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Generic substitution, financial interests, and imperfect agency

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Abstract Policy makers around the world seek to encourage generic substitution. In this paper, the importance of prescribing physicians' imperfect agency is tested using the fact that some Swiss jurisdictions allow physicians to dispense drugs on their own account (physician dispensing, PD) while others disallow it. We estimate a model of physician drug choice with the help of drug claim data, finding a significant positive association between PD and the use of generics. While this points to imperfect agency, generics are prescribed more often to patients with high copayments or low incomes.

Keywords Physician agency · Prescribing behavior · Drug dispensing · Generic substitution · Brand-name drugs

JEL Classification I10 · I18 · I19

Introduction

Policy makers around the world seek to encourage generic substitution (i.e. the replacement of brand-name by generic drugs) in an attempt to reduce the pharmaceutical bill. In the United States for instance, several state policies promote the use of generic products by Medicaid beneficiaries (CMS 2004). Similar initiatives exist in Germany (Leutgeb et al. 2009), Sweden (Andersson et al. 2007), Switzerland (Decollogny and Ruggli 2006), and Japan (Matsuda 2008). To be successful, these initiatives must be aligned with prescribing physicians' (or pharmacists') incentives. Generic substitution not only requires effort and time on the part of these professionals but also entails the risk of meeting with patient resistance. Three components of prescribers' utility can work to overcome resistance against

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generic substitution. First, prescribers may earn higher contributions to income from generic than from brand-named drugs. Second, acting as agents by taking patients' total (rather than merely health-related) utility into account, physicians are predicted to prescribe the generic if the savings accruing to the patient are important enough. Third, in view of public concern about growing health care expenditure, cost savings accruing to insurers might motivate physicians to prescribe lower-priced generic drugs.

In this context, evidence from Switzerland is of considerable interest. In some Swiss jurisdictions (cantons), physicians are allowed to dispense drugs to their patients on their own account. This setting will be referred to as 'physician dispensing' (PD) in the remainder of this paper.[1] In the remaining jurisdictions, physicians are obliged to let a pharmacy fill their prescriptions. Thus, both the PD and the non-PD (i.e. pharmacy-based) setting can be observed under otherwise very similar conditions. PD may well affect generic substitution provided physicians act as imperfect agents and given that generic drugs differ from brand-name drugs in terms of their contribution to physician income.

Retail prices paid by patients are regulated to be equal for all drug sellers (physicians and pharmacies). The contribution to the sellers' income, then, is the difference between manufacturers' prices and retail prices. Concerning manufacturers' prices, there is room for discounts and individual bargaining, causing the effective contributions to income to be unknown. However, several factors indicate that contributions to physician income can be higher for generic than for brand-name drugs. First, many generic alternatives are usually available for the same brand-name drug, leading to fierce competition for access to prescribers among generic producers. Second, the retail prices of generic drugs are markedly higher in Switzerland than in comparable European countries, suggesting that generic producers have ample leeway for rebates to prescribers.[2] Third, while there is no public information about such rebates, interviews conducted with Swiss wholesalers and physicians support the notion that prescribers derive more income from generic than brand-name drugs.

The remainder of this article is structured as follows. Section 2 contains a short review of the literature. Section 3 describes the institutional setting. Section 4 presents a theoretical model of physician prescribing behavior, along with a set of testable hypotheses. The empirical strategy used for hypothesis testing is explained in Sect. 5. Section 6 contains a description of the data. Results are shown in Sect. 7, while Sect. 9 rounds off with a summary and conclusions.

Literature review

To keep this survey concise, there will be no discussion of research into physician behavior in general. Rather, focus is on prescribing behavior. An early pertinent study is the one by Morton-Jones and Pringle (1993), who compare prescription patterns of PD and non-PD providers in the UK, finding that the share of generic drugs is lower in the PD segment. Liu et al. (2009) analyze the choice between generic and brand-name drugs in Taiwan, where PD is the dominant mode. According to them, financial incentives markedly influence this choice. Specifically, providers on a global budget are more likely to prescribe generic drugs than those reimbursed fee-for-service. Moreover, cheaper brand-name drugs (which in Taiwan

[1] PD is the counterpart of prescribing pharmacists, who exist e.g. in the case of refills in the United States, Canada, the United Kingdom, and New Zealand (Emmerton et al. 2005). In both cases, the prescriber and the dispenser is one and the same person or institution, respectively.

[2] The prices for brand-name drugs are also higher in Switzerland, but the markups for physicians are smaller (see Sect. 3.2).

contribute less to physician income, as in Switzerland) are more often replaced by generics than expensive ones. Using Japanese data on hypertension drug sales, Iizuka (2007) concludes that markups available to physicians significantly influence drug choice. However, he also finds that physicians take the cost of the drug to their patients into account. Finally, the 2000 reform in South Korea provides an interesting natural experiment. At that time, both drug dispensing by physicians and drug prescribing by independent pharmacists were outlawed. Descriptive statistics presented by Kim and Ruger (2008) indicate a marked increase in the market share of high-price drugs in the year following the reform. However, the longer-term effects of the reform could not be assessed on the basis of their data.

Papers that are methodically related to ours are Hellerstein (1998), Lundin (2000), and Hellstrom and Rudholm (2010). They analyze the choice between generic and brand-name drugs in a non-PD setting. Hellerstein argues that physicians bear higher information costs when prescribing generic rather than brand-name drugs because they have more personal experience with the brand-name than with the generic drugs. Contrary to the hypothesis of perfect agency, she finds that prescription is not influenced by patients' insurance status and hence financial burden. However, physicians who predominately treat patients in capitated or Health Maintenance Organization (HMO) settings are more likely to prescribe generics (controlling for individual insurance status). Her panel data specification also shows that a large part of the unexplained variance is physician-specific, which also holds true of Lundin's contribution. Interestingly, Lundin argues that physicians may want to honor R&D expenditure and pioneering effort by innovators, causing them to bear added psychic cost when prescribing a generic. He finds evidence that higher cost to the patient through copayment increases the probability of generics being prescribed, while higher cost to the insurer does not. Hellstrom and Rudholm argue that the uncertainty about the quality of generic drugs incites physicians to prescribe brand-name drugs. Their empirical evidence shows that physicians are indeed less likely to allow generic substitution for older (and presumably sicker) patients. However, their measure of uncertainty about quality came out insignificant in the decision equation.

Another reason why the prescription of generic drugs might require extra effort on the part of the physician is given by Griliches and Cockburn (1994). They argue that many patients perceive generic drugs as less safe and of lower quality, making the patient suffer a 'putative loss' when using them. Therefore, a physician prescribing the generic drug needs to convince the patient of its bioequivalence.

To our knowledge, there is no Swiss study that analyzes the effect of PD on the choice between generic and brand-name drugs. The one exception is Hunkeler (2008) who presents corroborating evidence for the hypothesis that PD leads to margin optimization or even margin maximization[3] through dispensing packages and dosages with higher official physician margins. These packages are launched first by companies entering the generics market; later, they are complemented by additional package sizes and dosages (for more institutional detail regarding Swiss health insurance, see Sect. 3). The other studies of PD in Switzerland have focused on its impact on total physician billings or health care expenditure (HCE), respectively. An early investigation by Zweifel (1985) concluded that while PD creates incentives to keep patients out of the hospital (where different physicians are in charge as a rule), the savings achieved through a reduced rate of hospitalization fall short of the extra drug expenditure induced in ambulatory care. At a more aggregate level, Dummermuth (1993) compares two otherwise similar neighboring cantons (Lucerne with PD and Argovia without PD), finding

[3] The difference between margin optimization and maximization is that in the first case, PD providers prescribe several small packages instead of one large package while in the second case, they prescribe a higher quantity to maximize their income.

