%, make parallel trade profitable (Kanavos & Costa-Font, 2005). In the EU, one source of price differences for pharmaceuticals are regulatory differences as a result of national competence in health policy (TFEU Art. 168).

A common form of pharmaceutical regulation, which is applied or has been applied by almost all EU member states, is reference pricing (Carone, Schwierz & Xavier, 2012). Reference pricing defines a common reimbursement price for a group of interchangeable pharmaceuticals. If consumers purchase a drug that is priced above the reference price, they have to pay the difference between both prices out-of-pocket. Reference pricing intends to enhance price competition, thereby reducing drug prices and public health expenditure. Empirical evidence seems to confirm the price-decreasing effect of reference pricing. For instance, Pavcnik (2002) finds price reductions of 10-20% for antiulcerants and antidiabetics in Germany. Brekke, Holmas & Straume (2011) show that the introduction of reference pricing for a sub-sample of drugs in Norway reduced brand-name prices by 33% and generic prices by 22%. Kaiser et al. (2014) find that a reference price reform in Denmark has resulted in price reductions of around 20%.

By inducing price reductions and creating cross-country price differences, regulatory differences may drive the direction and volume of parallel trade flows[2]. For instance, Costa-Font (2016) shows that parallel imports flows are driven among others by cross-country differences in statutory distribution margins.

Pharmaceutical regulation may also be one potential determinant of competition by parallel imports in destination countries. There is evidence that price competition by parallel imports may reduce drug prices. For instance, Ganslandt & Maskus, 2004 find price reductions of 12-19% due to parallel trade for Sweden. Duso, Herr & Suppliet (2014) show that competition by parallel imports has reduced drug prices in Germany by 11%. But there is little evidence on what determines the presence (or absence) and extent of competition. The design of the cost-sharing system, i.e. rules of copayment and reimbursement, seem to be an important factor in determining the effect of parallel trade (Kanavos et al., 2004; Enemark et al., 2006, Birg, 2018).

[2]Whether parallel trade is induced by regulatory differences, may also affect the welfare consequences of parallel trade, as Jelovac & Bordoy (2005) show.

Brekke et al. (2015) show that stricter price regulation (in the form of price caps) reduces competition from parallel imports.

Reference pricing (other than price caps) may enhance competition in pharmaceuticals markets, at least for generics. Empirical evidence on the effect of reference pricing on generic competition seems to be ambiguous. Aronsson, Bergman & Rudholm (2001) find mixed results for the effect of reference pricing on brand market shares in Sweden. Dalen, Haabeth & Strom (2006) find that reference pricing has increased generic market shares in Norway. Similarly, Brekke, Holmas & Straume (2011) find that reference pricing has reduced brand-name market shares, thus enhancing generic competition. Moreno-Torres, Puig-Junoy & Borrell (2009), find a negative effect of reference pricing on generic entry in Spain. Brekke, Canta & Straume (2015) show that the introduction of reference pricing in Norway in 2005 has increased the number of generic drugs and the generic market share.

The effect of reference pricing on competition by parallel imports has received less attention, with the difference to generics being that generics are often priced below the reference price, while parallel imports are not. Köksal (2009) compares price effects caused by parallel trade under coinsurance and reference pricing. Under reference pricing, price reductions from parallel trade in the destination country are higher than under coinsurance, while the price in the source country remains unchanged.

Against this background, I study the effect of reference pricing on competition by parallel imports, in particular the market share of parallel imports and the number of parallel traders.

First, I analyze the effect of reference pricing on competition by parallel imports in a vertical differentiation model with a locally sourced version and a parallel import offered by n identical parallel traders. Second, I explore the effect of reference pricing on competition by parallel imports using a data set with prescription drugs with competition from parallel imports. Both model and estimation results suggest that the introduction of reference pricing increases the market share of the parallel import and the number of parallel traders, while a decrease in the reference price decreases the market share of the parallel import and the number of parallel traders.

These results suggest that stricter regulation in destination countries of parallel imports may weaken competition from parallel imports.

The rest of the paper is organized as follows. In the next section, the model is presented. Section 3 presents the data set and section 4 studies the effect of reference prices on competition

by parallel imports empirically. Section 5 concludes.

2 The Model

Consider a (domestic) manufacturer M selling a drug b and n (identical) parallel traders selling the corresponding parallel import β.

