# MEMORANDUM

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## Generic substitution[1]

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# Generic substitution[1]

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**Abstract**

We examine the importance of prices, doctor and patient characteristics, and market institutions for the likelihood of choosing generic drugs instead of the more expensive original brand-name version. Using an extensive dataset extracted from The Norwegian Prescription Database (NorPD) containing all prescriptions written in March 2004 and 2006 on 23 different drugs (chemical substances) in Norway, we find strong evidence for the importance of both doctor and patient characteristics for the choice probabilities. The price difference between brand and generic versions and insurance coverage both affect generic substitution. Moreover, controlling for the retail chain affiliation of the dispensing pharmacy, we find that pharmacies play an important role for patients' willingness to substitute. In markets with more recent entry of generic drugs, the brand-name loyalty proves to be much stronger, giving less explanatory power to our demand model.

JEL: C35, I 18, L 65
Keywords: Generics, substitution, microdata, random utility model

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## 1. Introduction

When a pharmaceutical patent expires, firms may enter the market with a generic version of the original brand-name drug. As these drugs contain exactly the same active chemical substances, they are certified by drug authorities to be substitutable with the original branded drugs. The only requirement for approval to enter the market is that the generic producers are able to prove that its drug contains the same active substance. Other characteristics such as inert ingredients, shape, colour and name will generally differ. Although generic substitution plays an important role in cutting drug costs after patent expiration, it is well known that entry of generic drugs appears to be gradual in many countries (Berndt, 2002). Moreover, brand-name producers are often able to maintain a high-price strategy instead of engaging in fierce price competition with generic producers. Both theoretical and empirical research have shown that the brand-name producer may choose to meet generic competition by raising prices, targeting the market segment that remains loyal to the earlier patented drug.

The persistence of demand for branded drugs, when cheaper substitutes become available, may indicate that physicians and patients develop habits or product loyalties that are not easily changed. The patented drug benefits from a period of exclusiveness in treating patient with the particular chemical substance. During this period doctors receive brand-name specific information from the pharmaceutical company, and they gradually learn the drug's effectiveness in treating different types of patients. This may establish a brand-name loyalty that persists into the post-patent period. Habit formation is expected to be of particular importance in this market since physicians do not have economic incentives to let drug prices affect their choices, or to keep themselves informed about new generics entering the market. Physicians have incentives to serve the interests of their patients, but the insurance schemes in many countries make the patient ignorant about drug prices.

The patients themselves may have preferences for using the brand-name drug since this is the drug they are used to take. Note that generics, although having the same active chemical substance, differs in colour, shape, and in their use of other ingrediences. For some patient groups, it may be hard to accept that a drug with different names, colour and shape have exactly

the same therapeutic qualities. As the patient's agent, this may be another source for brand-name loyalty by the doctor itself. Since patients generally will be insulated from the extra cost of using the brand-name drug, even a small positive effect (other than price) for the patient of using the brand-name may lead the doctor to prefer to prescribe brand-name drugs.

Hellerstein (1998) was one of the first to examine the micro-evidence for habit formation and brand-name loyalty. Using survey data on physicians, their patients, and the multisource drugs prescribed, she finds that some physicians are more likely to prescribe generic drugs while other physicians are more likely to prescribe trade-name drugs. Very little of the prescription decision can be explained by observable characteristics of individual patients, but all of the evidence indicates that physicians are indeed an important agent in determining whether patients receive either trade-name or generic drugs. Her results indicates that some doctors are more inclined to prescribe brand-name drugs, while others more often choose a generic version, and that these choices only weakly changes with individual patient characteristics. Her analysis is based on survey data from doctors' responses to a questionnaire providing information about patients and drug choice.

Using a panel data set for a subsample of the population in Rome for the years 1990-1992, Coscelli (2000) are better able to reveal the habit behaviour claimed by Hellerstein (1998). His results support habit persistence among doctors, but differently from Hellerstein, the results prove patient characteristics affects the prescription choice as well. As noted by Lundin (2000), an important draw-back with these two studies is the lack of price data. The scope for habit persistence is expected to be affected by the price differences. Using data from two pharmacies in a small Swedish municipality Lundin (2000) investigates the importance of price differences for the drug choice. He finds support for habit persistence among doctors and patients, but the results indicate that these are affected by the price differences – especially the share of price differences covered by the patient. If the price differences between generic and brand-name increases, the doctor becomes more inclined to prescribe a generic version.

Having access to a newly established database, which contains data on all dispensed drugs in Norway,[2] the current paper makes new contributions to the understanding of generic substitution. The database registers all dispensed drugs since January 1, 2004, and contains information about the patient, the doctor, the dispensed drug, and the dispensing pharmacy. From this database, we have extracted the entire population of prescriptions in February 2004 and 2006 on 23 different drugs (chemical substances) subjected to generic competition. This amounts to 313.078 observations (102.201 in February 2004 and 210.877 in February 2006). Between 2004 and 2006, several drugs were opened for generic entry, and this explains the increase in the number of observations.

We develop a demand model in which doctor-patient's choices follows from a discrete choice structure with random utility function, which implies binomial logit choice probabilities. Using the extensive dataset, the model allows us to investigate the role played by a rich set of variable for the probability of using the brand name drug instead of a generic version. We find strong evidence for the importance of both doctor and patient characteristics for the choice probabilities.

With generic substation, pharmacies play an important role in the actual choice between the brand-name and a generic drug. In cases were the doctor has not refused substitution, the actual choice is made when the pharmacist meets the patient. All pharmacies are obligated to recommend the cheapest available version. Patients who are indifferent between brand-name and generic will just accept the version provided by the pharmacy. Others may oppose, and still after receiving information and advises, stick to a brand-name version, then at an extra cost of the patient reflecting the price difference. The incentives to spend effort convincing a patient to accept substitution are affected by the producer prices. If the pharmacy margin is largest on a generic drug, these incentives are strictly positive, while being absent if the margin is larger on brand-name drugs. We find that controlling for pharmacy identity is important. Some pharmacy chains are much more likely ending up with patient choosing the brand-name drug than others.