PD to be associated with slightly higher per capita drug expenditure as well as HCE. This finding is in line with Beck et al. (2004), who relate per-capita drug expenditure to several properties of cantons, among them, their PD status. By way of contrast, Vatter and Ruefli (2003), who control for a very comprehensive set of political and socioeconomic covariates, indentify a significantly negative effect of the share of PD providers on per capita HCE. More surprisingly still, Schleiniger et al. (2007) estimate a significantly negative effect of PD on cantonal drug expenditure which is robust across several specifications.

Institutional setting

Basic health insurance coverage in Switzerland written by some 80 competing private not-for-profit insurers is mandatory for a broad basket of services and drugs. Physicians in private practice are mostly paid according to a nationwide uniform fee schedule called TARMED [see Zweifel and Tai-Seale (2009) for description and criticism].[4] Provision of health care is decentralized and the 26 Swiss cantons ('jurisdictions') have considerable say in its regulation, including the regulation of drug dispensing.

Physicians' dispensing rights

Thirteen of the twenty-six Swiss cantons give dispensing rights to all physicians, seven apply mixed systems while six generally disallow PD. Physicians who dispense on average derive about 18 % of their revenue from PD. This number is higher for general practitioners (28 %) and lower for specialists (8 %) (see Hunkeler 2008). Therefore, the financial incentives linked with the amount and structure of PD are substantial. Acknowledging problems of asymmetric information between physicians and patients, some cantons with PD require physicians to inform patients about their right to obtain a prescription to be filled by the pharmacy of their choice.

In the context of the present study, an important question is whether cantons that allow PD attract substantially different types of physicians than do non-PD cantons. Since the data is provided by a health insurer, they do not contain information about the determinants of locational choice such as regional origin of the physician and her spouse, or the location of her medical school. This makes an analysis of physicians' choice of location impossible. Moreover, it is known that young physicians mainly take over existing practices rather than opening new ones in response to large administrative hurdles, resulting in a narrowed choice of location. Still, if physicians who are very susceptible to financial incentives are disproportionately located in the PD cantons, our estimates in Sect. 7 might be upwardly biased.[5]

Physicians in cantons without PD write prescriptions to be filled by a pharmacy of the patient's choice. The same is true for non-dispensing physicians in cantons with PD. In contrast to other countries, prescriptions in Switzerland contain the names of specific pharmaceuticals, not of active agents. Pharmacists are allowed to substitute the prescribed pharmaceutical by a cheaper generic on the condition that they inform the prescribing physician. However, as this requires considerable effort, generic substitution by pharmacies is not widely practiced. Being subject to coinsurance, patients have an incentive to ask for the

[4] A small number of physicians works in managed-care type arrangements, where other modes of payment are possible.

[5] This may be true although dummy variables for cantons and community types are included in the estimation in order to control for differences between regions (see Sect. 7).

cheaper generic as long as they have not reached their stop-loss limit. This incentive is the same across all cantons of Switzerland, irrespective of their PD legislation.

In the context of the present study, it is important to note that the prices of drugs are regulated and the same regardless of whether they are dispensed by a physician or a pharmacy. In addition, copayments as described in Sect. 3.3 do not differ between the PD and the non-PD modes.

Contributions to income from drug dispensing

For non-PD practitioners, the contribution to income from dispensing is zero. For PD practitioners, the contribution earned by selling a specific drug consists of three components, namely (i) a fixed lump sum, (ii) a percentage of the regulated manufacturer price, and (iii) discounts that are conceded to physicians by pharmaceutical companies. The first two components are regulated by the government and published in official registers. The third component is the outcome of an individual bargaining process between prescriber and sales representative, which is unobservable to us. However, they ultimately reflect the bargaining position of the pharmaceutical company, about which a few facts are known.

According to Liu et al. (2009), the discount on manufacturers' prices offered increases with market size, competition, and retail price but decreases with marginal cost. First, market size is small in Switzerland for both brand-name and generic drugs. With regard to competition, the market usually contains one brand-name drug only but a large number of generic alternatives (more than 10 in this analysis). Therefore, producers of generic drugs are more likely to use discounts in their attempt to increase market share. Next, marginal cost of brand-name and generic drugs can be assumed equal in the present setting.

In addition, international comparisons of reimbursement prices offer indirect evidence suggesting that generic producers in Switzerland have ample leeway for discounts. For fixing the reimbursement price of brand-name drugs, Switzerland uses a reference group comprising Germany, Denmark, UK, the Netherlands, France, Italy, and Austria. Reimbursement prices for generic drugs have to be at least 40 % lower than those of the original drug. However, this does not imply that generic producers earn lower effective margins. In fact, Santesuisse (2009) and IMS (2009) calculate price indexes for drugs with and without patent protection for Switzerland and the seven countries cited above. The two studies conclude that both prices for band-name (p_b) and generic drugs (p_g) are higher in Switzerland, i.e. $\Delta p_b = p_b - p_b^R > 0$ and $\Delta p_g = p_g - p_g^R > 0$, where R denotes the average drug price in the reference group. But they also find that the international price difference is larger in the case of generic than for brand-name drugs ($\Delta p_g > \Delta p_b$).[6] Assuming that producers have the same cost structure in Switzerland and elsewhere, the extra profit margin earned in Switzerland is therefore higher for generic than for brand-name producers, i.e. $\tilde{m} = \Delta p_g - \Delta p_b > 0$. They can use their net advantage $\tilde{m}$ for inducing physicians to prescribe their products.

In all, manufacturers of generic drugs are likely to offer larger discounts to physicians than brand-name producers. Indeed, interviews conducted with Swiss wholesalers and physicians support the notion that prescribers derive more income from generic drugs, although no market participant is willing to publish the exact discounts that are offered or accepted.

[6] The regulation of reimbursement allows generic producers to charge higher prices in Switzerland than elsewhere in Europe. In Switzerland, generic drugs have to be at least 40 % cheaper than the brand-name drugs. Thereafter, insurers are obliged to reimburse each price that is set by generic producers. By way of contrast, many European countries install reimbursement ceilings that are oriented towards the cheapest prices that are offered in the market (internal reference pricing, Vogler et al. 2008). If the price exceeds the ceiling, the difference needs to be paid by the insured, which is avoided by most generic producers.

In the context of the present study, it is important to note that the law forbids to give, promise or accept any monetary or monetary equivalent reward for the prescription of a specific drug. Therefore, manufacturers are not allowed to promise rewards (for example higher discounts) for the achievement of a higher sales volume.

Copayment arrangements

Prescription drugs are covered by compulsory health insurance, which kicks in when the annual deductible is exceeded. The minimum annual deductible amounts to CHF 300 (1 CHF $\approx$ 1.1 USD at 2011 exchange rates). Voluntary deductibles range from CHF 500 to 2,500 and are chosen by the insured at the beginning of the year. The deductible applies to all health care services except those related to maternity. When the deductible is exceeded, there is a 10 % rate of coinsurance up to a stop-loss of CHF 700 per year, independent of the chosen deductible. For instance, a patient with a deductible of CHF 2,500 would spend a maximum of CHF 3,200 out of pocket. For certain brand-name drugs, the rate of coinsurance was increased to 20 % during our observation period (2005–2007) to increase generic substitution. Prior to this policy change, the coinsurance rate was 10 % regardless of drug version. Under the new regulation, producers of brand-name drugs can escape this increased coinsurance by lowering their prices. As a consequence of different deductibles and changing rates of coinsurance, some patients have a stronger interest in receiving cheaper drugs than others.

