Parallel Imports and a Mandatory Substitution Reform

*A Kick or A Muff for Price Competition in Pharmaceuticals?**

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Abstract

What has been the effect of competition from parallel imports on prices of locally-sourced on-patent drugs? Did the 2002 Swedish mandatory substitution reform increase this competition? To answer these questions, we carried out difference-in-differences estimation on monthly data for a panel of all locally-sourced on-patent prescription drugs sold in Sweden during the 40 months from January 2001 through April 2004. On average, facing competition from parallel imports caused a 15-17% fall in price. While the reform increased the effect of competition from parallel imports, it was only by 0.9%. The reform, however, did increase the effect of therapeutic competition by 1.6%.

JEL Classification: I11, L51, L65.

Keywords: parallel imports; pharmaceutical drugs; price competition; reference pricing; therapeutic competition.

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Introduction

During the period 1998-2008, average annual real growth in pharmaceutical spending has exceeded that in overall health spending in the EU (OECD, 2010). The largest part of pharmaceutical spending, about 50%[1], is for on-patent locally-sourced drugs, i.e. drugs with patent protection that are directly supplied by the manufacturer via authorized wholesalers. Until the patent expires and generics enter the market – unless parallel trade is allowed – these drugs are only subject to competition from therapeutic alternatives with different active substances but similar therapeutic effects. We here analyze the price-effects of competition from parallel imports and the effects of a mandatory substitution reform on the intensity of such competition in the case of Sweden.

Parallel imported drugs are legally produced goods bought in low price countries for resale in high price countries without the authorization of the patent holder.[2] They have the same active ingredient in the same amount and the same dosage form (e.g., tablet or capsule) as the locally-sourced drugs. However, they might differ in packaging as, depending on the requirement of the importing country, they might be repackaged or relabeled, and the brand name might even differ slightly.

Medical insurance is likely to reduce the price competition in pharmaceuticals by making consumers less price sensitive. To counteract this, substitution policies, giving the right to or obliging the pharmacists to substitute the prescribed drug with a cheaper alternative, have been introduced in many European countries, namely Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, The Netherlands, Poland, Portugal, Spain, Sweden and Turkey (Dylst, Vulto, and Simoens, 2012), and all American states (Vivian, 2008). These are intended to make consumers react more to prices, decreasing cost both directly, as prescribed drugs are replaced with cheaper versions, and indirectly, through increased price competition.

[1] Own calculations based on the data used in this study.

[2] Parallel imports have considerable market shares ranging from ~8% to ~28% in 2006 with an average of 18.40% in key destination countries in Europe namely UK, Sweden, Denmark, Germany, Netherlands, and Norway (Kanavos and Kowal, 2008).

Sweden introduced a mandatory substitution reform in October 2002, requiring pharmacists to dispense, with the consent of the consumer, the cheapest available generic or parallel-imported drug, unless the prescribing physician opposed substitution for medical reasons (Ministry of Health and Social Affairs, 2002). The reform brought in a special form of "reference pricing", whereby drugs with the same active substance – e.g., an off-patent drug and its generics, or an on-patent drug and its parallel imported versions – are grouped together and the price of the cheapest drug in each group is set as the reference price for reimbursement. Maximum reimbursement is fixed at a percentage of the reference price, but the amount consumers actually pay depends on which drug they buy. Consumers who choose a drug with the reference price pay only a certain copayment, while consumers who choose a drug with a higher price still pay that copayment but, in addition, also pay the full price difference.

Despite the attention that substitution reforms and reference pricing have received[3], there have been, to the best of our knowledge, no empirical studies on how they affect competition from parallel imports. This paper attempts to fill this gap. There is, however, a theoretical paper by Köksal (2009) showing that reference pricing should increase price competition from parallel imports. The theoretical literature regarding parallel trade also includes Pecorino (2002), Ganslandt and Maskus (2004), Maskus and Chen (2004), Jelovac and Bordoy (2005), and Chen and Maskus (2005), which show, among other things, that parallel imports should create price competition and cause prices to fall in the destination country. The empirical literature about the effects of competition from parallel imports is limited to Ganslandt and Maskus (2004), Kanavos and Costa-Font (2005), Kanavos and Vandoros (2010), Kyle (2011) and Duso et al. (2014), none of them addressed reference pricing or substitution reforms in general.

Ganslandt and Maskus (2004) used Swedish data from 1994-1999 to study the effect of competition from parallel imports on the prices of the 50 molecules with largest sales values. Using instrumental variable method to account for potential endogeneity in the entry decisions of

[3] Theoretical literature on reference pricing includes Mestre-Ferrandiz (2003), Brekke et al. (2007), Miraldo (2009); empirical literature on reference pricing and substitution reforms includes Aronsson, Bergman, and Rudholm (2001), Pavcnik (2002), Bergman and Rudholm (2003), Buzzelli et al. (2006), Puig-Junoy (2007), Kanavos et al. (2008), Brekke et al. (2009), Granlund (2010), Granlund and Rudholm (2011), Kaiser et al. (2014). The survey of studies on the effect of the introduction of reference pricing policies concludes that reference pricing was generally associated with a decrease in the prices of the drugs subject to the policy (Galizzi, Ghislandi, and Miraldo, 2011).

parallel traders, they found that competition from parallel imports reduced prices by 12-19%. Using data on 30 countries and OLS estimations, Kyle (2011) examined the effect of both potential and actual entry of parallel imports on prices of locally-sourced drugs, and reported that prices were reduced by a few percent. Focusing on the German market for oral anti-diabetics Duso et al. (2014) found that parallel imports reduces the prices of brand-name drugs by 11%. On the other hand, Kanavos and Costa-Font (2005) and Kanavos and Vandoros (2010) estimated the effect of the market share of parallel imports on price competition and found no statistically significant effect.

In this paper, we identify the effects of competition from parallel imports and how these effects were influenced by the mandatory substitution reform using difference-in-differences estimation. Following Ganslandt and Maskus (2004), we also used instrumental variable estimation to address potential endogeneity in the entry decisions of parallel traders. The analyses were carried out using a product level panel dataset covering all locally-sourced on-patent prescription drugs sold in Sweden during January 2001 through April 2004. Since on-patent drugs constitute the largest group of drugs among the drugs facing competition from parallel imports and since the effect of facing competition from parallel imports is likely largest for these drug, we focus on on-patent drugs by excluding off-patent drugs facing generic competition from the analysis. This study adds to the limited knowledge of competition from parallel imports by analyzing how the price effect of competition from parallel imports is affected by a mandatory substitution reform as well as how this effect depends on the length of time the parallel imports have been available in the market. The dataset also allowed us to control for competition from therapeutic alternatives – drugs with different active ingredients but similar therapeutic effects in treating a particular disease – including indirect generic competition from off-patent therapeutic alternatives themselves facing generic competition.

The present study thus complements Ganslandt and Maskus (2004) by controlling for both "therapeutic competition" (inter-brand competition) and "indirect generic competition" (intra-brand competition), as well as by analyzing a period when parallel trade had been legal in Sweden for many years (it became legal when Sweden joined the EU in 1995) and investigating a somewhat different segment of the market. We restricted our attention to on-patent drugs, but

not just to big sellers. Like Ganslandt and Maskus (2004), we confined our analyses to the price-effects of facing competition from parallel imports; that is, for example, we did not analyze entry and exit decisions of parallel traders, or how those decisions might have been affected by the mandatory substitution reform.

We found that facing competition from parallel imports caused prices of locally-sourced drugs to fall on average with 15-17%. The mandatory substitution reform increased this effect causing prices to fall further, but only by one percentage point. The full effect of competition from parallel imports was not realized immediately, but instead prices kept decreasing over time.