Although generic substitution allows pharmacies to switch between branded and generic drugs, product preferences both by the physician and by the patient still play an important role for the

[2] Norwegian Prescription Database (NoPD)

choice. The physician can add a reservation to the prescription, which prohibits pharmacies to substitute. In this way, the physician can ensure that the branded drug is used instead of a cheaper generic version. This comes at no extra cost for the patient covered by the insurance scheme. In Norway, the physicians objected substitution on 5,2 % of the prescriptions in 2005, and on 4,5% in 2006. Even without such a reservation by the physician, the patient may insist on the branded drug, in which case the pharmacy is obligated to hand out the brand-name drug. In this case, the insurance scheme does not cover the price difference between the branded drug and the cheapest available version. The difference has to be paid by the patient himself. In 2005, the patients refused to substitute on 4,0 % of the prescriptions (4,3 % in 2006). These come in addition to the reservations made by the physicians, bringing total number refusals to substitute close to an average of 10 % of all prescriptions.

Both age of patient and doctor affect the choice. Generally, older doctors and patients end up choosing brand-name drugs more often.

Like in Lundin (2000), we find that the price difference between brand and generic versions affects generic substitution. In previous studies of generic substitution, however, there has been no attempt to control for the market age of generic versions. Some drugs have had generic versions available for many years, while others are more recently opened up for generic entry. Studies of brand-name loyalty based on aggregate market data reports that the market share of brand-name drugs steadily falls after generic entry (see Caves, Whinston, and Hurwitz (1991), Grabowski and Vernon (1992), and Frank and Salkever (1997), and Regan (2008)). We find that the price response is much lower for drugs that recently lost patent protection. Patients covered by the national insurance scheme are more likely to use the brand name drug.

The mean probability of choosing brand-name drugs is higher in younger generic markets, but for these drugs, the explanatory power of the model is much weaker. Prices and insurance coverage still have an impact on substitution, but the magnitude of this effect is lower.

The rest of the paper is organised as follows. Section reports 2 relevant aspects of the Norwegian pharmaceutical market. Section 3 contains a description of the dataset. Section 4 presents the econometric model. Section 5 shows the estimation results, and Section 6 concludes.

## 2. The pharmaceutical market in Norway

As in most other countries, the pharmaceutical market in Norway is subject to regulation. Regulation of prescription drugs concerns both producers' entry and pricing decisions, and the pharmacies' retail margins. The regulatory authority related to the pharmaceutical sector is the Norwegian Ministry of Health and Social Affairs. The Ministry, and its agency (Norwegian Medicines Control Authority), control the entry of new drugs, the wholesale prices, and the retail margins. The manufacturer price is unregulated. The Norwegian Health System offers statutory public health insurance, and close to 70 percent of total drug expenses are covered by this insurance scheme. These expenses have been increasing rather rapidly due to an ageing population and entry of new and more expensive drugs. For drugs approved for reimbursement by the social insurance scheme, the share of total cost paid by the patient amounts to 11 percent in Norway. This is much lower than in other Nordic countries. In Denmark, this share amounts to 42 percent, while in Sweden the patients cover 26 percent. In UK, Spain, and France the patients pay only 6-7 percent of total costs.

During the last decades there have been several policy initiatives by the Norwegian government to foster competition after patent expiration. From 1987 doctors were encouraged to prescribe the cheapest of the available versions of the drug. In 1991 this light-handed regulation was replaced by a law that instructed doctors to prescribe the cheapest available generic drug. Doctors could still prescribe a more expensive brand-name version, as long as a medical reason for this could be provided. The market share of generic products in Norway increased from 34 % to 52 % during the first two years after the passage of this law.

In this period, generic competition was entirely based on the prescription-choice of the doctor. The pharmacy was required to dispense the exact product name written on the prescription. This

changed in March 2001 when pharmacies were allowed to substitute a branded drug for a generic, independent of the product name prescribed by the doctor. Being permitted to intervene between the physician and the patient, the pharmacies now got an active role in the market for generics. The doctor can still guard against substitution, but this requires an explicit reservation to be added to the prescription note ("active substitution method").[3] If the doctor refuses to substitute on behalf of a patient who is covered by the social insurance scheme, the brand-name price mark-up (as compared with the cheapest generic version) is paid by the social insurance scheme.

Also, the patient can override the possibility of substitution by pharmacies, even in cases not supported by the doctor's prescription decision. The pharmacy is instructed to meet these patients' demand for brand-name drugs, but here the patients will have to pay the mark-up themselves. Their insurance coverage will be based on the cheapest available generic version.

In addition to generic substitution, several price-regulation schemes have been adopted (see Brekke et al. (2008), Dalen et al (2006), and Dalen and Strøm (2006)). In 2004, from which our first dataset is extracted, two schemes were in use: A reference price scheme termed "index pricing" and a "price cap scheme". Under the price cap scheme, the regulator sets a maximum price level defined by the lowest observed prices in a selection of European countries. This price cap is first set when the brand-name drug enters the market. After patent expiration, generic drugs are given the exact same price cap, and this cap will only fall if generic competition triggers price reductions in the reference countries. However, competition from generics (made possible by generic substitution) was supposed to lower prices below the price cap. After price comparisons with other Nordic countries, the Ministry of Health concluded that generic competition was not sufficiently successful in bringing down prices under the reference price scheme.