Theoretical model of physicians' drug choice

Because of their central role in the resource allocation in health care markets, the behavior of physicians has spawned a very rich literature (see McGuire 2000 for an overview). The purpose of this section is to derive testable hypotheses concerning generic drug substitution from existing theoretical models. Many of these models posit patients' health benefit as an argument in the physician's objective function. Thus, a physician (i) who prescribes a drug (d) to a patient (j) at time (t) has utility

$$V_{ijdt} = \alpha_i \left[\pi_{idt} - e_{ijdt}\right] + \beta_i \left[b_{jd} - \theta_{jdt}\, p_{dt} u'\{Y_{jt}\}\right] - \gamma_i \left[(1 - \theta_{jdt})\, p_{dt}\right] \quad (1)$$
$$\text{with } \pi_{idt} = f_{dt} + v_{dt}\, p_{dt} + \eta_{idt}.$$

Here, π_{idt} denotes the contribution to physician income. As explained in Sect. 3.2, it consists of a fixed lump sum (f_{dt}), a price-dependent component ($v_{dt}\, p_{dt}$), and an unobserved discount that is the outcome of an individual bargaining process between the physician and the pharmaceutical company (η_{idt}). For the reasons listed in Sect. 3.2, we assume that both discounts and total contributions to physician incomes are higher for generic than for brand-name drugs.

The effort (in money terms) associated with prescribing is denoted e_{ijdt}. In keeping with the literature cited in Sect. 2, this effort is higher for a generic ($d = g$) than a brand-name ($d = b$) drug. For simplicity, the cost of prescribing b is normalized to zero ($e_{ijbt} = 0$). The higher prescribing effort for generic drugs stems from two main sources. First, the physician needs to gather personal experience with the generic drug, which she has already collected for the brand-name drug during the period of patent protection. This cost decreases over time, hence the dependence on time index t. Still, every patient is different, making matching patients with drugs challenging even after an initial information effort. Second, the physician needs to convince the patient that the lower-priced generic drug is not of lower quality.

Table 1 Types of (im)perfect agency

Types of agency	Parameter values		
	Physician	Patient	Society
Perfect agency	$\alpha_i = 0$	$\beta_i > 0$	$\gamma_i > 0$
Imperfect agency on behalf of patients	$\alpha_i > 0$	$\beta_i > 0$	$\gamma_i \geq 0$
Imperfect agency on behalf of insurers	$\alpha_i > 0$	$\beta_i \geq 0$	$\gamma_i > 0$
Lack of agency	$\alpha_i > 0$	$\beta_i = 0$	$\gamma_i = 0$

Otherwise, the patient might suffer a 'putative loss' in the sense of Griliches and Cockburn (1994), which might jeopardize the physician's reputation. This cost also declines over time as patients become acquainted with the generic drug. The parameter $\alpha_i > 0$ in Eq. (1) denotes the weight the physician attaches to the drug's contribution to income. It may well differ between GPs and specialists.

The second term of Eq. (1) symbolizes net patient benefit. Therefore, a weight $\beta_i > 0$ (with no systematic difference between GPs and specialists assumed) reflects a consideration for the patient's *total utility* derived from health benefit and disposable income (Bradley and Lesu 2006; De Jaegher and Jegers 2000) rather than merely for the patient's *health benefit* (Ellis and McGuire 1986). Net patient benefit equals health benefit b_{jd} minus the drug's out-of-pocket price $\theta_{jdt} p_{dt}$, with θ_{jdt} denoting the patient's rate of coinsurance (which can be drug-specific) and p_{dt}, the price of the drug. The patient's utility from consuming other goods is $u\{Y_{jt}\}$, which is increasing and concave in patient's income Y_{jt} as well as additively separable from health. Since copayment for a single drug $\theta_{jdt} p_{dt}$ is small in our context, multiplying it by $u'\{Y_{jt}\}$ yields a good approximation of its impact on patient utility. As low-income patients have a high marginal utility of income, they suffer a particularly high utility loss from a given drug cost $\theta_{jdt} p_{dt}$. In the remainder of this paper, there will be no difference in health benefits between the brand-name and the generic drugs ($b_{jb} = b_{jg}$) because bioequivalent drugs are compared (see Sect. 6 for details).

The third term of Eq. (1) is motivated by agency on behalf of the insurers. Agency towards insurers can be motivated by fear of sanctions or tighter regulation in future.[7] Both types of threats concern GPs and specialists alike. Moreover, high and rapidly increasing health insurance premiums are one of the top concerns of the Swiss population. Therefore, promoting a cost-efficient practice style could create a warm-glow effect of doing what is good for society. Here, $(1-\theta_{jdt}) p_{dt}$ symbolizes the cost of the drug treatment falling on the patient's insurer, with $\gamma_i > 0$ indicating the importance of this concern. In view of Eq. (1), types of (im)perfect agency can be defined as in Table 1.

The generic drug is prescribed if $V_{ijgt} > V_{ijbt}$, hence

$$V_{ijgt} - V_{ijbt} = \alpha_i \psi \left[\pi_{igt} - \pi_{ibt} - e_{ijgt}\right] + \beta_i \left[(\theta_{jbt} p_{bt} - \theta_{jgt} p_{gt}) u'\{Y_{jt}\}\right] + \gamma_i \left[(1-\theta_{jbt}) p_{bt} - (1-\theta_{jgt}) p_{gt})\right] > 0. \quad (2)$$

Physician agency can now be analyzed with the help of Eq. (2). To begin with, non-dispensing physicians do not obtain income from drug prescription ($\pi_{igt} = \pi_{ibt} = 0$), while dispensing physicians are likely to receive a higher income contribution from generic than from brand-

[7] The Swiss health insurers' association (Santesuisse) scrutinizes physicians who exhibit inexplicably high cost of treatment compared to their peers and occasionally sues them.

name drugs ($\pi_{igt} > \pi_{ibt} > 0$, see Sect. 3.2).[8] PD is therefore expected to increase the prescription of generic drugs.

Hypothesis 1 Given imperfect or lack of agency, dispensing physicians are more likely to prescribe a generic drug compared to non-dispensing ones due to its higher income contribution.

Recall that due to bioequivalence, drug choice affects patient utility exclusively through differences in coinsurance. According to Eq. (2), both perfect and imperfect patient-related agency thus leads to the prediction that generic drugs are prescribed more often to patients with a high rate of coinsurance (high θ_{jdt}) or low income (high marginal utility of income, $u'\{Y_{jt}\}$), than to other patients.

Hypothesis 2 Given imperfect agency on behalf of patients, generic drugs are prescribed more often to patients with higher rate of coinsurance as long as the brand-name drug is more expensive than the generic, $p_{bt} > p_{gt}$.

Hypothesis 3 Given imperfect agency on behalf of patients, generic drugs are prescribed more to patients with lower incomes because of their higher marginal utility of income.

For the decision whether or not to prescribe a generic drug, only the sign of Eq. (2) is relevant. If the first term of Eq. (2) is zero (as for all non-dispensing physicians), the second term becomes relatively more important for the determination of its sign. Therefore, to the extent that agency motivates physicians to prescribe generic drugs, the effect of patient coinsurance should be more marked for non-PD providers.

Hypothesis 4 Given imperfect agency on behalf of patients, patients' rate of coinsurance is more influential if the physician does not dispense drugs on his or her own account.

Many models of physician agency neglect the third term of Eq. (2). However, if the influence of copayment represented by $[(\theta_{jbt}\, p_{bt} - \theta_{jgt}\, p_{gt})u'\{Y_{jt}\}]$ is low and $(\pi_{igt} - \pi_{ibt})$ is zero, as applies to non-PD providers, all that remains is the (extra) effort of prescribing the generic e_{ijgt}. Therefore, non-PD providers who treat patients with low coinsurance or high incomes should have a very low propensity to prescribe generics due to their higher cost of effort. It takes agency towards the payers of health care [$\gamma_i > 0$ in Eq. (2)] to make them prescribe a generic.