Our analysis has implications for the effect of reform on therapeutic competition as well. Facing therapeutic competition caused prices to fall on average 1.4% and the mandatory substitution reform increased the effect of therapeutic competition by 1.6 percentage points. The effect of therapeutic competition depended on whether the therapeutic alternatives were subject to generic competition. Facing therapeutic competition led to a statistically significant decrease in prices if the therapeutic alternatives were themselves subject to generic competition. The mandatory substitution reform increased this fall, indicating that the reform increased the effects of generic competition.

The next section, consisting of two sub-sections, presents the institutional structure of the Swedish pharmaceutical market, focusing first on reimbursement for prescription drugs and the implications of mandatory substitution reform in this regard, and then on price setting and distribution of pharmaceuticals. The following section provides an overview of the dataset including descriptive statistics. A section then explains the empirical strategy based on which the econometric analysis is carried out, followed by a section which reports and discusses the estimation results. Finally, the last section summarizes and concludes the paper.

The Institutional Structure of the Swedish Pharmaceutical Market

Reimbursement and Mandatory Substitution Reform

All Swedish residents are covered by a mandatory and uniform pharmaceutical benefit scheme where the coinsurance rate is a decreasing function of pharmaceutical cost and reaches zero when the costs exceed SEK 4300 during a 12 month period. During the study period, about 70% of total pharmaceutical costs were borne publicly, specifically by the 21 county councils (Köping Höggård and Redman, 2007; National Board on Health and Welfare, 2006). The county councils – also responsible for providing health care – are required to have at least one "drug and therapeutic committee", the purpose of which is to promote safe and cost effective use of pharmaceuticals, e.g., by writing recommendations to physicians regarding choices of pharmaceuticals (Anell and Persson, 2005).

Reference pricing was introduced as reimbursement scheme in Sweden in 1993. Each off-patent drug and its generics were grouped together, with substitution allowed only within groups. A reference price was set for each group at 110% of the price of the cheapest available drug within the group, usually a generic. Costs exceeding the reference price were not included in the maximum annual copayment limit (RFFS 1992:20, 1996:31). Thus consumers who bought an expensive drug had to pay the entire difference between it and the reference price, in addition to a certain percentage (the coinsurance rate) of the reference price.

This reference price system was reformed with the introduction of mandatory substitution in October 2002. The rule for setting the reference price was changed so that it now was set at 100% of the price of the cheapest available drug within the group. Still drugs with the same active ingredient are grouped together, but since October 2002 on-patent drugs and their parallel imported versions are also part of the reference price system (SOU 2000:86, Medical Products Agency, 2002).[4] The reform made substitution compulsory within the group of interchangeable drugs, requiring pharmacists to inform consumers of such drugs and to dispense the cheapest available generic instead of the off-patent brand-name drug, or the parallel import instead of the locally-sourced on-patent brand-name drug (with the consent of the consumer) unless the prescribing physician prohibited the substitution for medical reasons.[5] The pharmacist must also

[4] Läkemedelsverket – The Medical Products Agency (MPA) – defines a product as a substitute if it has the same active substance, strength, and form (e.g., pills or fluid) as the prescribed product, and if its package size is approximately the same as that of the prescribed one.

[5] If the physician prohibits the substitution for medical reasons, the consumer is still reimbursed based on the full

inform consumers that they can buy the more expensive prescribed drug instead of the cheapest substitute if they pay the difference.

The reform makes pharmacists substitute the available cheapest alternative within the reference price system where there had previously been no incentive for pharmacists to initiate substitution. Before the reform, Apoteket AB – the National Corporation of Swedish Pharmacies – recommended that pharmacists dispense parallel imported drugs only if the responsible drug and therapeutic committee had not recommended differently and if the prescribing physician had only written the name of the drug and thus had not specified either a locally-sourced package or a parallel import; and those committees only recommended dispensing parallel imports that had a record of reliable supply (Persson, Anell and Persson, 2001).

Three characteristics of the mandatory substitution reform may have contributed to making consumers more price sensitive, resulting in increased substitution and hence stronger price effects of facing competition from exchangeable substitutes. The reform lowered the transaction cost of substitution, since previously it had been recommended that physicians be contacted first if they had not explicitly consented to substitution on the prescription. Then, when substitution is offered (as it always should be after the reform), consumers gain information about the availability of cheaper substitutes, which might enhance their willingness to switch. Finally, only costs up to 100% of the cheapest substitutable product are now covered, compared with 110% previously. For these reasons, we expect the reform to increase the effect of competition from parallel imports resulting in lower prices.

Price Setting and Distribution

Pharmaceutical manufacturers, getting approval from the Medical Products Agency (MPA) to sell their products in Sweden, are free to set their own prices, but in order to be included in the pharmaceutical benefits scheme the prices must then be approved by Läkemedelsförmånsnämnden (LFN) – the Pharmaceutical Benefits Agency. Once included in the pharmaceutical benefits scheme by LFN, applications for price increases are required to

price of the more expensive prescribed drug. Physicians only prohibited substitution for a few percent of the prescriptions (Granlund, 2009).

include motivations for the price increase as well as information about the prices and treatment costs of comparable drugs (RFFS 1996:31, LFNFS 2003:1). If the requested price is the same as or less than the price of the most expensive substitutable product in the reference group, no motivation is needed and the price increase is always accepted (LFNAR 2006:1). Even though a locally-sourced brand name drug faces competition from parallel imports, the authority might still allow a price increase, since the supply of parallel imports is limited, and sometimes unreliable. If the drug would be removed from the market unless the price increase were approved and if supply of parallel imports was limited, patients would then face the risk of remaining untreated.

Unlike the regulations before the mandatory substitution reform (RFFS 1996:31), the regulations after the reform (LFNFS 2003:1) clearly state that the authority, the Pharmaceutical Benefits Agency, should consider marginal benefits and marginal costs of a drug when deciding whether or not to include it in the reimbursement scheme at the requested price. Hence competition between therapeutically equivalent drugs should be fiercer after the reform, not because of more price sensitive consumers – since the reform didn't allow substitution between therapeutic alternatives – but because of the requirement that marginal benefits and marginal costs should be considered to be included in the reimbursement system.

Retail pharmacies are the only legal entities in Sweden to dispense prescription drugs for outpatient care. Throughout the study period, all pharmacies were owned by the government monopoly, Apoteket AB – the National Corporation of Swedish Pharmacies – which paid and charged uniform prices nationwide for each drug.

Overview of the Data

The study is based on a panel-data set, compiled by IMS Sweden, covering all prescription drugs sold in Sweden during 1992-2007. An observation in the dataset represents a product with a certain active ingredient, strength, form, and package size, supplied by a certain firm and sold in a certain month (though only quarterly data for 1992-1994). For each observation the dataset

includes information about whether the product is brand-name or generic, locally-sourced or parallel imported, as well as total units sold and the total value.

In order to efficiently isolate the effect of the 2002 mandatory substitution reform on competition from parallel imports, only data from January 2001 through April 2004 was used. Using older data, due to adjustments to the existence of parallel imports, might have distorted the estimations. Parallel imports were allowed starting in 1995 when Sweden joined the European Union, but their extent was very limited the first two years, and Ganslandt and Maskus (2004) expressed the belief that the market was not in long-run equilibrium even at the end of their study period, in 1998. Data after April 2004 was not used since 10 countries – new potential source countries for parallel imports – joined the EU in May 2004.

The empirical analysis focuses only on locally-sourced on-patent prescription drugs. Off-patent and parallel imported drugs were used to create the relevant variables for the analysis but were excluded in the final dataset. No information on the dates of patent expiration was available. Instead, we defined pharmaceuticals as off-patent starting the first time any generic with the same active ingredient was sold in Sweden.