This weak price response of generic competition was the motivation behind a new scheme – "index pricing" – introduced in March 2003. The index price scheme was established on 6

[3] Another doctoral procedure would be the "two-line method". Here the doctor signs either on a line that reads "brand-name necessary" or on a line that reads "substitutions allowed". Both methods have been in use in the US, and prove to have an impact on the number of refusals. The two-line method generates more refusals than the active substitution method (Hellerstein, 1998).

different drugs: Omeprazol (ulcer), Enalapril (high blood pressure), Lisinopril (high blood pressure), Citalopram (depression), Cetirizin (allergy), Loratadin (allergy). Simvastatin (high cholesterol) was added in June 2004. For these drugs the regulator set a reimbursement price (the index price) to be paid to the expediting pharmacy, irrespective of what the chain paid for the chosen drug. This gives the pharmacies strong incentive to facilitate fierce price competition between producers of generic drugs. The index price on a drug (chemical substance) was updated every third months, and set equal to the average of the three lowest producer prices reported by the pharmacy chains, plus a fixed distribution (wholesale and retail) margin. If a retailer selected a producer with a price exceeding the average of the three lowest prices, the net margin of the integrated retailer-wholesale pharmacy firm drops below the fixed distribution margin, whereas a retailer selecting a producer with a lower producer price experiences an increase in his net margin. This way of regularly updating of the index price, based on observed producer prices from previous months, ensured that the index price tracked the development in producer prices over time. The index price scheme was expected to stimulate generic substitution in pharmacies, and thereby triggering price competition between producers.[4]

In January 2005 the index price scheme was replaced with a new price regulation scheme that abandoned the direct use of economic incentives to bring down pharmaceutical prices after patent expiration. The new scheme – called the *de-escalation* model – consists of a predetermined, stepwise reduction of the reimbursed price, starting from the time of generic entry into the market. The pharmacies are instructed to have the drug available at the reimbursable retail price.

The regulated reimbursable price is based on the maximum retail price of the patented drug before generics enters. Let *AUP** be the price before the patent expires. The de-escalation model determines the reimbursable price according to the following rule:

[4] Brekke et al. (2008) investigates to what extent index price scheme was successful in stimulating price competition compared to the price cap regulation. They find that index price regulation significantly reduced both brand-name (by 18-19 %) and generic prices (7-8 %).

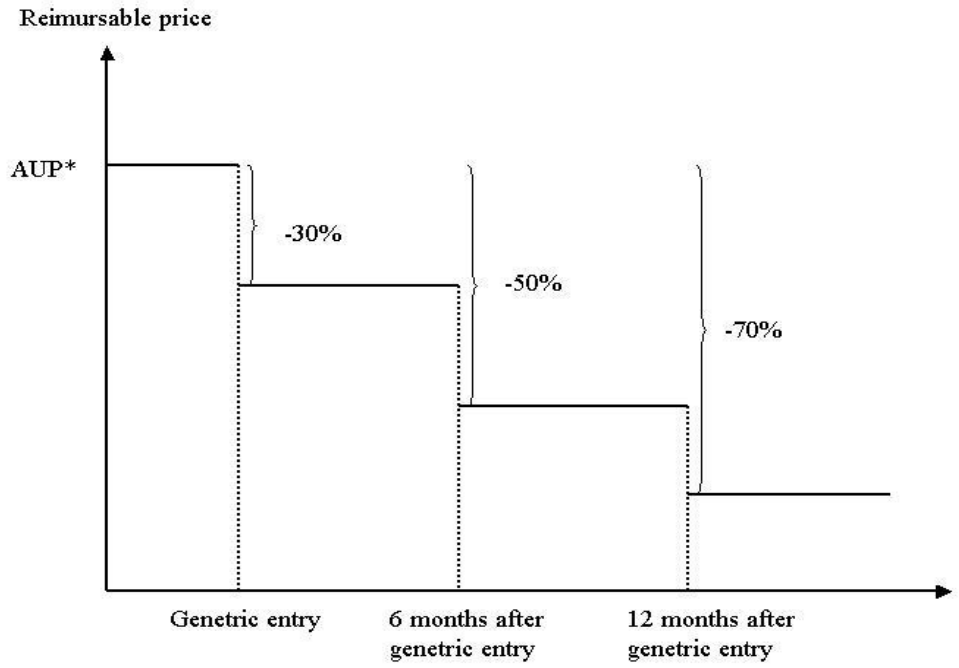


**Figure 1**: The de-escalation model

For drugs with annual sale above 100 million NOK prior to generic entry, the second price reduction was set equal to 40 percent (instead of 50 percent), and the third is set equal to 50 percent (instead of 70 percent). Lately, these cuts have been increased even more.

The scheme gives the pharmacy chains strong incentives to lower their purchasing prices. The model does not prescribe any future price reviews based on the development of these prices. All cost savings – in terms of reduced purchasing prices – are kept by the pharmacies themselves. This scheme illustrates the fundamental trade-off that often has to be made in regulation of prices. Maximum incentives to minimize costs (here put pressure on producer prices of generic drugs) are obtained by offering fixed retail prices. However, in order to be credible, these prices must be set at sufficiently conservative levels. If the government is too eager in reducing the cost of drug reimbursement – by setting the post-generic prices at very low levels – the pharmacies will report economic problems, which in turn will make it necessary for the government to increase the prices. When such a scheme could be enforced without protests from the pharmacy chains, there are good reasons to expect the predetermined prices to be pleasantly higher than the

purchasing prices.[5] Generic drugs are relatively cheap to produce, and the pre-generic prices reflect the cost of undertaking R&D-investments to innovate the drug in the first place. For many drugs, a price drop of 50 or 70 percent may still keep prices above the cost of producing generic drugs.