Hypothesis 5 Given agency on behalf of insurers, non-PD providers prescribe generic drugs to some degree.

In addition to the standard fee-for-service arrangement, Swiss insurers may also offer policies with managed care-type restrictions. Most of these arrangements are aimed at increasing the cost-consciousness of physicians, either by introducing provider cost sharing or by selectively contracting physicians based on indication of efficiency. In both cases, these arrangements are expected to align the interests of physicians with those of the insurers, resulting in an increased influence of the price difference $(p_{bt} - p_{gt})$ on physicians in managed care-settings.

Hypothesis 6 Physicians working in managed care-type settings prescribe more generic drugs because of their increased consideration of the cost of care.

[8] In fact, non-dispensing physicians get a fee (TARMED) for prescribing a drug, which however does not differ between brand-name and generic drugs. This fee is therefore irrelevant to our analysis.

A limitation of our model is that it focuses on physician utility only. This is justified to the extent that asymmetric information about treatment options makes patients delegate their decision-making authority to physicians. However, this delegation is unlikely to be complete in practice. If patients play a more active role, observed choices are the outcome of a bargaining process between them and physicians (Ellis and McGuire 1990). It is important to keep this limitation in mind when interpreting the empirical results in Sect. 7. For example, the patient's rate of coinsurance may impact drug choice not only because of physician agency (as our model suggests), but also because of the patients' own actions.

Econometric specification

We estimate the choice between brand-name and generic drugs using a binary choice model. The dependent variable takes on the value one if the physician prescribes g and zero otherwise. Following Ben-Akiva and Lerman (1985), the physician's utility is split into a deterministic and a random component, i.e. $U_{ijdt} = V_{ijdt} + \varepsilon_{ijdt}$, where ε_{ijdt} is unobserved by the researcher. A physician prescribes drug g instead of b if and only if $U_{ijgt} > U_{ijbt}$. Hence, the probability of physician i prescribing g to patient j at time t is given by

$$P_{ijgt} = Pr(V_{ijgt} + \varepsilon_{ijgt} > V_{ijbt} + \varepsilon_{ijbt}) = Pr(V_{ijgt} - V_{ijbt} > \varepsilon_{ijbt} - \varepsilon_{ijgt}) \quad (3)$$

with $V_{ijgt} - V_{ijbt}$ given by Eq. (2). If we assume the random term $\varepsilon_{ijt} \equiv \varepsilon_{ijbt} - \varepsilon_{ijgt}$ to have a logistic distribution, we get the logit choice probability

$$P_{ijgt} = \left(1 + e^{-(V_{ijgt} - V_{ijbt})}\right)^{-1} \quad (4)$$

which permits to derive and interpret odds ratios. The drawback of the logit model compared to the probit is that no simple estimators are available as soon as a physician-specific random effect is included. In the probit model, the linear combination of the normal error term and the normal random effect results in a normal distribution. This is not the case for the logit model (see Wooldridge 2002, Chap. 15). By including a physician-specific error term, we allow for within correlation among the observations belonging to the same physician while still assuming independence of observations across physicians. The physician-specific error captures unobserved factors that we are not able to control for (see also Lundin 2000). Examples of unobserved factors that may affect drug choice are favorable experience with a specific drug or the impact of pharmaceutical sales representatives visiting the physician. Therefore, we extend the random utility model above to allow for a physician-specific random effect, i.e. $U_{ijdt} = V_{ijdt} + \nu_i + \varepsilon_{ijdt}$. If $\nu \sim N(0, \sigma_\nu^2)$ one obtains the one-level random-effects logit model (see Wooldridge 2002, Chap. 15), with the share of total variance contributed by physician-level variance given by $\rho = \sigma_\nu^2/(\sigma_\nu^2 + \sigma_\varepsilon^2)$ where σ_ε^2 denotes the variance of the overall error term. In addition, one could allow for patient-specific random effects by nesting them with physician-level ones, resulting in a two-level hierarchical regression model (also called mixed-effects model, see Rabe-Hesketh et al. 2001). While theoretically attractive, the mixed-effects model could not be estimated due to the complexity of the estimation equation and the size of the dataset.[9] Therefore, we estimated the one-level random-effects model discussed previously. Testing the importance of the physician-specific error term using a likelihood ratio test showed that the one-level random-effects model performed better than the pooled logit regression.

[9] The mixed-effects model did not converge using Stata 10.

Table 2 Overview of the variables used for hypothesis testing

Variable	Term No. of Eq. (2)	Hyp. No.	Exp. sign	Confirmed?
PD	1	1	+	Y (O,A)
General Practitioner (GP)	1	n.a.	+	Y
Interaction of PD and GP	1	1	+	Y
Deductible category (DED2, DED3)	2	2	+	Y (O,A)
Interaction of PD and DED2, DED3	2	4	–	N
Increased rate of coinsurance (COINS)	2	2	+	Y
Interaction of PD and COINS	2	4	–	N
Extra hospital insurance (HOSP)	2	3	–	Y
Accident coverage (ACC)	2	3	–	Y (O,A)
High income area (HIA)	2	3	–	Y (O,A)
Price difference (P)	3	5	+	N (Y for O)
Interaction of PD and P	2, 3	n.a.	–	N (Y for O)
HMO contract (HMO)	3	6	+	Y
Gatekeeping contract (GATE)	3	6	+	Y

Control variables: six area types, 25 cantonal dummies, complementary insurance, time trend, patient age and sex, dosage, prescriptions per patient, year of first prescription
O omeprazole; *A* amlodipine

To estimate the coefficients of interest, the systematic component of the utility function $(V_{ijgt} - V_{ijbt})$ needs to be specified. Unfortunately, it is not possible to unambiguously relate the variables of the theoretical model to observed quantities. Still, it is possible to test all the hypotheses that were stated in Sect. 4. The assignments are displayed in Table 2.

As explained in Sect. 3.2, we cannot observe the *true* income contribution from physician dispensing, but we expect it to be higher for generic than for brand-name drugs [$\pi_{igt} - \pi_{ibt} > 0$ in Eq. (2)]. Therefore, we can only include a dummy that indicates whether or not a physician earns an income contribution from dispensing ($PD_{it} = 1$). We expect the coefficient pertaining to the income contribution to be positive, implying that PD increases the probability of choosing g.

The information cost (e_{ijgt}) in Eq. (2) cannot be measured and thus is absorbed by the random term. A dummy for general practitioners (GP) is interacted with PD to test for systematic differences in α_i of Eq. (2), i.e. whether GPs react in a different way to the financial incentives from PD than specialists do. A positive interaction effect is expected due to the lower average income of GPs and hence higher marginal utility of income.