Table 1 about here

Table 1 presents the variables used in the econometric analysis and the descriptive statistics on the data which includes a total of 102,235 observations for 3,339 on-patent prescription drugs with different active ingredient, strength, form, and package size. The variable ln p_{it} is the natural logarithm of the wholesale price of the on-patent locally-sourced product *i* in month *t*, deflated by consumer price index. $Picomp_{it}$ is an indicator for whether drug i in month *t* is subject to competition from parallel imports (hereafter pi-competition) and takes the value one if a parallel imported drug with the same active substance (i.e., 7-digit ATC code), strength, and form (e.g. pill or fluid) as drug *i* is sold in Sweden in month *t*. Since, for example, a 100-pill package can substitute for two 50-pill packages, it is not required that the parallel import be of the same package size as the locally-sourced drug. Mpi_{it} is defined as the number of months drug *i* had faced competition from parallel imports before month *t*. $Thcomp_{it}$ is a dummy controlling for whether a drug has any therapeutic competitors, $Nthcomp_{it}$ is the number of therapeutic

competitors and $Thgencomp_{it}$ is the share of drug i's therapeutic competitors facing generic competition.[6] Ref_t is a dummy variable taking the value one for the months after the mandatory substitution reform and the following five variables are interaction variables between Ref_t and the variables mentioned above. $Time_t$ is the number of the month, starting from January 2001, and $Timepi_{it}$ is an interaction variable between this variable and $Picomp_{it}$. The last two variables are used to generate instruments for the instrumental variable regressions: the SEK/Euro exchange rate and the logarithm of the number of months the product has been sold in Sweden (Ln$long_{it}$).[7] Table 2 presents the detailed descriptive statistics of the variables by the two groups of drugs – facing and not facing competition from parallel imports – before and after the reform. It show, among else, that the mean of Mpi_{it} is larger after the reform than before for both groups and for drugs facing pi-competition this difference is large: 7.74. Table 2 also shows that those facing pi-competition, both before and after the reform, are more likely to also face competition from therapeutic alternatives.

Table 2 about here

In 84% of the observations drugs faced therapeutic competition while only in 13% of the observations drugs faced pi-competition (Table 1). Descriptive statistics, not presented in the table, show that 7% of the 3339 different drugs always faced pi-competition while 82% never faced pi-competition, and 5% stopped facing pi-competition while 10% started facing pi-competition during the study-period. Overall the number of drugs facing pi-competition has increased over time (see Figure 1). Since in total 343 drugs, around 10%, changed from facing pi-competition to not facing it and/or vice versa, nearly all that started facing pi-competition experienced at least a month break-off. This explains the turnover pattern presented in Figure 2. For drugs that face pi-competition, the average market share in units for parallel imports is 39%.

Figure 1 and 2 about here

[6] Following Brekke et al. (2009) and Pavcnik (2002) pharmaceuticals with the same 5-digit ATC code were classified as therapeutic competitors.

[7] In order to be able to take the natural logarithm we defined $Longevity_{it}$ equal to 0.5 the first month a product was sold, and so on. Ln$long_{it}$ is the natural logarithm of a variable truncated at 108.5 months due to lack of older data.

Econometric Analysis

Difference-in-differences estimation was used to identify the effects of competition from parallel imports on prices of locally-sourced drugs and how these effects were influenced by the 2002 mandatory substitution reform. The effects of facing pi-competition were identified by comparing changes in prices of drugs that gained or lost pi-competition with those of drugs that did not face changes in pi-competition. The effect of the reform was identified by comparing the price-effects of changes in pi-competition before the reform with those after, as well as by comparing differences in prices before and after the reform for drugs that always faced pi-competition with those for drugs that never faced pi-competition.

We included drug specific fixed effects, α_i, to control for fixed differences among individual drugs. For example, the fixed effects control for differences in severity of side effects and other aspects of the drugs themselves that might affect their price. The fixed effects also control for most of the variation in demand across observations, in fact for 87% of the variation in units sold. To control for changes over time that are common to all drugs we included a linear time-trend; a dummy variable taking the value one after the mandatory substitution reform; and dummy variables for calendar months. We also included variables to control for price changes as a result of being subject to pi-competition; number of months a drug had faced such competition; being subject to competition from therapeutic alternatives; number of therapeutic alternatives; and share of therapeutic alternatives facing generic competition. In addition, we allow the time trend for those facing pi-competition to differ from those not facing pi-competition by including the variable $Timepi_{it}$. Then the main specification is

$$\begin{aligned}\ln p_{it} = {} & \beta_1 Picomp_{it} + \beta_2 Mpi_{it} + \beta_3 Timepi_{it} + \beta_4 Ref * Picomp_{it} + \beta_5 Ref * Mpi_{it} \\ & + \beta_6 Thcomp_{it} + \beta_7 Nthcomp_{it} + \beta_8 Thgencomp_{it} + \beta_9 Ref * Thcomp_{it} \\ & + \beta_{10} Ref * Nthcomp_{it} + \beta_{11} Ref * Thgencomp_{it} + \beta_{12} Time_t + \beta_{13} Ref_t \\ & + \sum_{m=2}^{12} \gamma_m Month_i + \alpha_i + \varepsilon_{it}.\end{aligned} \tag{1}$$

The specification was estimated with both fixed-effects OLS and a fixed-effects IV estimator. To check the robustness of the results and to verify what the estimates describe, we also estimated

many other specifications. These specifications and their results are briefly discussed in the Appendix.

The parameters β_1-β_3 describe the effects of competition from parallel imports before the mandatory substitution reform and, together with β_4 and β_5, the effects after the reform. β_1 and β_3 describe the effect of facing pi-competition at all and how this effect changed over time. β_2 shows the effect of the number of months a drug had already faced competition from parallel imports.[8] The identifying assumption for these parameters is that no other variables, except those included in the specification, caused price changes that are correlated with facing competition from parallel imports. Since therapeutic competition can have important effects on prices (Ellison et al., 1997; Lichtenberg and Philipson, 2002; Brekke et al., 2009) and are correlated with pi-competition, we included $Thcomp_{it}$, $Nthcomp_{it}$ and $Thgencomp_{it}$ in the specification as well.[9]

The parameters β_4 and β_5 for the interaction variables describe how the reform has influenced the price effect of competition from parallel imports. A requirement for these parameters to be correctly estimated is that no excluded variable influenced the price effect of facing pi-competition differently before the reform relative to after the reform. This requirement is one important motive for including Mpi_{it} and $Ref*Mpi_{it}$ in the specification. There are several reasons why Mpi_{it} – which is correlated with the reform – could influence prices.[10] First, before the reform, the pharmaceutical committees recommended pharmacists dispense only parallel imports that had a record of reliable supply (Persson, Anell and Persson, 2001). Second, the longer a parallel imported drug had been in the market, the more familiar consumers, physicians, and pharmacists would be with it, making it a stronger competitor for the locally-sourced drug.[11]

[8] Separate effects of Mpi_{it} and $Timepi_{it}$ were identified by data on drugs changing from facing pi-competition to not facing it, or vice versa, at different times during the study period. For the whole sample, the partial correlation between these variables are 0.80, while for drugs that faced pi-competition none or all months of the study-period, Mpi_{it} and $Timepi_{it}$ are perfectly correlated.

[9] The share of drugs facing therapeutic competition is statistically significantly higher among the drugs facing competition from parallel imports than those not facing such competition at all, but the difference is small in size: only 5 percentage points. After removing the effects of the time variables ($Time_t$, Ref_t, $Month_t$,) and the fixed effects, the partial correlation between $Picomp_{it}$ and $Thcomp_{it}$ is not statistically significant. However, there is a statistically significant partial correlation of 0.024 between $Picomp_{it}$ and $Thgencomp_{it}$.

[10] The mean of Mpi_{it} is statistically significantly larger after the reform than before. As shown in Table 2, this difference is large for drugs facing pi-competition.

[11] Ching (2010) provides evidence for the role of consumer learning on the diffusion of generics in the market.

Third, if a parallel import had been sold in Sweden for a long time, without any supply shortages, or even interruptions due to possible strategic response of manufacturers like supply rationing in the source countries, then the price approving authority might consider the parallel import a reliable alternative for the locally-sourced drug and therefore become tougher in its decisions regarding approval of price increases for the locally-sourced drug.