## 3. Data

Our data was extracted from the Norwegian Prescription Database (NorPD) at the Norwegian Institute of Public Health. The NorPD (Norwegian title: Reseptregisteret) was established on 1st January 2004.[6] The Database monitors all drugs that are dispensed by prescription in Norway, and provides information about the patient (age, sex, and insurance status), the physician (age, sex, and speciality), the pharmacy (location), and the dispensed drug (price, package size, strength, product name). Using other sources of information provided by the Norwegian Medicines Control Authority (list of pharmacies and a list of drugs approved for the Norwegian market), we get additional information about pharmacy ownership and producer name of the drugs. The latter is used to identify brand-name drugs and generics.

As a first step towards using this extensive database for research on drug demand, we extracted two months of observation – February 2004 and February 2006. This amounts to 313.078 observations (102.201 in February 2004 and 210.877 in February 2006).

The data covers pharmaceuticals in which the original brand-name producer competes in the market with producers of generic versions of the same product. Generic drugs contain the same chemical substance as the brand-name drug. We have selected chemical substances which were covered by the de-escalation price model (explained above) in place in 2006. Some of these substances were also present in the market in 2004 in the sense that there were brand and generics in 2004. The different chemical substances included in the 2006 are given in Table 1. The 2004 column indicates which of these substances that was present in the 2004 dataset as well. In 2004

[5] The de-escalation model was actually proposed by the pharmacy chains.
[6] See Furu (2001

four of the chemical substances were covered by the index price regime, which is indicated in the table. Data refers to all prescriptions transacted in February 2004 and 2006.

With up to 23 chemical substances, we are able to cover a broad set of indications, such as blood pressure and heart failure, cholesterol, depression, ulcer, antibiotics, and allergy. Several of the drugs in the study are among the most selling drugs in Norway. This includes Simvastatin (cholesterol), Cetirizin (allergy), and Enalapril (blood pressure). Simvastatin has been for several years the most selling drug in Norway, in 2007 with 110 DDD per 1000 capita (compared with 85 DDD per 1000 capita in 2006).[7]

**Table 1. Chemical substances included in the study**

| ATC code | Name | Main indication | 2004 | Generic entry |
|---|---|---|---|---|
| A02BA02 | Ranitidine | Ulcer | X | <2004 |
| A02BC01* | Omeprazole | Ulcer | X | <2004 |
| C07AB03 | Atenolol | Blood pressure | X | <2004 |
| C07AG02 | Carvedilol | Blood pressure | X | <2004 |
| C08CA01 | Amplodipine | Blood pressure, angina pectoris | | March 2004 |
| C08CA02 | Felodipine | Blood pressure | | <2004 |
| C09AA02* | Enalapril | Blood pressure, heart failure | X | <2004 |
| C09AA03* | Lisinopril | Blood pressure, heart failure | X | March 2004 |
| C09AA05 | Ramipril | Blood pressure, heart failure | | April 2004 |
| C09BA03 | Lisinopril/diuretics | Blood pressure | X | <2004 |
| C10AA01 | Simvastatin | Cholesterol | X | <2004 |
| D01BA02 | Terbinafine | Infection, skin and nails | | May 2005 |
| J01CA04 | Amoxicillin | Antibiotics | X | <2004 |
| J01MA02 | Ciprofloxacin | Antibiotics | X | <2004 |
| J02AC01 | Fluconazol | Antibiotics | | <2004 |
| M01AB05 | Diclofenac | Inflammation | X | <2004 |
| M01AC06 | Meloxicam | Inflammation | | September 2005 |
| M05BA04 | Alendroat | Osteoporose | | December 2005 |
| N06AB05 | Paroxetin | Depression | X | May 2004 |
| N06AB06 | Sertraline | Depression | | November 2005 |
| N06AX03 | Mianserin | Depression | X | <2004 |
| N06AX11 | Mirtazapine | Depression | | October 2004 |
| R06AE07* | Cetirizin | Allergy | X | <2004 |

* In the index price regime in 2004.

[7] Norwegian Association of Pharmaceutical Manufacturers (2008)

The variables that we employ in the econometric model are listed and described briefly in Table 2. The dependent variable is the purchase of a pharmaceutical for which there are available both the original product (brand) and generics with the same chemical substance. Thus the dependent variable, called brand in Table 2, is a dummy, which equals 1 if brand is chosen and zero otherwise, that is when a generic is chosen. If a brand is chosen, then the retail price of the chosen brand represents the price of the brand. Because we model the choice of brand versus generics we need to represent in the model the price of the generics not chosen. The price of the generics is calculated as the monthly average of the prices of the generics with the same chemical substance and strength as the brand sold by the same pharmacy chain selling the branded product.

**Table 2. Description of variables**

| **Variable name** | **Variable description** |
|---|---|
| Brand | =1 if brand is chosen, =0 otherwise |
| Price | Price of brand-Price of generics |
| Same_sex | =1 if patient and doctor-have the same sex, =0 otherwise |
| Pat_age 1 | =1 if the age of the patient:0-19, =0 otherwise |
| Pat_age 2 | =1 if the age of the patient: 20-39, =0 otherwise |
| Pat_age 3 | =1 if the age of the patient: 40-59, =0 otherwise |
| Pat_age 4 | =1 if the age of the patient: 60+, =0 otherwise |
| Dr_age 1 | =1 if the age of the doctor: 20-39, =0 otherwise |
| Dr_age 2 | =1 if the age of the doctor: 40-59, =0 otherwise |
| Dr_age 3 | =1 if the age of the patient: 60+, =0 otherwise |
| Dr_spec | =1 if the doctor is a General Practitioner, = 0 otherwise |
| Ph_chain 1 | =1 chain no 1, = 0 otherwise |
| Ph_chain 2 | =1 chain no 2, = 0 otherwise |
| Ph_chain 3 | =1 chain no 3, = 0 otherwise |
| Ph_chain 4 | =1 chain no 4, = 0 otherwise |
| Ph_chain 5 | =1 chain no 5, = 0 otherwise |
| Blue | =1 if reimbursed by government = 0 otherwise |
| N_DDD | Number of DDD, given chemical substance |
| New_generics | =1 if generics present in 2006, but not in 2004 |

| | |
|---|---|
| | = 0 otherwise |
| Reg_scheme | = 1 if index price regime in 2004<br>= 0 otherwise |

The summary statistics for the two months in 2004 and 2006 are given in Table 3. The prices are in NOK per DDD, and they are retail prices.