Copayment borne by patients is known from the patient's health insurance policy on the one hand and the drug-specific rate of coinsurance on the other. As explained in Sect. 3.3, policies differ in terms of deductibles (DED). Physicians acting as agents [$\beta_i > 0$ in Eq. (2)] would want to keep patients' out-of-pocket cost low. The higher DED, the more they are expected to prescribe the cheaper generic (Hypothesis 2). In formulating this hypothesis, DED is viewed as exogenous. Admittedly, high deductibles are typically chosen by higher-income individuals, making θ_{jdt} a function of $u\{Y_{jt}\}$ in Eq. (2). However, the dataset lacks information that would permit to control for this relationship. Hypothesis (2) can be detailed further. Before January 2006, drug expenditure in excess of DED was subject to a 10 % coinsurance rate regardless of type g or b. A natural experiment is provided by the policy change of 2006, when the coinsurance rate for (some) brand-name drugs was increased from 10 to 20 % while it stayed at 10 % for generics. Producers of brand-name drugs can

Table 3 Sample shares and sales volumes of generic and brand-name drugs

Physician dispensed?	Omeprazole		Amlodipine		Ciprofloxacin	
	Yes	No	Yes	No	Yes	No
Sample share of generics	94 %	89 %	82 %	66 %	86 %	79 %
Sales of generics[a]	6.3	9.2	3.7	3.5	2.0	1.7
Sales of brand-names[a]	1.0	2.8	1.5	3.1	0.4	0.6

[a] Values are shown in CHF, mn. for the period between March 2005 and December 2007. 1 CHF ≈ 1.1 USD at 2011 exchange rates

escape the increased rate of coinsurance by lowering their prices, which is observed in our dataset (see Sect. 6). The effect of the patient's rate of coinsurance on drug choice can be tested by including a dummy COINS that is one if the prescribed drug faces the increased rate of coinsurance at the time of purchase and zero otherwise. In addition, an interaction term PD·COINS serves to test for the influence of financial incentives on physician agency. According to Hypothesis 4, its coefficient is predicted to be negative, indicating less additional generic substitution in the case of PD.

The hypothesis that generic drugs are prescribed less to patients with higher income due to their lower marginal utility of income (Hypothesis 3) is tested by including dummies for residence in a high-income area (HIA), the purchase of extra hospital insurance (HOSP), and the purchase of accident insurance (ACC). Accident coverage is inversely related to labor force participation because it is usually provided by the employer rather than the health insurer. It thus may be interpreted as an indicator of high income, causing less prescription of generics according to Hypothesis 3.

As to the third term of Eq. (2), Hypothesis 5 (bearing on γ_i, the role of agency on behalf of insurers) can be tested using the price difference between the brand-name and generic drug ($p_t = p_{bt} - p_{gt}$), to be detailed below. Concerning the relevance of this agency, the following argument can be made. Beyond the deductible, the price difference borne by patients is very small compared to average income. Thus, it is unlikely that consideration for the patients' coinsurance [second term in Eq. (2)] provides enough motivation for most of non-dispensing physicians to bear the greater cost of prescribing generic drugs (e_{ijgt}). Therefore, the fact that the market share of generic drugs in our dataset is substantial in the non-PD setting (see Table 3) supports the view that $\gamma_i > 0$ in Eq. (2), suggesting that physicians do consider the cost to insurers when choosing a drug. The interaction term PD·P is used to test whether physician agency is weakened by PD. As the price difference is part of both the second and the third term of Eq. (2), both agency on behalf of insurers or agency on behalf of patients could be affected here.

For calculating the price difference, note that it has to be determined for each combination of package size and dosage, with p_{gt} denoting the average price of N generic products each time. Further, since prices are subject to change, the price difference for a specific size-dosage combination has to be calculated for each month t, i.e. $p_t = p_{bt} - (\sum_n p_{nt})/N \ \forall n = g$. For some of these combinations, only one version is available and no price difference can be calculated. These observations are excluded from the regression analysis. This is not a problem because a prescriber who needs this specific amount of pills and dose does not have a choice between b and g.

For testing Hypothesis 6, differences in health insurance policies can be exploited. Apart from conventional fee-for-service contracts with varying deductibles, consumers can opt for a Health Maintenance Organization (HMO) or a gatekeeping alternative (GATE). In the HMO setting, physicians are paid by capitation rather than the usual fee-for-service.

The gatekeeping arrangement uses fee-for-service payments but requires patients to obtain a referral from their general practitioner (chosen from a list issued by their insurer) before seeing a specialist. Moreover, patients in a gatekeeping plan are required to ask for generic drugs. Hypothesis 6 states that both kinds of arrangements should lead to increased consideration of the cost of care by prescribing physicians [higher γ_i in Eq. (2)] and hence more generic drugs being prescribed. However, it is important to note that patients choosing these contracts are likely less risk-averse and more price sensitive than patients opting for the standard fee-for-service setting. These differences relate to the second rather than third term of Eq. (2) yet also contribute to more generic drugs being prescribed.

We complete the econometric specification by a few control variables. Because we expect a positive time trend in favor of generic drugs as practitioners get more familiar with them, we include a variable for the time trend. Patient age and gender serve to control for demographic effects. Also, political attitudes and institutions vary between cantons. In some, PD is widely accepted or even desired while in others, it is disputed. Moreover, unobserved detailing effort by pharmaceutical companies likely differs between cantons. This calls for the inclusion of 25 cantonal dummies, with Zurich constituting the reference category. Individuals can also purchase complementary insurance that covers additional procedures (such as traditional Chinese medicine or otherwise uncovered drugs). These dimensions of complementary insurance likely reflect risk aversion on the part of consumers, making them eschew drug substitution because they are less familiar with the generic alternative.

Drug substitution may also depend on dosage and package size. The reason is that the unobserved contribution to physician income could vary with these two parameters. Therefore, total prescribed dose (number of pills times dosage per pill) is included in the regression. The number of prescriptions per patient controls for long-run chronic patients. Because there is a high likelihood that a patient initiated with a given variety of the drug remains with it, two dummies indicate whether the patient's first prescription took place in 2006 or 2007, when the higher coinsurance rate was already in place.

The deterministic part of utility for generics is estimated as

$$\begin{aligned} V_{ijgt} = {} & b_0 + b_1\mathrm{PD} + b_2\mathrm{GP} + b_3\mathrm{PD}\cdot\mathrm{GP} + b_4\mathrm{DED2} + b_5\mathrm{PD}\cdot\mathrm{DED2} + b_6\mathrm{DED3} \\ & + b_7\mathrm{PD}\cdot\mathrm{DED3} + b_8\mathrm{COINS} + b_9\mathrm{PD}\cdot\mathrm{COINS} + b_{10}\mathrm{HOSP} + b_{11}\mathrm{ACC} \\ & + b_{12}\mathrm{HIA} + b_{13}\mathrm{P} + b_{14}\mathrm{PD}\cdot\mathrm{P} + b_{15}\mathrm{HMO} + b_{16}\mathrm{GATE} + b_x X, \end{aligned} \tag{5}$$

where the b's are the parameters of interest, X denotes the vector of control variables, and b_x the vector of coefficients of the control variables. The patient-specific deductible level (DED) is included using two dummies DED2 (CHF 1,000 or 1,500) and DED3 (CHF 2,000 or 2,500), respectively. The base category is DED1 for individuals with a deductible of CHF 300 or 500.

Data

Chemical agents selected

The data was provided by a major Swiss health insurer covering about 15 % of the Swiss population. They relate to the years 2005–2007. The chemical agents selected for analysis are omeprazole (O), amlodipine (A), and ciprofloxacin (C).[10] Omeprazole is used to treat

[10] ATC-code: omeprazole (A02BC01), amlodipine (C08CA01), ciprofloxacin (J01MA02). For more details about the investigated agents see www.drugbank.ca/drugs.