The identifying requirement for the parameters β_4 and β_5 was also the main reason why we included $Timepi_{it}$ in the specification, to capture changes over time in the effect of facing pi-competition not caused by the substitution reform but perhaps by changed consumer attitudes toward parallel imports. $Timepi_{it}$ accounts for the differences in the time trend of drugs subject to pi-competition and drugs not subject to it. Before the reform, the time trend of drugs subject to pi-competition was different from that of drugs not subject to it. Even though the time trend differs between the two groups, the difference in time trend was stable over time, implying that the difference could be captured by $Timepi_{it}$. Lastly, interaction variables between the reform and controls for therapeutic competition were included since, as discussed before, there are reasons to expect that the effects of facing therapeutic competition were increased by the reform.

An obvious problem is that entry decisions of parallel traders are determined by the prices of pharmaceuticals. In other words, the variables controlling for pi-competition might be endogenous, and hence the OLS estimator might be biased. We therefore conducted instrumental variable estimations.

The five possible endogenous variables, $Picomp_{it}$, Mpi_{it}, $Ref*Picomp_{it}$, $Ref*Mpi_{it}$, and $Timepi_{it}$, are all functions of $Picomp_{it}$ and highly correlated; with correlations among the five ranging from 0.54 to 0.91. To overcome the difficulties this creates for finding strong instruments, we first generated instruments, utilizing the fact that Mpi_{it}, $Ref*Picomp_{it}$, $Ref*Mpi_{it}$, and $Timepi_{it}$, are

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Using U.S. aggregated market share data for 14 drugs, he found that the generics' market share would be much larger right after patent expiration if there were no uncertainty at all about the quality of generics and unless it slowly resolves. No such study is done for parallel imports, but using data on on-patent prescription drugs sold in the county of Västerbotten, Sweden, during 2003-2006 (see Granlund and Rudholm (2012) for details of the dataset), we found that patients were statistically significantly less likely to oppose substitution by a parallel import the larger Mpi_{it} was. Controlling for Mpi_{it}, however, the patients became more likely to oppose substitution over time. Since Mpi_{it} is correlated with sales volume of the parallel import, we estimated the fixed-effects IV regression including the market share of parallel imports, but got similar results regarding Mpi_{it}, suggesting that this is not the explanation to its effect.

known functions of $Picomp_{it}$, and then employed a standard 2SLS instrumental variable estimation.[12] To create the instruments, we first employed OLS estimation to explain and predict $Picomp_{it}$, using the exogenous variables, including fixed effects, and a set of basic instruments (explained below). Thus, the endogenous variables Mpi_{it}, $Ref*Picomp_{it}$, $Ref*Mpi_{it}$, and $Timepi_{it}$, was not used in this regression. Drugs with no variation in $Picomp_{it}$ during the study period were not included in this regression since the basic instruments have no predictive power for $Picomp_{it}$ for them, and since the inclusion of fixed effects means that there is no endogeneity problem for them either. Instead, true values were used as predictions for $Picomp_{it}$ for these drugs. Then, the predictions for $Picomp_{it}$, and the exogenous variables Ref_t, and $Time_{it}$, were used to create predictions for Mpi_{it}, $Timepi_{it}$, $Ref*Picomp_{it}$, and $Ref*Mpi_{it}$. Lastly, the predictions for all five possible endogenous variables are used as instruments for their actual values in a 2SLS estimation, using the xtivreg2 command by Schaffer (2010). The results of the regressions used to generate instruments, presented in Table A3, show that the coefficients for both basic instruments have the expected sign. Results of the first stage regressions are presented in Tables A4-A6. These results show that each of the generated instrument, as expected, have positive coefficients for the endogenous variables they are meant to predict, with point estimates in the interval 0.78 to 1.23.

The main advantage of this instrumental variable approach is that it yields robust estimates for the possible endogenous variables. When predicting all endogenous variables directly, the instrument sets were found to be weak for at least one of the possible endogenous variables, resulting in unreliable estimates which were not robust even to small changes in the instrument sets.

We have tested all instrument sets used by Ganslandt and Maskus (2004), except those including prices in other countries, as well as some other instruments, and present results for the strongest basic instruments. We report the full results obtained when using the SEK/Euro exchange rate as basic instrument but also the key results obtained when using the logarithm of the number of months the product had been sold in Sweden ($Lnlong_{it}$), as well as key results obtained when

[12] Wooldridge (2003) suggests that instruments can be generated by interacting predictions of an endogenous variable with exogenous variables and proofs the consistency of the estimator using generated instruments. Wooldridge (2010, pp. 262-268) discusses an example of this approach. For an empirical application, see e.g., Giles and Yoo (2007).

using both the exchange rate and $Lnlong_{it}$ as basic instruments. Both of these basic instruments are versions of instruments used by Ganslandt and Maskus (2004). The SEK/Euro exchange rate is the instrument thought most likely to be exogenous, though $Lnlong_{it}$ should also be exogenous since we controlled for therapeutic competition. Other sets of basic instrument tested include interaction between $SEK/Euro_t$ and sales values in 1995 and transformations of $Lnlong_{it}$.[13]

During the study period, important source countries such as Italy, Greece, and Spain switched to the Euro as currency or fixed their exchange rate towards the Euro. The SEK/Euro exchange rate therefore affected price differences between locally-sourced drugs in Sweden and the source countries, an important determinant for parallel traders' entry decisions. Many parallel importers also have a large part of their transportation and repackaging costs in Euros or currencies with fixed exchange rates towards the Euro. A higher value of $SEK/Euro_t$, i.e. a weaker Swedish currency, is thus expected to reduce parallel importers revenues, all else equal, and therefore to have a negative effect on the probability of a drug facing pi-competition. $Lnlong_{it}$ could also be a good instrument since the probability that a drug is also sold in low price countries increased with the number of months it had been sold in Sweden, and since it takes several months[14] after it was first sold in both Sweden and a source country before parallel traders could establish relevant contacts and get the approval from the Medical Products Agency. Thus, this variable is expected to have a positive effect on the probability of a drug facing pi-competition. We used the natural logarithm since the effect of the number of months on entry of parallel traders was thought likely to decrease. Also, an untransformed variable representing the number of months from first sale would be perfectly correlated with $Time_{it}$ and therefore unusable as an instrument, while the partial correlation between $Lnlong_{it}$ and $Time_{it}$ is 0.31.

Results

[13] As mentioned above, $Lnlong_{it}$ is the natural logarithm of a variable truncated at 108.5 months due to lack of older data. Including a dummy variable for those with a value of 108.5 or higher did not contribute to explaining $Picomp_{it}$, however, so this dummy variable was not included as an instrument.

[14] The chairperson of Läkemedelshandlarna, an association consisting of ten parallel traders, estimates this time to be 1-2 years (source: an email from the chairperson to us on March 13, 2012).

The two main sets of full estimation results are presented in Table 2, while Table 3 presents the key results from regressions with other instruments. All reported coefficients and standard errors in the tables and elsewhere are the estimates multiplied by 100.

Differentials are also presented at the bottom of the Table 2 and in Table 3 describing the average effect of the variables of main interest on prices. The differential dlnP_{it}/d$Picomp_{it}$ was calculated using the estimates for the seven pi-variables as well as the average value of these variables when $Picomp_{it}$ equals one.[15] For the IV estimation (Table 2), the differential indicates that drugs facing pi-competition had 15% lower prices on average compared to what they would have had if they had never faced pi-competition.[16] Similar results were obtained from estimations 3 and 4 (Table 3). That the results from the different IV estimations are that similar, despite that the basic instruments $SEK/Euro_t$ and $Lnlong_{it}$ describe quite different factors that can affect the probability for facing pi-competition and have a partial correlation of just 0.01, supports our judgment that the instruments are valid.

For the OLS estimations, the corresponding figures are less than 4%. The large increase in the differentials for the IV estimation compared to the OLS estimation indicates that endogeneity bias is considerable. The OLS estimation was strongly affected by the positive association of entry decision with price, as parallel traders tend to enter in products with high prices, and not only by the negative association of entry with price.