Consumers associate a lower quality with the parallel import, which is captured by a discount factor $\tau \in (0,1)$ in consumer valuation. This perception may result from differences in appearance and packaging (Maskus, 2000). Moreover, there is evidence that the price of a drug may serve as a quality indicator (Waber et al., 2008). Accordingly, due to a lower price, the parallel import may be associated with lower quality.

Consumers in both countries are heterogeneous with respect to the gross valuation of the drug, represented by a parameter θ which is uniformly distributed on the interval $[0,1]$. The consumer heterogeneity with respect to valuation θ can be interpreted as differences in willingness to pay for a locally sourced version, differences in risk aversion regarding the trial of substitutes or differences in the severity of the condition or differences in prescription practices (see e.g. Brekke, Holmas & Straume, 2011).

Health insurance reimburses a fraction of the drug price, the remaining fraction γ is paid by the patient. Under no regulation, the drug copayment is $c_i = \gamma p_i$, where γ is the coinsurance rate, and $(1-\gamma)\, p_i$ is reimbursed. Under reference pricing, the copayment is $c_i^r = \gamma r + p_i - r_i$, if $p_i > r_i$ and $c_i^R = \gamma p_i$, if $p_i < r_i$, where r is the reference price.

Each consumer demands either one or zero units of the most preferred drug. The utility derived from no drug consumption is zero, while consumer k with valuation θ_k who buys one unit of drug i obtains a net utility $U = \theta I - c_i$, with $I = 1$ if $i = b$ and $I = (1-\tau)$ if $i = \beta$. Here $\tau \in (0,1)$ reflects the perceived quality difference between both versions b and β of the drug, $\gamma \in (0,1)$ is the coinsurance rate and p_i is the price of drug $i = b, \beta$.

The marginal consumer who is indifferent between buying the locally sourced version b and the parallel import β has a gross valuation $\theta^{b,\beta} = \frac{c_b - c_\beta}{\tau}$, the consumer who is indifferent between buying the parallel import β and not buying at all (0) has a gross valuation $\theta^{\beta,0} = \frac{c_\beta}{(1-\tau)}$. Consequently, demand for the authorized product b and for the parallel import β is given by $q_b = 1 - \frac{c_b - c_\beta}{\tau}$ and $Q_\beta = \frac{c_b - c_\beta}{\tau} - \frac{c_\beta}{(1-\tau)}$, with $nq_\beta = Q_\beta$.

Production technologies exhibit constant marginal costs, which are normalized to zero for

simplicity.

The structure of the model can be summarized by the following two-stage game: In the first stage, potential parallel traders simultaneously decide whether to enter the market at fixed cost of entry f. In the second stage, firms compete in quantities.

2.1 Coinsurance

Consider a system with coinsurance as a benchmark. Copayments are given as $c_b = \gamma p_b$ and $c_\beta = \gamma p_\beta$. Inverse demand is given as $p_b = \frac{1-q_b-nq_\beta(1-\tau)}{\gamma}$ and $p_\beta = \frac{(1-\tau)\left(1-q_b-nq_\beta\right)}{\gamma}$.

In the second stage, firms maximize $\pi_b = q_b\frac{1-q_b-nq_\beta(1-\tau)}{\gamma}$ and $\pi_{\beta_i} = q_b\frac{(1-\tau)\left(1-q_b-nq_\beta\right)}{\gamma}$. Assuming symmetry, quantities are $q_b = \frac{1+n\tau}{n(\tau+1)+2}$ and $q_\beta = \frac{1}{n(\tau+1)+2}$.

In the first stage, the number of parallel trader is determined by the zero-profit condition:

$$n = \frac{1}{1+\tau}\left(\frac{\sqrt{1-\tau}}{\sqrt{f\gamma}} - 2\right). \tag{1}$$

Equilibrium quantities are

$$q_b = \frac{\sqrt{f\gamma\left(1-\tau\right)}+\tau}{\left(1+\tau\right)},\ q_\beta = \frac{\sqrt{f\gamma}}{\sqrt{1-\tau}}, Q_\beta = \frac{\sqrt{1-\tau}-2\sqrt{f\gamma}}{\sqrt{1-\tau}\left(1+\tau\right)}. \tag{2}$$

Drug prices are

$$p_b = \frac{\sqrt{f\gamma\left(1-\tau\right)}+\tau}{\gamma\left(1+\tau\right)},\ p_\beta = \frac{\sqrt{f\gamma\left(1-\tau\right)}}{\gamma}. \tag{3}$$