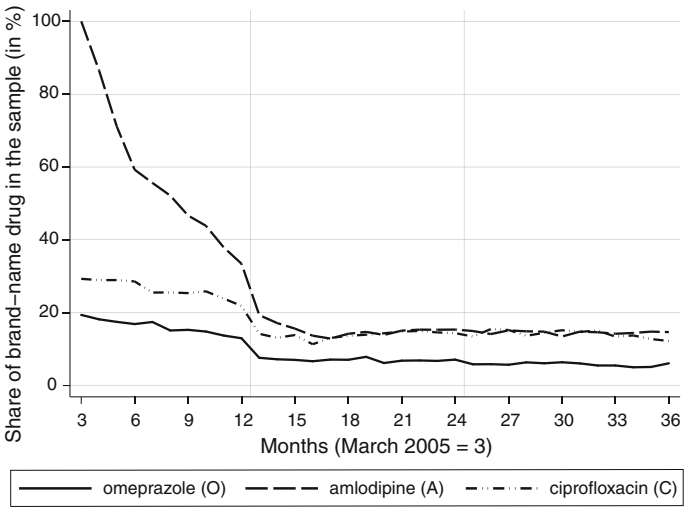

Fig. 1 Share of brand-name drug between March, 2005 and December, 2007

gastric and duodenal abscesses; amlodipine is a calcium channel blocker for the treatment of angina; ciprofloxacin is used to treat specific bacterial infections. Their choice can be justified on the grounds that they have many bioequivalent generic competitors that are available on the Swiss market.[11] Furthermore, these agents belong to the therapeutic categories with substantial sales volume, causing the number of prescriptions in the data to be high. We observe 183,874 (O), 143,358 (A), and 95,580 (C) prescriptions where exactly one package was sold.

The shares of the three brand-name drugs in the sample are depicted in Fig. 1 for 33 months, starting from March 2005. They dropped throughout 2005, quite likely because prescribing physicians anticipated the increase of coinsurance for certain brand-name drugs from 10 to 20 % effective January 2006. The new rate was to apply to brand-name drugs whose sales price was 20 % higher than the cheapest therapeutically equivalent generic.[12] During the first months of 2006, this was the case for all three agents. However, the brand-name producers of amlodipine and ciprofloxacin lowered their prices in month 20 (August, 2006) in order to avoid the extra copayment. In month 29 (May, 2007), the producer of the brand-name for omeprazole lowered its prices as well, but only for the most commonly prescribed dose (10 mg).

As to amlodipine, the brand-name drug (Norvasc®) went off patent in the spring of 2005, causing it to lose its monopoly position. Since then, the generic Amlodipin-Mepha® has expanded its share in the sample from 18 to 37 % (2006) and to 38 % (2007), respectively.

Physician and patient descriptors

In the data set, there are 7,441 physicians prescribing O, 5,995 prescribing A, and 7,693 prescribing C, respectively (the three subsets are overlapping); the share of PD varies between 43

[11] Number of generics available on the Swiss market (2005–2007): omeprazole (11), amlodipine (12), ciprofloxacin (11).

[12] This is regulated by national law (specifically paragraph Art.38a KLV).

Table 4 Descriptive statistics

	Omeprazole			Amlodipine			Ciprofloxacin		
	MN	MD	SD	MN	MD	SD	MN	MD	SD
PD	0.43	0.00	0.50	0.47	0.00	0.50	0.54	1.00	0.50
General practitioner (GP)	0.84	1.00	0.37	0.88	1.00	0.32	0.78	1.00	0.42
Patient's deductible (DED)	406	300	297	386	300	246	477	300	413
Increased rate of coinsurance (COINS)	0.72	1.00	0.45	0.21	0.00	0.41	0.20	0.00	0.40
Extra hospital insurance (HOSP)	0.22	0.00	0.42	0.27	0.00	0.44	0.25	0.00	0.43
Accident insurance (ACC)	0.75	1.00	0.43	0.83	1.00	0.37	0.68	1.00	0.47
High-income area (HIA)	0.03	0.00	0.16	0.03	0.00	0.16	0.03	0.00	0.17
Urban area	0.38	0.00	0.49	0.36	0.00	0.48	0.40	0.00	0.49
Suburban area	0.26	0.00	0.44	0.27	0.00	0.44	0.25	0.00	0.43
Average price difference (P)	102	71	75	28	11	30	12	8	9
HMO contract (HMO)	0.03	0.00	0.16	0.02	0.00	0.13	0.02	0.00	0.14
Gatekeeping contract (GATE)	0.05	0.00	0.22	0.05	0.00	0.22	0.06	0.00	0.24
Complementary insured (COMP)	0.87	1.00	0.33	0.89	1.00	0.32	0.90	1.00	0.31
Patient's age (in years)	62	64	17	70	72	12	58	61	19
Patient's sex (male = 1)	0.38	0.00	0.49	0.48	0.00	0.50	0.40	0.00	0.49
Total dosage (in 100 mg)	9.99	11.20	5.90	6.20	5.00	2.80	61.26	50.00	28.60
Prescriptions per patient	7.84	6.00	7.55	8.05	8.00	4.02	2.83	2.00	3.78
First prescription in 2006	0.35	0.00	0.48	0.36	0.00	0.48	0.36	0.00	0.48
First prescription in 2007	0.39	0.00	0.49	0.38	0.00	0.48	0.36	0.00	0.48
Share of prescriptions in 2006	0.35	0.00	0.48	0.36	0.00	0.48	0.36	0.00	0.48
Share of prescriptions in 2007	0.38	0.00	0.49	0.38	0.00	0.49	0.36	0.00	0.48

Note Descriptive statistics are mean (MN), median (MD), and standard deviation (SD). The prescription is the unit of observation used for calculating the statistics. We use nine regional categories in the regression, but only the three most important categories are displayed here

and 54 % from March 2005 to December 2007. With 78–88 %, the majority of the prescribers are GPs rather than specialists.

The median deductible is the lowest possible (CHF 300). During the study period, about 70 % of omeprazol prescriptions were subject to the increased rate of coinsurance while this share was lower for amlodipine and ciprofloxacin with shares of 21 and 20 %, respectively. The share of consumers with extra hospital coverage lies between 22 and 27 %. The majority of physicians have their practice in urban (36–40 %) or suburban (25–27 %) areas while only 3 % are located in high-income areas. The average savings per prescription for a patient or insurer due to the substitution of the brand-name by a generic counterpart is highest for *O* with CHF 102, followed by CHF 28 and CHF 12 for *A* and *C*, respectively. The share of insured with an HMO policy varies between 2 and 3 %, of those with a gatekeeping policy, between 5 and 6 %. In contrast, between 87 and 90 % of the insured had signed up for at least one voluntary extra option to broaden the scope of reimbursed services. High shares of 68 and 83 % have purchased accident insurance. Both the 61,825 patients receiving *O* and the 27,080 patients receiving *C* have an average age of about 60 years, and 40 % are male. The 58,489 patients obtaining *A* have an average age of 70 years, and 48 % are male. Ciprofloxacin is prescribed with an average total dosage per prescription of 6,126 mg, compared to a dosage of 999 mg for *O* and 620 mg for *A*. On average, a patient receives 8 prescriptions if in need

of O or A. In contrast, C is prescribed three times per patient on average. Observations are distributed equally over the three years, with about one third of prescriptions taking place per year. Also, the number of patients starting medication is roughly constant over the years.

Estimation results

The odds ratios (ORs) and standard errors resulting from the random-effects logit model described in Sect. 5 are displayed in Tables 4, 5.[13] The physician-specific variance component contributes 50–70 % of the total error variance, and a likelihood-ratio test clearly speaks in favor of the random-effects specification. The physician-specific variance component is higher than the 40 % reported by Lundin (2000) and 29 % reported by Hellerstein (1998). A possible explanation is that some physicians in our dataset only have a small number of patients, the data coming from one insurer only. Moreover, the available information does not permit to distinguish between part-time and full-time, female and male, and younger and older physicians. Coscelli (1998) also mentions considerable physician-specific components in unexplained variance.