Tables 2-4 about here

The coefficients for Mpi_{it} in all estimations indicate that the full effect of facing pi-competition was not felt immediately.[17] The differential dlnP_{it}/d($Ref*Picomp_{it}$) indicates that mandatory substitution had increased the effect of pi-competition, but by less than one percentage point. For

[15] As an example, the differential d*lnP*/d (*Ref*Picomp)* was calculated as a linear combinations of the estimates of β_5 and β_7 that is: $b_5 + b_7*31.31797$, where b_5 and b_7 are the estimates of β_5 and β_7 and where 31.31797 is the mean of *Ref*Mpi* when *Ref*Picomp* equals one. The Stata command lincom is used to calculate the differentials. Point estimates are used even they are not statistically significantly different from zero.

[16] Since the dependent variable is in logarithmic form, the exact change in price (in percent) should be calculated using the formula $100*[\exp(\beta)-1]$.

[17] For observations with *Picomp* equal to one, the average values for *Mpi* and *Ref*Mpi* are 27.26 and 15.49, respectively. The Mpi-variables thus account for more than 75% of the estimates for d*lnP*/d*Picomp* in all three estimations.

the OLS regression the result is driven by the effect of $Ref*Picomp_{it}$, but for the IV regression it is mainly explained by the negative estimate for $Ref*Mpi_{it}$.

The estimates for the therapeutic competition variables, $Thcomp_{it}$, $Nthcomp_{it}$, and $Thgencomp_{it}$, indicate that, before the reform, the effect of facing such competition was small if the therapeutic alternatives did not face generic competition, but the effect increased substantially if they gained generic competition. The reform increased the importance of whether therapeutic competitors face generic competition, reflecting that the reform led to lower generic prices and lower prices of brand-name drugs facing generic competition. The reform also substantially increased the effect of $Thcomp_{it}$, probably because the Pharmaceutical Benefits Agency, unlike its predecessor prior to the reform, had a clear instruction to consider marginal benefits and costs of a drug before deciding whether or not to approve its suggested price and list it for reimbursement. The average effect of facing therapeutic competition during the study-period was a price reduction of 1.4% and the reform increased the effect of therapeutic competition by 1.6 percentage points. This means that the reform more than tripled this effect from 0.7% to 2.3%. Our results on therapeutic competition are consistent with Brekke et al. (2009) and Ellison et al. (1997) showing that drugs with the same active ingredient – generics in their case – are closer substitutes than drugs with different active ingredients but similar therapeutic effects.

Lastly, the estimates for $Time_t$ show that the prices of drugs not facing pi-competition fell over time. The estimates for Ref_t indicate that the prices of drugs not subject to pi- or therapeutic competition were positively associated with the reform, but this coefficient might capture not only the causal effects of the reform but also the effect of other changes in the market.

Conclusions

Using an instrumental variable method, we found that drugs facing competition from parallel imports had 15-17% lower prices on average compared to what they would have had if they had never faced such competition. The corresponding estimate from the OLS regression was only 4%. The results are of similar magnitude to those of Ganslandt and Maskus (2004) despite that we controlled for therapeutic competition and indirect generic competition, covered all the on-

patent prescription drugs, and analyzed a different period. Thus, our results confirm their conclusion that parallel imports substantially reduce prices of locally-sourced drugs.

The large difference between the IV and the OLS results indicates that it is important to account for endogeneity caused by simultaneous determination of prices and entry decisions of parallel traders. The OLS result describes the association between prices and pi-competition which was affected both by high prices encouraging entry of parallel traders, causing more positive (or less negative) association, and by the causal effect of competition from parallel imports itself. Therefore, OLS result gives only a lower bound on the absolute causal effect of pi-competition.

The results show that the full effect of parallel imports was not realized immediately, but rather the prices of locally-sourced drugs fell continuously as they faced competition from parallel imports. The IV-results indicate that the reform has increased the intensity of competition from parallel imports mainly by strengthening this gradual effect. By accounting for the gradual effect, our empirical strategy made it possible to analyse the full effect of competition from parallel imports. The same strategy could be used to analyze the full effect of generic competition, which is a subject for future research.

The mandatory substitution reform increased the effect of pi-competition, but by less than one percentage point in absolute value. Thus, the effect of pi-competition was large also when substitution was not mandatory. One reason could be that many pharmacies already before the mandatory substitution reform dispensed parallel imports to consumers whose physicians had not specified either a locally-sourced or parallel imported package.

Our analysis has implications for the effect of mandatory substitution reform on therapeutic competition as well. The prices of drugs facing such competition were 1.4% less on average than they would have been otherwise. The reform increased the effect of therapeutic competition by 1.6%. The results also show that the effect of therapeutic competition depended on whether the therapeutic competitors were subject to generic competition. Facing therapeutic competition led to a substantial fall in prices if the therapeutic competitors themselves were subject to generic competition. The reform increased the effect of generic competition and thus this effect as well.

Using sales values from 2003, our estimates suggest that the reform, by strengthening the effect of pi-competition and therapeutic competition for on-patent drugs, reduced the overall price level for prescription pharmaceuticals by 0.83%. Nearly six-sevenths of this reduction was due to the harder therapeutic competition, since the reform strengthened this competition more and since the total sales value for those facing this competition was 3.7 times larger than for those facing pi-competition.

Lichtenberg and Philipson (1997) showed that between-patent competition (therapeutic competition), most of which occurs while a drug is under patent, costs the patent holder at least as much as within-patent competition (generic competition), which cannot occur until a drug is off-patent. The results of this paper, when interpreted in relation to theirs, show that patent holders might be significantly hurt by competition, both from parallel imports and therapeutic alternatives, and also by the reform since both of these forms of competition, particularly therapeutic competition, was strengthened by the reform. This evidence points at the debate on potential drawback of parallel trade and substitution policies, that is, they might cause patent holders to lose profits and hence to invest less in innovation.

Appendix: Robustness Analysis and Instrument Regressions

As noted earlier, the identifying assumption for the effect of the mandatory substitution reform on the price-effect of pi-competition is that no excluded variable influence the price-effect of facing pi-competition differently before and after the reform. By including the interaction variable between time trend and dummy for facing pi-competition ($Timepi_{it}$), we allowed drugs facing such competition to have a different time trend relative to those not facing it, without this biasing the estimator of how the reform affected the effect of facing pi-competition. Still, this estimator might be biased if factors not accounted for in the regressions affected the two groups differently, and if these factors increased or decreased over time in an unstable manner so that their effects could not be captured by $Timepi_{it}$, for example, if something affecting the two groups differently occurred only during a certain part of the study-period. To test the importance of this problem we ran regression 2 for different periods: January 2000-April 2004, January 2001-June 2003, and using the normal study period (January 2001-April 2004) but excluding observations from April 2002, when the law regarding mandatory substitution was passed by parliament,

through October 2002. Besides functioning as sensitivity analyses, the latter regression were designed to give an idea whether firms started to adjust their prices even before the reform came into effect. The results from these regressions, presented in Table A1, indicate that the key estimates are stable to changes in the study-period and there is no evidence of firms adjusting prices before the reform came into effect.