The market share of the parallel import is

$$\chi_\beta = \frac{Q_\beta}{Q_\beta + q_b} = \frac{2\sqrt{f\gamma}-\sqrt{1-\tau}}{\left(1+\tau\right)\left(\sqrt{f\gamma}-\sqrt{1-\tau}\right)}. \tag{4}$$

2.2 Reference Pricing

Consider an exogenous reference price r with $p_b, p_\beta > r$. Copayments are given as $c_b^r = \gamma r + p_b^r - r$ and $c_\beta^r = \gamma r + p_\beta^r - r$. Inverse demand is given as $p_b^r = 1 + r\left(1-\gamma\right) - q_b - \left(1-\tau\right)Q_\beta$ and $p_\beta^r = 1 - \tau + r\left(1-\gamma\right) - \left(1-\tau\right)q_b - \left(1-\tau\right)Q_\beta$.

In the second stage, firms maximize $\pi_b = x$ and $\pi_{\beta_i} = x$. Assuming symmetry, quantities are $q_b = \frac{1+n\tau+r(1-\gamma)}{(n(1+\tau)+2)}$ and $q_\beta = \frac{1-\tau+r(1-\gamma)(1+\tau)}{(1-\tau)(n(1+\tau)+2)}$.

In the first stage, the number of parallel trader is determined by the zero-profit condition:

$$n = \frac{1}{1+\tau}\left(\frac{1-\tau+r\,(1-\gamma)\,(1+\tau)}{\sqrt{f\,(1-\tau)}} - 2\right). \tag{5}$$

Equilibrium quantities are

$$q_b = \frac{\tau+\sqrt{f\,(1-\tau)}}{1+\tau},\ q_\beta = \frac{\sqrt{f}}{\sqrt{1-\tau}}, Q_\beta = \frac{1-\tau+r\,(1-\gamma)\,(1+\tau)-2\sqrt{f\,(1-\tau)}}{1-\tau^2}. \tag{6}$$

Drug prices are

$$p_b = \frac{\left(\tau+\sqrt{f\,(1-\tau)}\right)}{1+\tau},\ p_\beta = \sqrt{f\,(1-\tau)}. \tag{7}$$

The market share of the parallel import is

$$\chi_\beta = \frac{Q_\beta}{Q_\beta+q_b} = \frac{\left((1-\tau+r\,(1-\gamma)\,(\tau+1))-2\sqrt{f\,(1-\tau)}\right)}{(1+\tau)\left(1-\tau+r\,(1-\gamma)-\sqrt{f\,(1-\tau)}\right)}. \tag{8}$$

Proposition 1 summarizes the effect of reference pricing on competition by parallel traders:

Proposition 1 *An exogenous reference price r that is binding for both versions of the drug and sufficiently high ($r \geq \widehat{r_n}$, $\widehat{r_{\chi_\beta}}$) increases the number of parallel traders, i.e., $\Delta n = n^r - n > 0$, and increases the market share of the parallel import, i.e., $\Delta\chi_\beta = \chi_\beta^r - \chi_\beta > 0$.*

Proposition 2 summarizes the effect of a change in the reference price on competition by parallel traders:

Proposition 2 *A decrease in the reference price decreases the number of parallel traders ($\frac{\partial n^r}{\partial r} > 0$) and decreases the market share of the parallel import ($\frac{\partial \chi_\beta^r}{\partial r} > 0$).*

3 Institutional Background

The German pharmaceutical market had a volume of € 38 bn. in 2015 (German Pharmaceutical Industry Association, 2016). In 2016, roughly 47,000 prescription drugs were listed for reimbursement in Germany (German Pharmaceutical Industry Association, 2016). The share of parallel imports in pharmacy market sales was 9% in 2015 (EFPIA, 2017).

In Germany, reference pricing was introduced in 1989. Reference price groups and reference prices are determined in a two-stage procedure: The Federal Joint Committee (*Gemeinsamer*

Bundesausschuss), a self-regulatory association with representatives of the statutory health insurances, physicians, and hospitals, defines reference price groups. Groups can be defined for drugs with the same active substance, drugs with pharmacologically and therapeutically comparable active substances, and drugs with therapeutically comparable effects (§35 (1), Social Insurance Code Vol 5). Then the National Association of Statutory Health Insurance Funds (*Spitzenverband der Gesetzlichen Krankenversicherung*) sets a reference price. Reference prices should not exceed the highest price of the lower third of the interval between the lowest and the highest price of a standard package. At the same time, at least one fifth of prescriptions and packages should be available at the reference price. (§35 (5), Social Insurance Code Vol 5). The reference prices are reviewed at least once a year and adjusted to changes in the market situation (§35 (5), Social Insurance Code 5), based on prices 12 months prior the revision. Firms cannot foresee revisions, but revisions are announced one quarter before the adjustment (Herr, Stühmeier & Wenzel, 2014).