Testing for the influence of physician dispensing

Hypothesis 1 predicts that PD increases the likelihood of generic prescription. It is tested by Model 1, with physician and patient characteristics controlled for. Additional hypothesis testing calls for interaction terms involving PD and patient characteristics which are added in Model 2 (to be discussed in Sect. 7.2). Therefore, the coefficient of PD in Model 1 shows the average OR across physician and patient groups. In the case of O, it amounts to 3.0 (2.6, 3.4), with the parentheses indicating its 95 % confidence interval.[14] For a detailed discussion of its calculation, see Norton et al. (2004) and Garrett (1997). The OR indicates that if the drug is sold on the physician's own account, the odds of generic substitution are three times higher no matter whether the prescriber is a GP or a specialist. For all three agents, the likelihood of generic substitution is around twice as high among GPs than among specialists. Moreover, the interaction between PD and GP yields a positive and significant coefficient in the case of A and C. This could be a sign that GPs with their lower average income, hence higher marginal utility of income, are more influenced by the income contribution of PD than their specialized colleagues. In the case of O, the interaction of PD and GP was insignificant and therefore excluded from the estimation.

The effect of (PD·GP) cannot be inferred from the interaction coefficient directly but needs to be calculated according to the different categories (see Norton et al. 2004). In present case, it is given by $exp(\hat{\beta}_{PD})$ for specialists and $exp(\hat{\beta}_{PD} + \hat{\beta}_{PD \cdot GP})$ for GPs. For amlodipine, PD has an OR of 2.4 (1.9, 2.9) for specialists and 3.7 (3.4, 4.1) for GPs, indicating that PD has a much stronger effect among GPs than among specialists. In the case of C, the discrepancy between GPs and specialists is even stronger. Dispensing specialists reveal a negative PD effect with an OR of 0.7 (0.6, 0.8), while GPs again exhibit a positive PD effect on generic substitution with an OR of 2.9 (2.6, 3.3). All the OR values discussed have confidence intervals that do not include 1 and thus are significant.

[13] The concept of odds ratios and their calculation in the presence of interaction terms can be found in Hosmer and Lemeshow (2000).

[14] The 95 % confidence interval is calculated according to $CI = exp(\hat{\beta} \pm 1.96 \cdot \widehat{SE}(\hat{\beta}))$, where $\hat{\beta}$ is the logit coefficient. Because Tables 5 show ORs, the reader can calculate the necessary quantities according to $\hat{\beta} = ln(\widehat{OR})$ and $\widehat{SE}(\hat{\beta}) = \widehat{SE}(\widehat{OR})/\widehat{OR}$ using the values from the table.

Table 5 Estimated odd-ratios from logistic regression (generics = 1),

	Omeprazole (O)		Amlodipine (A)		Ciprofloxacin (C)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
PD	2.99***	3.34***	2.36***	2.24***	0.71***	0.74***
	(0.18)	(0.26)	(0.25)	(0.24)	(0.06)	(0.07)
General practitioner (GP)	2.12***	2.13***	1.91***	1.92***	2.21***	2.21***
	(0.22)	(0.22)	(0.16)	(0.16)	(0.19)	(0.19)
Interaction of PD and GP			1.58***	1.56***	4.09***	4.08***
			(0.18)	(0.17)	(0.42)	(0.42)
Deductible category DED2[a]	2.01***	2.22***	1.15**	1.06	1.02	1.07
	(0.17)	(0.23)	(0.07)	(0.08)	(0.05)	(0.07)
Interaction of PD and DED2		0.70*		1.26*		0.90
		(0.13)		(0.17)		(0.08)
Deductible category DED3[a]	1.95***	2.50***	1.25	1.42**	1.12	1.20
	(0.39)	(0.66)	(0.18)	(0.25)	(0.11)	(0.16)
Interaction of PD and DED3		0.51		0.71		0.85
		(0.21)		(0.20)		(0.17)
Increased coinsurance (COINS)	2.04***	1.89***	4.52***	4.58***	2.14***	2.26***
	(0.08)	(0.08)	(0.10)	(0.13)	(0.09)	(0.11)
Interaction of PD and COINS		1.35***		0.97		0.88*
		(0.07)		(0.05)		(0.06)
Extra hospital insurance (HOSP)	0.68***	0.68***	0.75***	0.75***	0.93**	0.93**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
Accident insurance (ACC)	0.80***	0.80***	0.89***	0.89***	0.97	0.97
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
High-income area (HIA)[b]	0.47***	0.48***	0.57***	0.57***	0.91	0.91
	(0.11)	(0.11)	(0.09)	(0.09)	(0.17)	(0.17)
Price difference (P, in 10 CHF)	1.03***	1.04***	0.82***	0.81***	0.94**	0.93**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)	(0.03)
Interaction of PD and P		0.97***		1.02***		1.00
		(0.00)		(0.01)		(0.03)
HMO contract (HMO)[c]	1.94***	1.91***	1.99***	1.99***	1.37***	1.37***
	(0.25)	(0.25)	(0.25)	(0.25)	(0.15)	(0.15)
Gatekeeping contract (GATE)[c]	2.43***	2.37***	1.63***	1.64***	1.35***	1.35***
	(0.21)	(0.21)	(0.09)	(0.09)	(0.09)	(0.09)
Complementary insurance (COMP)	1.15***	1.15***	1.17***	1.17***	1.00	1.00
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Time trend (in months)	1.03***	1.03***	1.08***	1.08***	1.05***	1.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Patient age (in 5 years)	1.01**	1.01**	0.98***	0.98***	0.99***	0.99***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Patient sex (male = 1)	1.26***	1.26***	1.14***	1.14***	1.02	1.02
	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)

Table 5 continued

	Omeprazole (O)		Amlodipine (A)		Ciprofloxacin (C)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Tot. dosage (in 100 mg)	0.93***	0.93***	1.09***	1.09***	1.00*	1.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Prescription per patient	0.94***	0.94***	0.96***	0.96***	0.98***	0.98***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
First prescription in 2006	1.33***	1.32***	1.21***	1.21***	1.23***	1.23***
	(0.04)	(0.04)	(0.03)	(0.03)	(0.05)	(0.05)
First prescription in 2007	1.38***	1.37***	1.04*	1.04*	1.09*	1.09*
	(0.04)	(0.04)	(0.03)	(0.03)	(0.05)	(0.05)
Log-likelihood at convergence:	−35,970	−35,918	−51,481	−51,473	−29,390	−29,388
Observations/physicians	183,874/7,441		143,358/5,995		95,580/7,693	

Note Standard errors displayed in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$; six additional area and 25 cantonal dummies are included but not shown here [a] DED2 = CHF 1,000 or 1,500, DED3 = CHF 2,000 or 2,500 Ref. categories are: [b] urban area, [c] basic insurance

In summary, Hypothesis 1 receives a good deal of support, permitting one to conclude that PD increases the likelihood of generic substitution due to its higher contribution to physician income. This conclusion holds regardless of whether prescribers are GPs or not and for all of the three chemical substances analyzed, with the one exception of specialized physicians prescribing *C*. However, it should be noted that there may be additional reasons for dispensing physicians to choose the cheaper generic drug. First, storage entails capital user cost, which is lower for cheap generics. Second, dispensing physicians may be better informed about availability and prices of generics than non-dispensing physicians because of especially targeted marketing activities. Unfortunately, these effects cannot be analyzed with the available data.