**Table 3a. Summary statistics: February 2004. 102 201 observations**

| Variable name | Mean | Std.dev. | Min | Max |
|---|---|---|---|---|
| Brand | 0.4974 | 0.5000 | 0 | 1 |
| Price | 6.1415 | 7.2271 | 0.2810 | 940.2756 |
| Same_sex | 0.5170 | 0.4997 | 0 | 1 |
| Pat_age 1 | 0.0167 | 0.1280 | 0 | 1 |
| Pat_age 2 | 0.0955 | 0.2940 | 0 | 1 |
| Pat_age 3 | 0.2857 | 0.4518 | 0 | 1 |
| Pat_age 4 | 0.6020 | 0.4895 | 0 | 1 |
| Dr_age 1 | 0.1988 | 0.3991 | 0 | 1 |
| Dr_age 2 | 0.6564 | 0.4749 | 0 | 1 |
| Dr_age 3 | 0.1448 | 0.3518 | 0 | 1 |
| Dr_spec | 0.8524 | 0.3548 | 0 | 1 |
| Ph_chain 1 | 0.2448 | 0.4300 | 0 | 1 |
| Ph_chain 2 | 0.3498 | 0.4769 | 0 | 1 |
| Ph_chain 3 | 0.2280 | 0.4195 | 0 | 1 |
| Ph_chain 4 | 0.1501 | 0.3572 | 0 | 1 |
| Blue | 0.7934 | 0.4048 | 0 | 1 |
| N_DDD | 97.0995 | 83.7055 | 0.5000 | 1045.3330 |
| Reg_scheme | 0.2357 | 0.4244 | 0 | 1 |

**Table 3b. Summary statistics: February 2006. 210 877 observations**

| Variable name | Mean | Std.dev. | Min | Max |
|---|---|---|---|---|
| Brand | 0.5201 | 0.4996 | 0 | 1 |
| Price | 8.0554 | 23.6126 | 0.0890 | 893.4033 |
| Same_sex | 0.5230 | 0.4995 | 0 | 1 |
| Pat_age 1 | 0.0121 | 0.1094 | 0 | 1 |
| Pat_age 2 | 0.0670 | 0.2499 | 0 | 1 |
| Pat_age 3 | 0.2550 | 0.4359 | 0 | 1 |
| Pat_age 4 | 0.6660 | 0.4717 | 0 | 1 |
| Dr_age 1 | 0.1959 | 0.3969 | 0 | 1 |
| Dr_age 2 | 0.6305 | 0.4827 | 0 | 1 |
| Dr_age 3 | 0.1736 | 0.3788 | 0 | 1 |
| Dr_spec | 0.8653 | 0.3414 | 0 | 1 |
| Ph_chain 1 | 0.2008 | 0.4006 | 0 | 1 |
| Ph_chain 2 | 0.3297 | 0.4701 | 0 | 1 |
| Ph_chain 3 | 0.2816 | 0.4498 | 0 | 1 |
| Ph_chain 4 | 0.1575 | 0.3643 | 0 | 1 |
| Blue | 0.8637 | 0.3430 | 0 | 1 |
| N_DDD | 114.9059 | 89.6818 | 0.2500 | 2800.0000 |
| New_generics | 0.3628 | 0.4808 | 0 | 1 |

We note that there are more observations in 2004 than in 2006. The reason is that more drugs become available for generic competition. On average every second prescription ends up with a brand-name being dispensed by pharmacy. In 2006 this ratio has increased slightly, and as shown below, this is due to the entry of new generic markets. In 2006 66 % of the patients are of age 60 or older, and 63 % of the doctors are of age 40 to 60.

The market shares of the pharmacy chains are stable, with a market share of 33 % in 2006 for the largest one. Note that there are five different pharmacy categories. There are three pharmacy chains Apotek 1 (owned by a Finnish company Tamro), Vitus (owned by a German company Celesio), and Alliance (owned by Alliance Boots). In addition there are the group of hospital pharmacies and a few small independent retail pharmacies.

In 2006, 86 % of the prescriptions were dispensed to patient covered by the national insurance scheme.

## 4. The econometric model

The problem we analyse is the patient's/doctor's choice of a drug when both the original (brand-named) and previously patented product and generics are available in the market. To model this choice of generic substitution we will apply a random utility model.

Let $U_{Bjn}$ be the utility for patient/doctor *n* of choosing the brand-name version of the chemical substance *j* and let $U_{Gjn}$ be the utility of choosing a generic version of the same substance. Let $X_{kjn}$ be a vector of individual and/or substance specific explanatory variables, k=B (brand), G (generic), and let $\beta$ be the corresponding vector of unknown coefficients. Furthermore let $\varepsilon_{kjn}$ , k=B,G, be random taste-shifter, i.i.d. extreme value distributed with zero expectation and variance $\sigma^2$. The latter variance is also called the scale coefficient. Then

$$(1) \quad U_{kjn} = \alpha_{kj} + X_{kjn}\beta + \varepsilon_{kjn}; k = B, G$$

where $\alpha_j$ is chemical substance specific constant.