Table A1 about here

When predicting $Picomp_{it}$ we used only data from the period January 2001 through April 2004. Thus, only variations in Mpi_{it} within this period could be predicted for each product. With fixed effects, subtracting a product specific constant (i.e. the value at Mpi_{it} in December 2000) from Mpi_{it} do not affect the estimates for this variable. However, this prevented us from including Mpi_{it} nonlinearly, e.g., Mpi_{it}^2. Another constraint on the specification is that year-month dummies cannot be included since this would prevent us from using $SEK/Euro_t$ which has no cross-sectional variation as a basic instrument. We have studied the effect of not including Mpi_{it}^2 and year-month dummies using OLS regression. More precisely, we conducted an OLS estimation including Mpi_{it}^2 and $Ref*Mpi_{it}^2$ as well as an estimation including 40 year-month dummies instead of 11 month dummies ($Month_t$), the time trend ($Time_t$) and the dummy for the reform (Ref_t). Comparing estimation 8, presented in Table A2, with estimation 1 in Table 2, we see that including Mpi_{it}^2 and $Ref*Mpi_{it}^2$ reduced $\mathrm{d}lnP_{it}/\mathrm{d}Picomp_{it}$ by about 0.5 percentage point and $\mathrm{d}lnP_{it}/\mathrm{d}$ ($Ref*Picomp_{it}$) by about 0.1 percentage point in absolute terms. Similarly, estimation 9 shows that including year-month dummies reduced the average estimated effect of pi-competition by about 0.6 percentage point, but changed the estimate for $\mathrm{d}lnP_{it}/\mathrm{d}$ ($Ref*Picomp_{it}$) by less than 0.1 percentage point. Thus, *Time* and *Ref* seem to have captured changes over time common to all drugs sufficiently well that such changes have little effects on the key results.

To check whether the instrumental variable results are affected by either of the basic instruments having a direct effect on the prices, we include $SEK/Euro_t$ and $Lnlong_{it}$, respectively, as explanatory variables in estimations which are otherwise identical with estimation 4. We can do this since when we for example include $SEK/Euro_t$ as an explanatory variable, the five generated instruments are still not a linear combination of the included variables, which is enough for identification. Comparing the key results from these estimations, which are presented as estimations 10 and 11 in Table A2, with those for estimation 4, we see that differentials are largely unaffected by controlling for either $SEK/Euro_t$ and $Lnlong_{it}$. This indicates that, at most, a very minor part of the estimated effects for the differentials of main interest could be explained by a direct effect of either of the basic instruments on the prices. In other words, the

instruments identify the causal effect of pi-competition, by capturing the exogenous variation generated on the profitability of parallel import.

Table A2 about here

The results from the regressions used to generate the instruments are presented in Table A3 while the result from the first-stage regressions are given in Tables A4-A6.

Tables A3-A6 about here

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Figure 1 - Number of drugs facing competition from parallel imports in each month during the study period

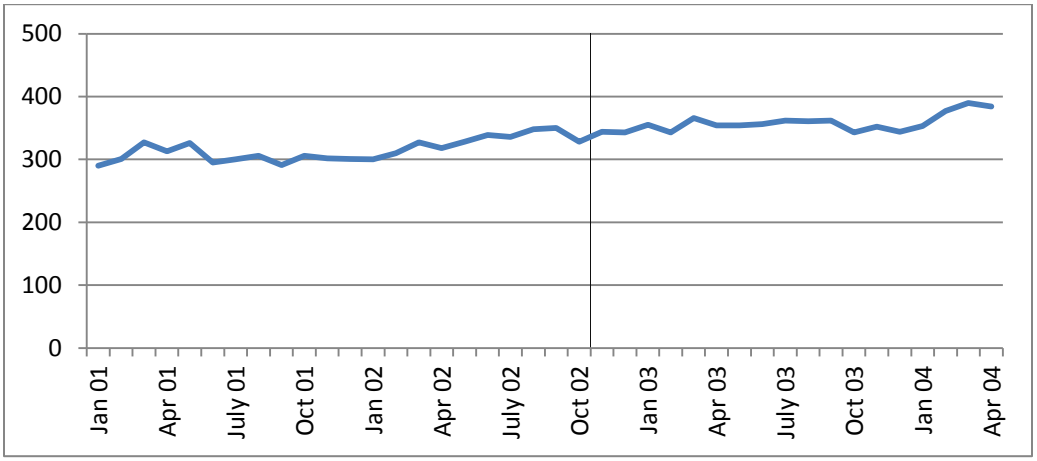

Figure 2 - Number of drugs not facing competition from parallel imports at month t-1 but facing it month t (entry), and number of drugs facing competition from parallel imports at month t-1 but not facing it month t (exit) over the study period

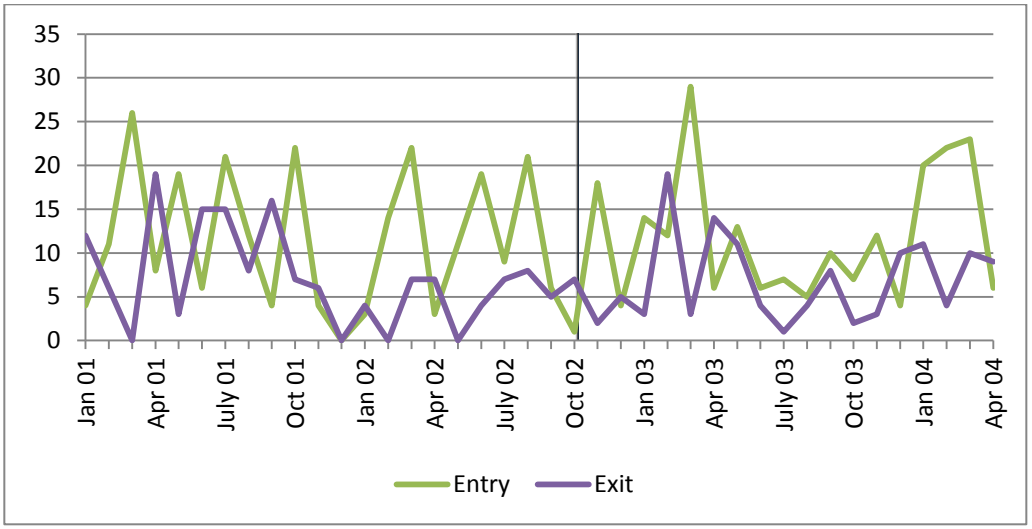

Table 1. Descriptive statistics for variables used in estimations

Variable	Mean	Std. Dev.	Min	Max
p (price)	1180.241	4092.281	6.821	127692.1
Ln*p*	5.757	1.535	1.920	11.757
Picomp	0.130	0.337	0	1
Mpi	4.001	11.619	0	79
Thcomp	0.843	0.363	0	1
Nthcomp	3.140	2.475	0	12
Thgencomp	0.207	0.340	0	1
Ref	0.466	0.498	0	1
*Ref*Picomp*	0.066	0.248	0	1
*Ref*Mpi*	2.315	9.661	0	79
*Ref*Thcomp*	0.384	0.488	0	1
Ref Nthcomp*	1.481	2.323	0	12
*Ref*Thgencom*	0.104	0.260	0	1
Time	20.265	11.534	1	40
Timepi	2.789	8.311	0	40
SEK/EURO	9.179	0.148	8.896	9.667
Longevity	78.635	33.885	0.5	108.5
Ln*long*	4.171	0.798	-	4.687

Table 2. Detailed descriptive statistics of the variables by the two groups of drugs – facing and not facing competition from parallel imports – before and after the reform

		Before the Reform		After the Reform	
Variable		**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
p (price)	For drugs facing competition from parallel imports	635.132	838.363	767.351	1088.237
ln*p*		5.889	1.085	6.036	1.124
Mpi		23.577	13.770	31.318	19.826
Thcomp		0.868	0.338	0.905	0.293
Nthcomp		3.273	2.422	3.365	2.391
Thgencomp		0.298	0.392	0.311	0.390
SEK/EURO		9.220	.177	9.133	.0716
Longevity		91.930	22.412	90.534	24.512
lnLong		4.260	0.676	4.350	0.670
Variable		**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
p (price)	For drugs not facing competition from parallel imports	1178.413	4237.346	1338.746	4516.414
ln*p*		5.695	1.570	5.763	1.608
Mpi		0.343	2.939	0.603	4.345654
Thcomp		0.838	0.368	0.836	0.370
Nthcomp		3.087	2.467	3.144	2.504
Thgencomp		0.179	0.324	0.208	0.335
SEK/EURO		9.222	.183	9.131	.0713
Longevity		74.436	34.665	79.539	34.789
Ln*long*		3.969	0.981	4.096	0.973