4 Data and Descriptive Statistics

The panel data set from Insight Health covers all prescription drugs with competition from parallel imports sold in Germany from January 2004 to December 2011. For each drug, the data set contains information on the central pharmaceutical number, 3-digit Anatomical Therapeutic Chemical Classification System code (ATC code), trade name, active ingredient, administration form, package size, defined daily dose (DDD), strength, manufacturer, launch date, dispensing requirements, and the status as import or locally sourced version (and in the latter case the selling firm).

The data set comprises monthly data on sales by pharmacies to consumers (in units and in Euro, at the pharmaceutical manufacturer price), sales by wholesalers to pharmacies (in units), returns from pharmacies to wholesalers (in units), pharmaceutical manufacturer price, pharmacy retail price, and reference price.

An observation is identified by the central pharmaceutical number, representing a product with a certain active ingredient, administration, form, strength, and package size, sold by a certain firm and sold in a certain month.

This paper focuses on on-patent prescription drugs with the status of locally sourced drug or parallel import. The data set contains no information on source countries of parallel imports

or purchase prices of wholesalers. It also provides no information on patent expiration dates.

Reference prices for on-patent drugs have been introduced in 2005. Since then, reference prices have been introduced subsequently in some markets at different points of time. Reference prices usually have been kept constant or have been lowered over time. An exception is in January 2007, when the VAT rate rose in Germany from 16% to 19%. Reference prices have been raised accordingly.

Figure 1 shows the development of reference prices over time in form of an index. For each market, the reference price index is set to 100 at the time of introduction. Each line represents the average index value for all markets in which reference prices were introduced at the same month. As is clearly visible, except for the increase in January 2007 resulting from the VAT increase, the trend of all reference prices is negative.

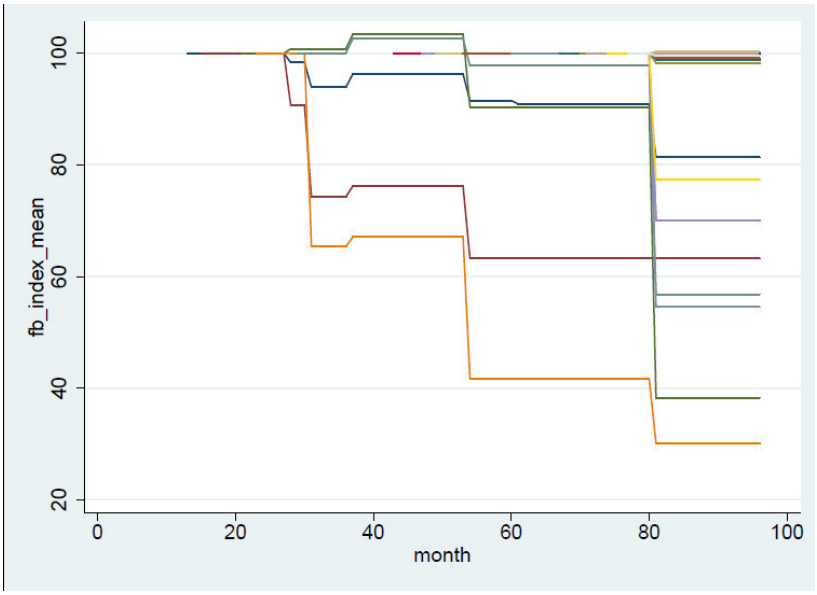

Figure 1: Index of reference prices for markets with the same date of introduction

Only markets of prescription drugs for which reference prices are introduced in the sample are kept for the empirical analysis. Reference prices for on-patent drugs were introduced for the first time in January 2005. Therefore, the sample for the empirical analysis contains only observations beginning in this month. Each market is defined by the active substance, package size, and dose strength. This maps substitution patterns at pharmacies, where locally sourced drugs may be substituted by parallel imports of the same active substance, package size, and dose strength. I include only tablets in the estimation. Thereby I avoid difficulties arising from eventual limited substitutability between tablet and non-tablet products.