We observe that $\frac{\varepsilon_{kjn}}{\sigma} = e_{kjn}$ is extreme value distributed with zero expectation and unit variance. Thus

(2) $U_{kjn} = \alpha_{kj} + X_{kjn}\beta + \sigma e_{kjn}$

or

(3) $W_{kjn} = a_{kj} + X_{kjn}b + e_{kjn}$

where

$W_{kjn} = \frac{U_{kjn}}{\sigma}, a_{kj} = \frac{\alpha_{kj}}{\sigma}, b = \frac{\beta}{\sigma}$

Let $\varphi_{kjn}$ denotes the probability that agent n chooses alternative$\{k,j\}$. By assuming utility maximization we get

(4) $\varphi_{Bjn} = \Pr(W_{Bjn} \geq W_{Gjn}) = \frac{\exp(a_{Bj} + X_{Bjn}b)}{\exp(a_{Bj} + X_{Bjn}b) + \exp(a_{Gj} + X_{Gjn}b)}$

or

(5) $\varphi_{Bjn} = \frac{\exp(a_j + (X_{Bjn} - X_{Gjn})b)}{1 + \exp(a_j + (X_{Bjn} - X_{Gjn})b)}$

where

$a_j = a_{Bj} - a_{Gj}$

and

(6) $\varphi_{Gjn} = 1 - \varphi_{Bjn} = \frac{1}{1 + \exp(a_j + (X_{Bjn} - X_{Gjn})b)}$

We will assume that $a_j$ are random coefficients, normally distributed across the chemical substances, with expectation $\bar{a}$, variance $\mu^2$ and correlation coefficient $\rho$. When estimating the model, the random part has to be integrated out of the probabilities. Note that when the coefficients $a_j$ are random, the IIA assumption is avoided.

## 5. Empirical results

The unknown coefficients $\bar{a}, b, \mu, \rho$ are estimated in a mixed logit maximum likelihood procedure, see Train (2003). The estimates, including the marginal effects and the 95% confidence interval of marginal effects, are reported in Tables 4 and 5.

**Table 4 Estimates of the probability of choosing brand, and their marginal effects. 2004**

| Variable name | Estimates | t-values | Marginal effects | 95%confidence interval |
|---|---|---|---|---|
| Constant ( $\bar{a}$ ) | -5.0885 | -36.3 | | |
| Price | -.0954 | -56.8 | -.0228 | -.02361; -.0221 |
| Same_sex | .0818 | 5.2 | .0195 | .0122; .0269 |
| Pat_age 2 | 1.0986 | 8.7 | .2661 | .2094; .3229 |
| Pat_age 3 | 1.8931 | 15.5 | .4376 | .3895; .4857 |
| Pat_age 4 | 2.4029 | 19.7 | .4969 | .4582; .5356 |
| Dr_age 1 | -.0543 | -1.9 | -.0128 | -.0259; .0003 |
| Dr_age 2 | -.0340 | -1.5 | -.0081 | -.0185; .0023 |
| Dr_spec | 0.1405 | 6.2 | .0331 | .0227; .0434 |
| Ph_chain 1 | -.1321 | -2.5 | -.0310 | -.0555; -.0065 |
| Ph_chain 2 | .3959 | 7.5 | .0954 | .0705; .1204 |
| Ph_chain 3 | -.2241 | -4.2 | -.0524 | -.0766; -.0282 |
| Ph_chain 4 | -.0565 | -1.0 | -.0131 | -.0385; 0.0122 |
| Blue | 4.0053 | 86.5 | 0.5779 | .5730; .5827 |
| N_DDD | .0012 | 12.5 | 0.0003 | .0003; .0004 |
| Reg_scheme | -1.2239 | -68.1 | -.2623 | -.2691; -.2556 |
| $\mu$ | .2261 | 23.1 | | |
| $\rho$ | .0155 | 11.7 | | |
| No of observations | 102201 | | | |
| McFaddens rho | 0.2993 | | | |

**Table 5. Estimates of the probability of choosing brand, and their marginal effects. 2006**

| Variable name | Estimates | t-values | Marginal effects | 95%confidence interval |
|---|---|---|---|---|
| Constant ( $\bar{a}$ ) | -4.4350 | -55.0 | | |
| Price | -.0129 | -52.7 | -.0032 | -0033; -.0031 |
| Same_sex | .0190 | 1.9 | .0047 | -.0001; .0094 |
| Pat_age 2 | .9617 | 12.7 | .2234 | .1927; .2541 |
| Pat_age 3 | 1.5556 | 21.3 | .3547 | .3268; .3826 |
| Pat_age 4 | 1.9711 | 27.2 | .4447 | .4182; .4712 |
| Dr_age 1 | -.0455 | -2.7 | -.0112 | -.0193; -.0031 |
| Dr_age 2 | -.0249 | -1.9 | -.0062 | -.0127; 0.0003 |
| Dr_spec | .0409 | 2.7 | .0101 | .0029; .0174 |
| Ph_chain 1 | -.0593 | -2.1 | -.0147 | -.0287; -.0007 |
| Ph_chain 2 | 1.2349 | 43.1 | .2926 | .2804; .3048 |
| Ph_chain 3 | -.0183 | -3.8 | -.0268 | -.0405; -.0131 |
| Ph_chain 4 | .3980 | 13.5 | .0974 | .0835; .1113 |

| | | | | |
|---|---|---|---|---|
| Blue | 2.1031 | 97.0 | .4318 | .4260; .4375 |
| N_DDD | .0023 | 38.1 | .0005 | .0005; 0.0006 |
| New_generics | .7141 | 65.8 | .1738 | .1687; .1788 |
| $\mu$ | .2326 | 22.7 | | |
| $\rho$ | .0162 | 11.5 | | |
| No of observations | 210 877 | | | |
| McFaddens rho | 0.1595 | | | |

*5.1 Price response of generic substitution*

The estimates imply that the probability of choosing brand is decreasing in the price differential between the brand and generics. The price impact is sharply estimated and it implies that the generic substitution may occur due to price differentials. However, the marginal impacts are not strong compared to the impact of other variables. This is particular the case of 2006.