Table 3. Estimation results on logarithmic price (lnP_{it}), multiplied by 100

	(1) OLS	(2) IV
$Picomp_{it}$	0.323**	-11.555***
	(0.150)	(1.633)
Mpi_{it}	-0.135***	-0.452***
	(0.011)	(0.054)
$Timepi_{it}$	-0.004	0.373***
	(0.011)	(0.060)
$Ref*Picomp_{it}$	-1.043***	-0.078
	(0.252)	(0.413)
$Ref*Mpi_{it}$	0.010	-0.031***
	(0.006)	(0.011)
$Thcomp_{it}$	-0.404	-0. 313
	(0.340)	(0.344)
$Nthcomp_{it}$	0.126**	0.105**
	(0.050)	(0.051)
$Thgencomp_{it}$	-3.167***	-3.004***
	(0.360)	(0.365)
$Ref*Thcomp_{it}$	-0.819***	-0.723***
	(0.207)	(0.210)
$Ref*Nthcomp_{it}$	-0.185***	-0.189***
	(0.027)	(0.027)
$Ref*Thgencomp_{it}$	-0.542***	-0.656***
	(0.161)	(0.165)
Ref_t	1.147***	1.158***
	(0.158)	(0.160)
$Time_t$	-0.037***	-0.038***
	(0.005)	(0.005)
d lnP_{it}/d $Picomp_{it}$	-3.848***	-16.484***
	(0.213)	(1.796)
d lnP_{it}/d ($Ref*Picomp_{it}$)	-0.735***	-0.882***
	(0.185)	(0.180)
d lnP_{it}/d $Thcomp_{it}$	-1.490***	-1.411***
	(0.357)	(0.362)
d lnP_{it}/d ($Ref*Thcomp_{it}$)	-1.659***	-1.605***
	(0.153)	(0.155)
Sample size	102,187	102,187
F-statistic	165.79***	151.83***
Log likelihood	148,558.8	147,808.3
Underident. stat		222.301***

Notes: The asterisks ***, ** and * denote significance at the 1%, 5%, and 10% levels. Standard errors that are robust against heteroskedasticity and autocorrelation are shown in parentheses. The differentials were evaluated at the mean of each variable when the relevant explanatory variable, i.e., $Picomp_{it}$, $Ref*Picomp_{it}$, $Thcomp_{it}$, or $Ref*Thcomp_{it}$, took the value one. Estimation results for calendar months are suppressed to save space, but are available from the author upon request. F-statistic reports the F value for all variables. The log likelihood values are calculated using the postestimation command "estat ic". Underident. stat reports the Kleibergen-Paap rk LM statistic, with asterisks indicating at which significance level underidentification is rejected.

Table 4. Estimation results on logarithmic price (lnP_{it}) from IV regressions with instruments *Lnlong*, and both *SEK /EURO* and *Lnlong*, multiplied by 100

	(3) IV	(4) IV
d lnP_{it}/d $Picomp_{it}$	-18.970***	-17.881***
	(1.986)	(1.897)
d lnP_{it}/d (*Ref*Picomp*$_{it}$)	-0.876***	-0.878***
	(0.209)	(0.207)
Sample size	102,187	102,187
F-statistic	141.21***	147.39***
Log likelihood	147,518.6	147,663.4
Underident. stat	199.946***	229.299***

See notes to Table 2.

Table A1. Estimation results on logarithmic price (lnP_{it}) from IV regressions on different time periods, multiplied by 100

	(5) From	(6) To June 2003	(7) Law, April
d lnP_{it}/d $Picomp_{it}$	-16.439***	-18.064***	-16.110***
	(4.001)	(2.825)	(2.241)
d lnP_{it}/d (*Ref*Picomp*$_{it}$)	-1.145***	-1.000***	-0.905***
	(0.323)	(0.199)	(0.315)
Sample size	134,246	77,357	86,783
F-statistic	200.25***	152.97***	147.39***
Log likelihood	172,896.6	125,732.3	123,519.2
Underident. stat	132.447***	124.650***	148.443***

Notes: These estimations differ from estimation (2): by also including the observations from 2000 (estimation 5); by not including observation from July 2003 through April 2004 (estimation 6); and by not including observations from April 2002, when the law regarding mandatory substitution was passed by parliament, through October 2002 (estimation 7). Also, see notes to Table 2.

Table A2. Estimation results on logarithmic price (lnP_{it}) from robustness analysis, multiplied by 100

	(8) OLS	(9) OLS	(10) IV	(11) IV
d lnP_{it}/d $Picomp_{it}$	-3.330***	-3.248***	-17.695***	-15.916***
	(0.231)	(0.214)	(1.870)	(1.794)
d lnP_{it}/d	-	-	-0.854***	-
	(0.198)	(0.183)	(0.207)	(0.206)
Sample size	102,187	102,187	102,187	102,187
F-statistic	190.37***	101.88***	141.34***	163.60***
Log likelihood	148,570.3	148,866.7	147,709.7	147,996.4
Underident. stat			228.830***	227.695***

Notes: Estimations 8 and 9 differ from estimation (1) by also including Mpi^2 and *Ref*Mpi*^{2} (estimation 8) and by including year-month dummies (estimation 9). Estimations 10 and 11 differ from estimation (4) by also including *Sek/Euro* and *Lnlong*, respectively, as control variables. Also, see notes to Table 2.

Table A3. Estimation results for regressions used to generate instruments, multiplied by 100

	(2) IV	(3) IV	(4) IV
$Thcomp_{it}$	-22.926***	-21.316***	-21.200***
	(3.653)	(3.645)	(3.643)
$Nthcomp_{it}$	-3.801***	-3.855***	-3.974***
	(0.919)	(0.915)	(0.915)
$Thgencomp_{it}$	21.454***	17.077***	17.014***
	(4.092)	(4.105)	(4.103)
$Ref*Thcomp_{it}$	16.088***	15.000***	15.056***
	(2.905)	(2.898)	(2.896)
$Ref*Nthcomp_{it}$	-0.859**	-0.664*	-0.651*
	(0.348)	(0.347)	(0.347)
$Ref*Thgencomp_{it}$	-21.245***	-16.930***	-16.926***
	(2.077)	(2.119)	(2.117)
Ref_t	1.378***	1.127***	1.148***
	(0.061)	(0.065)	(0.065)
$Time_t$	-3.402	-2.420	-3.834
	(2.762)	(2.725)	(2.752)
SEK/Euro$_t$	-8.262***		-9.309***
	(2.592)		(2.585)
Lnlong$_{it}$		13.907***	14.130***
		(1.470)	(1.471)
Sample size	12,239	12,239	12,239
F	135.57	140.44***	134.50***
F basic instrument	10.16***	89.49***	51.28***
R^2	.186	.191	.192
R^2-adj	.161	.166	.167
Log likelihood	-4,862.84	-4,822.10	-4,815.42

Estimation results for calendar months are suppressed to save space, but are available from the authors upon request. 89,948 observations are not used in these regressions since they are for drugs with no variation in $Picomp_{it}$ during the study period.