The empirical analysis consists of two parts. In the first part, I estimate the effect of the

introduction of reference prices on competition from parallel imports. To analyze the effect of the introduction of reference prices on competition from parallel import, I use an unbalanced panel, where for each market I use observations beginning twelve months before the introduction of the reference price and eleven months after the month in which the reference price is introduced. Therefore, for each market, I use observations of twenty four months around the introduction of the reference price.

5 Empirical Analysis

In order to identify the effect of reference prices on the market share of parallel imports, I estimate the following fixed effects model

$$y_{it} = \alpha + \beta RP_{it} + \rho \mathbf{X}_{it} + \gamma_i + \delta_t + \varepsilon_{it}, \tag{9}$$

where y_{it} is the (log) market share of imported products (in packages or in turnover) or the number of importers in a market i in month t. RP_{it} is either a dummy variable indicating that a reference price for market i at month t exists or it is the (log) reference price for market i in month t. $\mathbf{X}_{it}$ contains a set of characteristics that vary over time (the market size measured in number of packages sold and the number of products in the same ATC3 group), γ_i is a product fixed effect, δ_t is a month fixed effect, and ε_{it} is the error term.

5.1 Introduction of Reference Pricing

Table 1 shows summary statistics for the panel used to analyze the effect of the introduction of reference pricing on parallel imports.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Reference Price	61.766	32.266	14.11	183.59	1817
Number of Importers	1.834	2.272	0	12	3833
Sales Originals	5427.499	11954.398	1	136278	3460
Sales Imports	433.444	653.918	0	6512	1969
Market Share Imports	0.104	0.159	0	1	3470
Number of Products in ATC 3 Group	388.768	262.669	24	663	3833
Market Share Imports Weighted by Prices	0.274	0.199	0	0.999	3460

In some markets, reference prices change within this time span. In these markets, I only use

observations before the change in reference prices to focus on the effect of the introduction of the reference price (and not on the change in reference prices).

The main empirical results for the effect of the introduction of the reference price on the market share of parallel imports are summarized in Table 2. In this specification, market size and market shares are measured in units.

Table 2: Market Shares

	(1)	(2)	(3)
	Market Share Imports	Market Share Imports	Market Share Imports
Dummy Reference Price	0.854***	0.751**	0.785***
	(0.000)	(0.001)	(0.001)
Market Size		-0.230	-0.229
		(0.208)	(0.206)
Number of Products in ATC3 Group			0.0299
			(0.254)
Constant	-2.158***	-0.867	-13.59
	(0.000)	(0.519)	(0.216)
N	1961	1951	1951
R^2	0.240	0.252	0.252

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The dummy variable indicating the introduction of a reference price in a market a has a positive sign in all specifications of this estimation. The introduction of reference prices has a positive and quite substantial effect. Since I use the natural logarithm of market shares in my estimations, the coefficient of the dummy is to be interpreted as semielasticity. The introduction of reference prices has increased the market share of parallel imports by 75% to 85%. Since all specifications include month fixed effects, this is not a result of a time trend. Since I use only observations in markets where a reference price is introduced, the estimation result cannot be caused by the possibility that market shares for parallel imports are in general higher in markets where a reference price is introduced (compared to other markets).

The coefficient for the market size (measured by packages sold in each market in each month) has a negative sign. The market share of parallel imports seems to be lower in larger markets. However, the estimated coefficient is not statistically significant. The estimated coefficient for the number of products in the same ATC3-group is small and positive. However, it also is statistically not significant.

The main empirical results for the effect of the introduction of the reference price on the number of importers are summarized in Table 3.

The dummy variable indicating the introduction of a reference price in a market has a

Table 3: Number of Importers

	(1) Number of Importers	(2) Number of Importers	(3) Number of Importers
Dummy Reference Price	0.548***	0.512***	0.504***
	(0.000)	(0.000)	(0.000)
Market Size		0.0257	0.0255
		(0.712)	(0.714)
Number of Products in ATC3 Group			-0.00714
			(0.532)
Constant	0.796***	0.709	3.753
	(0.000)	(0.183)	(0.434)
N	1969	1959	1959
R^2	0.353	0.360	0.360

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

positive sign in all specifications of this estimation. The introduction of reference prices has a positive and substantial effect on the numbers of importers. The number of importers is measured in natural logarithms, the coefficient of the dummy captures the semielasticity. The introduction of reference prices has increased the number of importers on average by 50% to 54%. The market size (measured in units) has a small but positive effect on the number of importers. However, the coefficient is not statistically significantly different from zero. The number of products in the same ATC3-group has a very small negative effect, but is also not statistically significantly different from zero.