The price elasticity related to the probability $\varphi_{Bjn}$ is given by the following formula:

$$(7) \quad El\left[\varphi_{Bjn} : q_j\right] = \frac{q_j}{\varphi_{Bjn}} \frac{\partial \varphi_{Bjn}}{\partial q_j} = b_P(1-\varphi_{Bjn})q_j \ .$$

Here $q_j$ denotes the price differential $P_{Bj}$-$P_{Gj}$ and $b_P$ the coefficient attached to the price in the probabilities. In order to get an overall price elasticity one has to take the weighted average across the ATC codes (j indicates the ATC code; that is the chemical substances) and across individuals. In addition one has to integrate out the random elements related to the coefficients $a_j$. Doing this we get the following weighted elasticities:

2004

| Weighted average elasticity | 95% confidence interval |
|---|---|
| -.3475 | -.3601; -3348 |

2006

| Weighted average elasticity | 95% confidence interval |
|---|---|
| -.0508 | -.0527; -.0489 |

We thus observe that the price responses are moderate and considerably weaker in 2006 than in 2004.

*5.2. Importance of doctor and patient characteristics*

In 2004 the probability of choosing brand was significantly higher when the patient and the doctor were of the same sex. In 2006 the tendency is the same, but the impact is not significant. In both years the probability of choosing brand is increasing with the age of the patient. Thus, brand loyalty is increasing with the age of the patient. In the same vein the probability of choosing brand is increasing with the age of the doctor. The impact is significant or close to significant, in both years, and indicates that in particular the youngest doctor is more willing to prescribe generics than their older colleagues.

Approximately 85 % of the prescriptions are written by general practitioner doctors, both in 2004 and 2006. These doctors are estimated to be more likely to end with patients choosing brand-name drugs.

The estimates of the impact of "blue" on the probability of choosing brand are positive and the marginal impact is strong. This is what one should expect. "Blue" means that the government is reimbursing a large part of the expenses, and the doctor/patient thus has a weaker incentive to switch to cheaper generic versions. Note that if the doctor explicitly claims in the prescription that the brand name should be used, the patient does not have to pay for the price-difference between the brand-name and a generic version. This difference is covered entirely by the insurance scheme. This result is consistent with the moral hazard problem arising between the insurer and the doctors.

*5.3 Market and institutional characteristics*

According to the rule of generic substitution in Norway, the pharmacy should dispense the cheapest generic to the patient, unless that the doctor or patient has said explicitly that this should not be done. Patients who are indifferent between brand-name and generic will accept the version provided by the pharmacy. Others may oppose, and after receiving information and advises, still stick to a brand-name version, but then at an extra cost of the patient reflecting the price

difference. There are also cases in which the patient after more careful information from the pharmacist accepts to substitute.

The incentives to spend effort convincing a patient to accept substitution are affected by the producer prices. If the pharmacy margin is largest on a generic drug, these incentives are strictly positive, while being absent if the margin is larger on brand-name drugs. Of the five pharmacy chains (including the group of independent pharmacies) in Norway, chain no. 2 stands out from the others with an estimate that imply that this chain is more inclined to give the patient the original and previously patented product. This effect is very strong. Looking at the marginal impact, we observe that a patient receiving the drug from chain no. 2 is 15 % more likely to end up with a brand-name drug compared to patients receiving drug from chain no. 3 in 2004. In 2006 this difference has increased to 32 %.

Of particular interest is the result of the impact of the index price regime on the choice of brand versus generics. As mentioned above, in 2004 this regime should give the pharmacy an incentive to dispense cheaper versions. In our dataset there are four chemical substances that were covered by this regime in 2004 (the *reg_scheme* dummy). For these substances, the probability of choosing brand turns out to be lower than for other substances. The impact is strong, with 26 % lower probability of choosing brand-name versions. This result is in line with results derived by Brekke et al. (2008). They find that the index-price scheme had a significant and strong impact on prices, both of generic and brand-name versions.

*5.4 New generic markets*

In the 2006 results, the dummy-variable "New_generics" identifies chemical substances that experienced generic entry after 2004. It takes time to adjust to new products, and brand loyalty may contribute to slow down the process of having the original product replaced by the cheaper generics. Therefore, we expect generic substation to behave differently in newer generic markets. This is confirmed in our estimates for 2006. The marginal impact of the "new generics" dummy is sizeable, positive on the demand for brand, and highly significant.

We also see that the price response of substitution is much lower in 2006. As reported above, the price elasticity changes from -0.34 in 2004 to the very low level of -0.05 in 2006. More generally, we also see that the explanatory power of the variables included in the model fall from 2004 to 2006. McFadden's rho is 0.30 in 2004, but drops to 0.16 in 2006.