Table A4. First stage estimation results for estimation 2, multiplied by 100

	$Picomp_{it}$	Mpi_{it}	$Timepi_{it}$	$Ref*Picomp_{it}$	$Ref*Mpi_{it}$
$Thcomp_{it}$	0.673	-7.921	-44.208*	-1.184*	19.824***
	(1.220)	(5.706)	(25.078)	(0.685)	(6.920)
$Nthcomp_{it}$	-0.099	2.289***	8.938***	0.184**	13.088***
	(0.153)	(0.730)	(3.129)	(0.084)	(1.450)
$Thgencomp_{it}$	1.731***	11.205***	37.279**	1.464***	-37.211***
	(0.651)	(2.813)	(17.144)	(0.478)	(6.057)
$Ref*Thcomp_{it}$	0.256	6.397***	4.430	0.238	-10.319***
	(0.306)	(1.483)	(6.844)	(0.188)	(2.731)
$Ref*Nthcomp_{it}$	0.012	-0.821***	0.048	-0.015	-0.975***
	(0.052)	(0.246)	(1.268)	(0.037)	(0.352)
$Ref*Thgencomp_{it}$	-0.506	-4.993***	-3.184	-0.212	1.196
	(0.344)	(.1624)	(8.666)	(0.240)	(3.370)
Ref_t	-0.279	-4.830***	-18.535***	-0.951***	7.180***
	(0.209)	(1.053)	(4.671)	(0.129)	(2.022)
$Time_t$	0.010*	-0.051**	0.965***	0.041***	0.096**
	(0.005)	(0.026)	(0.133)	(0.004)	(0.048)
GI_Picomp_{it}	78.038***	-66.406	-281.821	-7.661	-109.172*
	(10.693)	(58.162)	(241.373)	(6.446)	(65.072)
GI_Mpi_{it}	1.019**	103.525***	16.831	0.443	11.382***
	(0.504)	(2.664)	(13.273)	(0.347)	(2.922)
GI_Timepi_{it}	-0.426	-2.265	88.084***	-0.442	-8.012***
	(0.494)	(2.647)	(13.191)	(0.348)	(2.890)
$GI\_Ref*Picomp_{it}$	34.672***	96.356***	726.272***	123.323***	163.967***
	(1.839)	(8.868)	(39.572)	(1.088)	(26.244)
$GI\_Ref*Mpi_{it}$	-1.030***	-1.612***	-19.501***	-0.525***	96.024***
	(0.041)	(0.189)	(0.857)	(0.023)	(0.631)
Sample size	102,187	102,187	102,187	102,187	102,187
F-statistic	109	203,745	7,927	15,373	31,742
Log likelihood	70,009	-84,226	-251,371	115,533	-137,261
Angrist & Pischke X^2	66.11***	1765.75***	56.06***	6847.61***	14716.37***

Notes: The asterisks ***, ** and * denote significance at the 1%, 5%, and 10% levels. Standard errors that are robust against heteroskedasticity and autocorrelation are shown in parentheses. Estimation results for calendar months are suppressed to save space, but are available from the author upon request. F-statistic reports the F value for all variables. The prefix GI is short for generated instrument. Angrist & Pischke X^2 is an underidentification statistic, with asterisks indicating at which significance level underidentification is rejected.

Table A5. First stage estimation results for estimation 3, multiplied by 100

	$Picomp_{it}$	Mpi_{it}	$Timepi_{it}$	$Ref*Picomp_{it}$	$Ref*Mpi_{it}$
$Thcomp_{it}$	0.527	-9.564*	-40.686*	-1.062	18.885***
	(1.193)	(5.697)	(24.680)	(0.675)	(6.710)
$Nthcomp_{it}$	-0.100	1.911***	7.823**	0.138*	13.004***
	(0.151)	(0.722)	(3.096)	(0.083)	(1442)
$Thgencomp_{it}$	1.698***	10.575***	32.785*	1.324***	-37.269***
	(0.643)	(2.794)	(16.893)	(0.473)	(6.043)
$Ref*Thcomp_{it}$	0.234	7.065***	2.304	0.181	-9.337***
	(0.307)	(1.520)	(6.889)	(0.191)	(2.739)
$Ref*Nthcomp_{it}$	0.014	-0.809***	0.141	-0.011	-1.010***
	(0.052)	(0.247)	(1.266)	(0.037)	(0.352)
$Ref*Thgencomp_{it}$	-0.527	-5.338***	-2.563	-0.191	0.517
	(0.343)	(1.621)	(8.655)	(0.241)	(3.353)
Ref_t	-0.236	-5.483***	-17.716***	-0.955***	6.792***
	(0.211)	(1.081)	(4.707)	(0.130)	(2.037)
$Time_t$	0.006	-0.035	0.892***	0.039***	0.089*
	(0.005)	(0.026)	(0.132)	(0.004)	(0.048)
GI_Picomp_{it}	64.861***	-185.805***	-251.331	-5.476	-24.783
	(9.266)	(51.657)	(201.899)	(5.346)	(52.235)
GI_Mpi_{it}	0.420	99.015***	15.784	0.482	15.820***
	(0.452)	(2.410)	(11.956)	(0.311)	(2.607)
GI_Timepi_{it}	0.206	2.152	89.797***	-0.470	-12.356***
	(0.442)	(2.399)	(11.847)	(0.310)	(2.531)
$GI\_Ref*Picomp_{it}$	33.999***	98.657***	692.483***	122.275***	164.035***
	(1.824)	(8.725)	(39.351)	(1.088)	(26.112)
$GI\_Ref*Mpi_{it}$	-1.022***	-1.599***	-18.929***	-0.503***	95.945***
	(0.041)	(0.187)	(0.849)	(0.023)	(0.624)
Sample size	102,187	102,187	102,187	102,187	102,187
F-statistic	112	85,725	4,579	10,537	32,357
Log likelihood	70,380	-83,868	-250,746	115,869	-136,774
Angrist & Pischke X^2	54.83***	1492.64***	50.21***	7499.79***	15789.32***

See notes to table A4.

Table A6. First stage estimation results for estimation 4, multiplied by 100

	$Picomp_{it}$	Mpi_{it}	$Timepi_{it}$	$Ref*Picomp_{it}$	$Ref*Mpi_{it}$
$Thcomp_{it}$	0.559	-9.114	-41.362*	-1.047	19.289***
	(1.194)	(5.688)	(24.692)	(0.675)	(6.706)
$Nthcomp_{it}$	-0.100	2.015***	7.857**	0.146*	12.991***
	(0.151)	(0.722)	(3.090)	(0.083)	(1.442)
$Thgencomp_{it}$	1.680***	10.352***	32.637*	1.301***	-37.291***
	(0.639)	(2.784)	(16.792)	(0.469)	(6.049)
$Ref*Thcomp_{it}$	0.228	6.957***	2.454	0.177	-9.394***
	(0.307)	(1.521)	(6.894)	(0.191)	(2.739)
$Ref*Nthcomp_{it}$	0.014	-0.803***	0.139	-0.011	-1.012***
	(0.052)	(0.246)	(1263)	(0.037)	(0.351)
$Ref*Thgencomp_{it}$	-0.522	-5.137***	-2.831	-0.188	0.628
	(0.343)	(1.623)	(8.661)	(0.241)	(3.352)
Ref_t	-0.230	-5.720***	-16.934***	-0.927***	6.906***
	(0.211)	(1.087)	(4.694)	(0.129)	(2.034)
$Time_t$	0.006	-0.023	0.867***	0.039***	0.085*
	(0.005)	(0.026)	(0.130)	(0.004)	(0.047)
GI_Picomp_{it}	68.053***	-164.820***	-279.955	-4.743	2.897
	(9.711)	(53.360)	(217.537)	(5.764)	(56.268)
GI_Mpi_{it}	0.557	99.791***	14.624	0.510	16.948***
	(0.474)	(2.508)	(12.579)	(0.329)	(2.805)
GI_Timepi_{it}	0.065	1.433	90.773***	-0.499	-13.460***
	(0.464)	(2.492)	(12.451)	(0.328)	(2.726)
$GI\_Ref*Picomp_{it}$	34.017***	96.325***	697.952***	122.291***	162.594***
	(1.812)	(8.662)	(39.017)	(1.077)	(25.978)
$GI\_Ref*Mpi_{it}$	-1.020***	-1.578***	-18.965***	-0.503***	95.966***
	(0.040)	(0.186)	(0.846)	(0.023)	(0.622)
Sample size	102,187	102,187	102,187	102,187	102,187
F-statistic	112	80,389	4,628	10,378	32,415
Log likelihood	70,429	-83,875	-250,762	115,833	-136,766
Angrist & Pischke X^2	57.51	1551.89	50.43	7649.54	16102.90

See notes to table A4.