5.2 Changes of Reference Prices

Reference prices change over time in many markets. The trend of decreasing reference prices increase the strictness of regulation and therefore may change the incentives for parallel importers to compete with local incumbents.

To analyze the effect of changes in reference prices on the market share of parallel imports or the number of importers, I use only observations in each market beginning with the introduction of the reference price. This results in an unbalanced panel with different entry dates.

Table 4 presents summary statistics for the sample in this sample.

Table 5 summarizes the effect of the magnitude of reference prices on the (log) market shares of imports.

The reference price and the market share are measured in natural logarithms. Therefore, the coefficient for the (log) reference price captures the elasticity. A decrease in the reference price

Table 4: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Reference Price	57.361	30.703	10.79	190.83	10121
Number of Importers	3.513	4.108	0	28	10121
Sales Originals	4859.451	8393.835	1	73045	9927
Sales Imports	517.482	843.133	0	8000	6997
Market Share Imports	0.155	0.202	0	1	10025
Number of Products in ATC3 Group	371.208	250.835	24	663	10121
Market Share Imports Weighted by Prices	0.306	0.215	0	0.999	9927

Table 5: Market Shares

	(1) Market Share Imports	(2) Market Share Imports	(3) Market Share Imports
Reference Price	1.100*	1.467***	1.166**
	(0.043)	(0.001)	(0.005)
Market Size		-0.750***	-0.799***
		(0.000)	(0.000)
Number of Products in ATC3 Group			0.150***
			(0.000)
Constant	-6.244**	-2.245	-66.08***
	(0.004)	(0.170)	(0.000)
N	6992	6894	6894
R^2	0.0643	0.140	0.162

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

by one percent decreases the market share of parallel imports by 1.1% to 1.4%. The estimated coefficient is statistically significantly different from zero at least at the five percent level in all specifications. This coefficient may be interpreted as the effect of a change in the reference price. I employ product fixed effects. Therefore, the coefficient for the reference price does not simply capture the difference between markets with a high reference price compared to markets with a low reference price.

The market size decreases the market share of parallel imports with an elasticity of -0.7 to -0.79. The number of products in the same ATC3-group has a positive effect on the market share of parallel imports. The estimated elasticity is 0.15. All controls are statistically significant at the 0.1 percent level.

The results for the number of importers are shown in Table 6.

A decrease in the reference price by one percent decreases the number of importers by 0.91% to 1.2%. The estimated coefficient is statistically significant at the 0.1 percent level. The market size has a small but negative impact on the number of importers. However, the

Table 6: Number of Importers

	(1) logimporterno	(2) logimporterno	(3) logimporterno
Reference Price	0.978***	1.021***	0.915***
	(0.000)	(0.000)	(0.000)
Market Size		-0.0170	-0.0341
		(0.835)	(0.668)
Number of Products in ATC3 Group			0.0532***
			(0.000)
Constant	-2.094**	-2.099*	-24.75***
	(0.002)	(0.013)	(0.000)
N	6997	6899	6899
R^2	0.232	0.248	0.257

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

estimated coefficient is not statistically significant. The number of the same products in the same ATC3-group has a very small but significant impact on the number of importers.

6 Robustness

In this section, I show whether the estimation results are robust to different specifications of the empirical model. In the main estimations, market size and market shares are measured in packages sold. If market shares are measured by units weighted by prices, the results do not change considerably. The results of this modified estimations for the introduction of the reference price is shown in Table 7. The direction and the magnitude of the effect of the introduction of reference prices is similar to the original estimation based on packages. The same holds for the estimated effect of changes in the reference price on the market share of parallel imports as shown in Table 8.

In the time span of the sample, the VAT rate for pharmaceuticals in Germany rose from 16% to 19%. Reference prices have been increased parallel to the VAT increase. To rule out the possibility that this has had an effect on market shares, I have calculated reference prices net of VAT. The effects of these net reference prices are identical to the real reference prices as shown in Table 9 for market shares and in Table 10 for the number of parallel importers.

If markets are defined only by active substance and dose strength, then less but larger markets are considered. Compared to the original estimations, the results change to a small extend. Results for the effect of the introduction of a reference price on market shares are shown in Table 11. The sign of the estimated coefficient is still positive. The magnitude of the coefficient

differs from the original estimation. In the specification without control variables (first column), the magnitude is slightly lower compared to the original estimation. In specifications that include control variables (second and third column), however, the magnitude of the coefficient is larger compared to the original estimation. The market size in this specification has a positive effect (compared to a negative effect in the original estimation) on the market share of parallel imports.