In order to investigate further the effect of new the generic market for generic substitution, we estimated the model separately on the drugs that first experienced generic competition after 2004 (and therefore not included in the 2004 data), and on the drugs that were included in the 2004 data (older generic markets). The results are reported in Tables 6 and 7 below:

**Table 6 New generic markets. Estimates of the probability of choosing brand, and their marginal effects for drugs experiencing generic entry after 2004.**

| Variable name | Estimates | t-values | Marginal effects | 95%confidence interval |
|---|---|---|---|---|
| Constant ( $\bar{a}$ ) | -.1956 | -1.5 | | |
| Price | -.0131 | -52.1 | -.0030 | -.0031; -.0028 |
| Same_sex | -.0984 | -6.1 | -.0225 | -.0298; -.0152 |
| Pat_age 2 | -.0326 | -.3 | -.0074 | -0634.; .0484 |
| Pat_age 3 | -.0978 | -.8 | -.0225 | -.0773; .0321 |
| Pat_age 4 | .1672 | 1.4 | .0387 | -.0161; .0935 |
| Dr_age 1 | .1041 | 3.8 | .0236 | .0114; .0358 |
| Dr_age 2 | .0518 | 2.4 | .0118 | .0019; .0218 |
| Dr_spec | -.0813 | -3.3 | -.0184 | -.0294; -.0074 |
| Ph_chain 1 | .1634 | 3.3 | .0369 | .0154; -.0585 |
| Ph_chain 2 | 1.2063 | 24.14 | .2517 | .2336; .2697 |
| Ph_chain 3 | -.1806 | -3.7 | -.0418 | -.0644; -.0193 |
| Ph_chain 4 | .4006 | -7.9 | .0876 | .0669; 0.1083 |
| Blue | .5989 | 19.1 | .1443 | .1291; .1594 |
| N_DDD | -.0000 | -0.2 | -0.0000 | -.00005; .00004 |
| No of observations | 73939 | | | |
| McFaddens rho | 0.0733 | | | |

**Table 7. Older generic markets. Estimates of the probability of choosing brand, and their marginal effects for drugs with generic competition established before 2004.**

| Variable name | Estimates | t-values | Marginal effects | 95%confidence interval |
|---|---|---|---|---|
| Constant ( $\bar{a}$ ) | -6.5117 | -44.4 | | |
| Price | -.2682 | -66.4 | -.0586 | -.0602; -.0569 |
| Same_sex | .0980 | 7.4 | .0213 | .0157; .0270 |
| Pat_age 2 | 1.3940 | 10.3 | .3334 | .2727; .3940 |
| Pat_age 3 | 2.6737 | 20.6 | .5821 | .5388; .6253 |
| Pat_age 4 | 3.1770 | 24.6 | .5430 | .5123; .5737 |
| Dr_age 1 | -.0465 | -2.1 | -.0101 | -.0195; -.0006 |
| Dr_age 2 | -.0436 | -2.4 | -.0095 | -.0171; -.0019 |
| Dr_spec | .0748 | 3.7 | .0161 | .0077; .0245 |
| Ph_chain 1 | -.4070 | -10.6 | -.0843 | -.0990; -.0696 |

| | | | | |
|---|---|---|---|---|
| Ph_chain 2 | 1.1706 | 31.1 | .2653 | .2485; .2821 |
| Ph_chain 3 | -.3057 | -8.3 | -.0652 | -.0801; -.0502 |
| Ph_chain 4 | .1355 | 3.5 | .0300 | .0130; .0470 |
| Blue | 4.1215 | 73.0 | .4653 | .4608; .4698 |
| N_DDD | .0005 | 7.3 | .0001 | .00008; 0.00015 |
| No of observations | 136938 | | | |
| McFaddens rho | 0.2773 | | | |

There are significant differences in generic substitution in new and older markets. The estimated probability of choosing the brand-name drug in a new generic market is 0.63. In older generic markets this amounts to 0.45.

The low price response indicated by the estimation on merged data is confirmed here. The marginal impact on the probability of choosing the brand is -0.06 for drugs with earlier generic entry, but drops to -0.003 for new generic markets. The estimate is still highly significant.

According to the estimates, patient age has no systematic effect on generic substitution in new generic markets. For all patient age groups, the estimated effect (relative to group of patients below the age of 40) is both weak and insignificant. Doctor's age has a significant effect on the substitution pattern. In older generic markets, older doctors are more loyal to the brand-name than their younger colleagues. The likelihood that a doctor of age below 40 ends up with a patient using a generic version is 1 % higher than for doctors above the age of 60. This changes when we look into newer generic markets. The likelihood that the patients of young doctors choose a brand-name version is now 2.4 % higher than for the patients of the oldest group of doctors.

Insurance status still has a strong effect on the substitution decisions. The probability that patients covered by the social insurance scheme choose the brand-name drug is 14 % higher than patients without coverage. In older generic markets, this difference amounts to 46 %.

Interestingly, the effect of pharmacy chain is still strong and significant. Again pharmacy chain 2 has a strong, and positive, effect on the probability of choosing the brand-name. The estimated magnitude of this effect is the same in older and new generic markets.

## 6. Conclusions

A binomial logit model with random effects has been employed to estimate the probabilities of choosing brand named drugs versus generics on a unique dataset containing the entire population of prescriptions in Norway in February 2004 and 2006. Two different regulatory schemes were present in these periods. We observe various characteristics of the patient and the doctor, together with price and other attributes of the drug and pharmacies. We find that price matter for the choice of drugs and that generic substitution driven by price differences is significantly weaker in markets where generics have recently been introduced. Patient and doctor characteristics have an impact on the choice of branded products versus generics. The younger the doctor and/or the patient are the more likely it is that a generic will be chosen. The ownership of the pharmacies matters also for the degree of generic substitution. One of the pharmacy chains operating in Norway is far more inclined to give the patient the branded product than generics. Finally we find that the regulatory scheme that was in use in 2004 but not in 2006 had a positive impact on the use of generics.

The Norwegian prescription data (NorPD) allows studies of the repeated decisions of both the patient and doctor. In further research we hope to develop a dynamic model, exploiting the panel structure of the data. Following the entire population of patients and prescribing doctors in Norway over several years offers a unique possibility of accounting for heterogeneity among decision makers in the drug market.

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