With respect to the number of parallel importers the wider market definition does not change a lot. Size and significance of the estimated coefficient for the dummy indicating the introduction of a reference price are similar to the original estimation.

In the wider market definition, the effect of a change in the reference price on market shares of parallel imports is much higher in magnitude compared to the original estimation. But still, the direction of the effect remains the same. Also the effect of a change in reference prices on the number of importers is stronger for the wider market definition. Irrespective of which market definition is considered to be the better one, the main results of the theoretical model are confirmed by the estimations.

7 Conclusion

In this paper I have studied the effect of the reference pricing on competition by parallel imports, in particular the market share of parallel imports and the number of parallel traders. First, I have analyzed the effect of reference pricing on competition by parallel imports in a vertical differentiation model with a locally sourced version and a parallel import offered by n identical parallel traders. Second, I have explored the effect of reference pricing on competition by parallel imports using a data set with prescription drugs with competition from parallel imports. Both the model and estimation results suggest that decrease in the reference price decreases the market share of the parallel import and the number of parallel traders.

These results suggest that stricter regulation in destination countries of parallel imports may weaken competition from parallel imports. Policy makers face a trade off between reducing drug price by lowering reference prices and promoting competition by parallel imports.

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Appendix A

Introduction of Reference Pricing

$\Delta n = n^r - n = \frac{1}{\tau+1}\left(\frac{(1-\tau+r(1-\gamma)(\tau+1))}{\sqrt{f(1-\tau)}} - \frac{\sqrt{1-\tau}}{\sqrt{f\gamma}}\right) > 0,$
if $r > \widehat{r_n} = \frac{1-\tau}{(\gamma+\sqrt{\gamma})(1+\tau)}$.
$\Delta\chi_\beta = \chi_\beta^r - \chi_\beta =$
$\frac{\Psi}{(1+\tau)(1-\tau-f\gamma)\left((1-\tau+r(1-\gamma))^2-(1-\tau)\right)},$
with $\Psi = r\tau\left(1-\gamma\right)\left(1-\tau\right)\left(1-\tau+r\left(1-\gamma\right)\right) - f\left(1-\gamma\right)\left(1-\tau\right)\left(1-\tau-r\gamma\left(2-\tau\right)-r^2\gamma\left(1-\gamma\right)\right)$
$-\sqrt{f\left(1-\tau\right)}\left(1-\tau\right)\left(1+r\left(1-\gamma\right)\right)\left(1-\tau-f\gamma\right) + \sqrt{f\gamma\left(1-\tau\right)}\left(\left(1-\tau+r\left(1-\gamma\right)\right)^2 - f\left(1-\tau\right)\right)$
$\Delta\chi_\beta > 0,$
if $r > \widehat{r_{\chi_\beta}} = \frac{\sqrt{f(1-\tau)}(1-\tau)(1-\tau-f\gamma)-2\sqrt{f\gamma(1-\tau)}(1-\tau)-f\gamma(1-\tau)(2-\tau)-\tau(1-\tau)^2+\sqrt{\Omega}}{2(1-\gamma)(1-\tau)(\tau+f\gamma)+2\sqrt{f\gamma(1-\tau)}(1-\gamma)},$
with $\Omega = \tau^2\left(1-\tau\right)^4 + f\left(1-\tau\right)^3\left(\left(1+\tau\right)^2 - 2\tau^2\gamma\right) + f^2\gamma\left(1-\tau\right)^2\left(6-\tau^2\left(2-\gamma\right)\right)$
$+f^3\gamma^2\left(1-\tau\right)^3 + 2\tau\sqrt{f\left(1-\tau\right)}\left(1-\tau\right)^2\left(1+\tau+f\gamma\right)\left(1-\tau-f\gamma\right)$
$+4f\sqrt{f\gamma\left(1-\tau\right)}\left(1-\tau\right)^2\left(1+\tau+f\gamma\right) + 4\tau\sqrt{f\gamma\left(1-\tau\right)}\sqrt{f\left(1-\tau\right)}\left(1-\tau\right)\left(1-\tau-f\gamma\right).$

Decrease in Reference Price

$\frac{\partial n^r}{\partial r} = \frac{(1-\gamma)}{\sqrt{f(1-\tau)}} > 0.$
$\frac{\partial \chi_\beta^r}{\partial r} = \frac{(1-\tau)(1-\gamma)\left(\tau+\sqrt{f(1-\tau)}\right)}{(1+\tau)\left(1-\tau+r(1-\gamma)-\sqrt{f(1-\tau)}\right)^2} > 0.$

Appendix B

Table 7: Market Shares Weighted by Prices

	(1) Market Share Imports	(2) Market Share Imports	(3) Market Share Imports
Dummy Reference Price	0.716**	0.617**	0.653**
	(0.002)	(0.006)	(0.005)
Market Size		-0.231	-0.230
		(0.210)	(0.208)
Number of Products in ATC3 Group			0.0321
			(0.220)
Constant	-2.038***	-0.770	-14.44
	(0.000)	(0.569)	(0.190)
N	1961	1951	1951
R^2	0.239	0.250	0.251

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Market Shares Weighted by Prices

	(1) Market Share Imports	(2) Market Share Imports	(3) Market Share Imports
Reference Price	1.030*	1.387***	1.071**
	(0.046)	(0.001)	(0.007)
Market Size		-0.734***	-0.786***
		(0.000)	(0.000)
Number of Products in ATC3 Group			0.158***
			(0.000)
Constant	-6.028**	-2.111	-69.29***
	(0.003)	(0.192)	(0.000)
N	6992	6894	6894
R^2	0.0630	0.136	0.160

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Market Shares

	(1) Market Share Imports	(2) Market Share Imports	(3) Market Share Imports
Reference Price Net of Taxes	1.100*	1.467***	1.166**
	(0.043)	(0.001)	(0.005)
Market Size		-0.750***	-0.799***
		(0.000)	(0.000)
Number of Products in ATC3 Group			0.150***
			(0.000)
Constant	-6.053**	-1.990	-65.87***
	(0.003)	(0.209)	(0.000)
N	6992	6894	6894
R^2	0.0643	0.140	0.162

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Number of Importers

	(1) Number of Importers	(2) Number of Importers	(3) Number of Importers
Reference Price Net of Taxes	0.978***	1.021***	0.915***
	(0.000)	(0.000)	(0.000)
Market Size		-0.0170	-0.0341
		(0.835)	(0.668)
Number of Products in ATC3 Group			0.0532***
			(0.000)
Constant	-1.924**	-1.921*	-24.59***
	(0.003)	(0.019)	(0.000)
N	6997	6899	6899
R^2	0.232	0.248	0.257

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: Market Shares

	(1) Market Share Imports	(2) Market Share Imports	(3) Market Share Imports
Reference Price	0.774*	1.068**	1.068**
	(0.015)	(0.003)	(0.002)
Market Size		0.439	0.439
		(0.240)	(0.238)
Number of Products in ATC3 Group			0.000410
			(0.991)
Constant	-3.759***	-7.600*	-7.775
	(0.000)	(0.024)	(0.597)
N	736	736	736
R^2	0.346	0.354	0.354

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: Number of Importers

	(1) Number of Importers	(2) Number of Importers	(3) Number of Importers
Reference Price	0.525***	0.649***	0.629***
	(0.000)	(0.001)	(0.000)
Market Size		0.185	0.183
		(0.421)	(0.426)
Number of Products in ATC3 Group			-0.0171
			(0.397)
Constant	1.173***	-0.445	6.856
	(0.000)	(0.823)	(0.361)
N	740	740	740
R^2	0.434	0.440	0.441

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13: Market Shares

	(1) Market Share Imports	(2) Market Share Imports	(3) Market Share Imports
Reference Price	1.433	2.512***	2.127**
	(0.063)	(0.001)	(0.004)
Market Size		-1.074***	-1.124***
		(0.000)	(0.000)
Number of Products in ATC3 Group			0.170*
			(0.028)
Constant	-8.503*	-3.672	-74.31*
	(0.013)	(0.105)	(0.018)
N	2641	2631	2631
R^2	0.0749	0.183	0.206

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 14: Number of Importers

	(1) Number of Importers	(2) Number of Importers	(3) Number of Importers
Reference Price	1.416***	1.683***	1.564***
	(0.000)	(0.000)	(0.000)
Market Size		-0.281*	-0.296*
		(0.024)	(0.018)
Number of Products in ATC3 Group			0.0528
			(0.068)
Constant	-3.424*	-2.085	-23.96*
	(0.013)	(0.132)	(0.041)
N	2642	2632	2632
R^2	0.252	0.275	0.282

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$