As pointed out in Sect. 3.1, physicians who are strongly attached to money might open practice in PD regions. This selection effect would result in an overestimation of the PD coefficient. However, this bias cannot be very important because during the observation period, a ban on new practices was in effect that was lifted no sooner than at the end of 2011. Therefore, physicians had to buy existing practices, which served their choice of location. In addition, most physicians prefer to settle in their respective region of origin, and they tend to stay where they started their practice.[15]

Still, PD is associated with increased generic substitution. It contributes to lower pharmaceutical expenditure as long as it does not go along with an increase in drug use through supplier-induced demand. This qualification is not addressed here but is analyzed in other recent work. In particular, Rischatsch (2012) analyzes whether dispensing physicians optimize their income contribution from drug dispensing by selling smaller packages, while

[15] We additionally compared the prescribing behavior of non-dispensing physicians from regions where PD is prohibited with those located in communities that allow PD. While the first type of physicians might want to sell drugs but lack authorization, the latter type is free to dispense but does not size the opportunity to do so. Hence, the second type serves as a reference group, comprised of physicians that are not (or at least comparatively less) prone to financial incentives, because they let go on profits from drug selling. We found no empirical evidence for a difference in prescribing patterns between non-PD across cantons for the two substances omeprazole and amlodipine. For the third substance (ciprofloxacin), the likelihood of generic substitution is significantly lower in cantons with a less restrictive stance with regard to PD.

Trottmann (2011) looks at the impact of PD on total expenditure for drugs, general practitioners' services, specialists' services and hospital services.

The role of physician agency on behalf of patients

To the extent that physicians take the consequences of their prescriptions for the utility of their patients into account, Hypothesis 2 predicts a positive relationship between copayment and generic substitution. Patients with a higher deductible face a higher expected level of copayment; therefore, they should be more likely to receive the generic alternative. The empirical evidence comes from the coefficients of DED2 and DED3 in Model 2 of Table 5. In the case of O, the ORs for DED2 and DED3 indicate that a higher deductible increases the likelihood of generic substitution. A stronger effect for DED3 compared to DED2 could not be found for O, however. Patients with a deductible in excess of the legal minimum are two times as likely to receive a generic drug, which supports Hypothesis 2. For A, the ORs increase from the lowest to the highest deductible category, but only the OR for DED2 is statistically significant. The tendency is the same for C but the effect is insignificant. The dummy variable indicating the 2006 increase in coinsurance for expensive brand-names (COINS) is strongly positive for all chemical agents, again supporting Hypothesis 2 (see Table 2).

Hypothesis 3 revolves around patient income, stating that richer patients are less likely to receive the generic drug. In Table 5, three indicators are used, viz. the purchase of extra hospital insurance, accident insurance, and residence in a high-income area. As to the first indicator, the OR values are consistently below one, indicating that generic drug substitution indeed is less likely. The same is also true for patients with accident insurance and from high-income areas in two of the three cases (C is the exception with a negative but insignificant effect). Therefore, there is some supporting evidence for Hypothesis 3 (see Table 2 again).

Hypothesis 4 predicts that patients' rate of coinsurance is less influential in the PD mode than in the pharmacy mode. To test it, Model 2 contains interactions between the DED dummies and PD. The interaction terms are generally negative, but only the medium category for O is significant, giving some support to Hypothesis 4. Here, the OR for DED2 is 2.2 (1.8, 2.7) for non-PD and 1.6 (1.1, 2.1) for PD. Evidence contradicting Hypothesis 4 comes from A, where the interaction effect PD·DED2 is positive and significant but the main effect DED2 is insignificant, leading to the conclusion that non-PD providers do not react to a higher deductible but PD providers do. This difference vanishes again at the highest deductible level since PD·DED3 does not reach statistical significance.

A second test of Hypothesis 4 is provided by the interaction of PD with COINS. However, the evidence is inconclusive. For omeprazole, PD·COINS is highly significant and positive with an OR of 1.9 (1.7, 2.0) among non-PD providers and 2.6 (2.3, 2.8) PD providers, respectively, while for ciprofloxacin, it is weakly significant but negative, suggesting that PD providers react less to the increase in the rate of coinsurance than their non-PD colleagues. No significant difference could be found for amlodipine. Hence, the evidence does not permit to either confirm or reject the notion that drug dispensing weakens physician agency on behalf of the patient.

The role of physician agency on behalf of insurers

Hypothesis 5 states that given agency on behalf of insurers, non-PD providers prescribe generic drugs in spite of higher information cost. Therefore, we expect a higher difference between brand-name and generic prices ($p_{bt} - p_{gt}$) to be positively related to the probability

of prescribing the cheaper generic drug. While the estimates for O support Hypothesis 5 with a weak positive effect in favor of generics, the estimates for A and C do not because an increase in the price difference lowers the probability of generic substitution slightly. However, there is other evidence hinting at agency on behalf of insurers. In fact, the descriptive statistics in Table 3 show that, for the three selected agents, the share of generic drugs is 66–89 % in our dataset even in the non-PD market. Recall that non-PD providers do not benefit financially from drug choice, while patient coinsurance beyond the deductible is rather limited compared to average income in Switzerland. Therefore, the high share of generic drugs shows that some physicians choose the lower-priced alternative even in situations when neither they nor their patients derive significant financial benefit from it. It takes agency toward the insurers to motivate physicians to prescribe generic drugs despite higher information cost.

The interaction PD·P is again used to test whether the financial incentives attached to PD weaken physician agency. The price difference being part of both the second and the third term of Eq. (2), both agency on behalf of the patient and on the behalf of the insurer can be affected. For O, the price difference has an OR of 1.0 (1.03, 1.05) for non-PD physicians and an OR of 1.01 (1.00, 1.02) for PD physicians, pointing to a weakly negative association of PD and agency. The opposite is observed in the case of A, where the OR pertaining to non-PD providers is 0.81 (0.80, 0.82) and the OR pertaining to PD providers is 0.83 (0.82, 0.83). For C, no significant difference between non-PD and PD providers is observed, with ORs amounting to 0.93 (0.88, 0.99) and 0.94 (0.88, 1.00), respectively. Therefore, the evidence with regard to the interaction of PD and agency is inconclusive.

With respect to Hypothesis 6, the managed-care variables 'HMO' and 'gatekeeping' reveal an increasing likelihood of generic substitution for all three chemical agents, with ORs between 1.4 and 2.0, as predicted (see Table 2).

Control variables

The control variables lead to the following conclusions. In Model 2 of Table 5, there is evidence for the expected positive time trend towards generic drugs, a higher likelihood of generics being prescribed to men compared to women, and no evidence of the total amount of dosage prescribed having influence on the choice of drug version. The negative sign pertaining to the number of prescriptions observed per patient can be interpreted as follows. From the physician's perspective, repeated prescriptions make it more profitable to convince a patient to accept generics. From the patient's perspective, however, a high quantity of drugs prescribed increases the likelihood of exceeding the deductible, beyond which insurance coverage sets in, undermining interest in generics. Apparently, this second effect prevails.[16]

Finally, the year when the patient's medication started is important for drug choice and significant for all three chemical agents. Patients who received the first prescription in 2006 are between 1.2 and 1.3 times more likely to be prescribed a generic. In the case of amlodipine and ciprofloxacin, the likelihood for 2007 is higher than for 2005 but lower than for 2006. This could reflect the fact that the two pertinent brand-name producers lowered their price in the interest of a decreased coinsurance rate, enabling them to regain market-share. By way of

[16] The theoretical model focuses on the first prescription, neglecting decisions with regard to follow-up prescriptions. In an attempt to make the econometrics match theory more closely, an estimation using only the first observation per patient was performed as well. The odds-ratios are 2.84 (0.38) for omeprazole, 1.90 (0.16) [specialists] and 6.84 (0.81) [GPs] for amlodipine, and 1.04 (0.11) [specialists] and 6.77 (0.72) [GPs] for ciprofloxacin, respectively. Therefore, the conclusions based on Table 5 seems to hold regardless of whether physicians decide about a first or a follow-up prescription.

contrast, the brand-name producer of omeprazole waited until 2007, causing it to lose market share in both years.

One might criticize that dispensing physicians do not react to an individual patient when choosing between g and b because they have already decided what pharmaceuticals to have in their portfolio. However, they are likely to make this choice anticipating the kind of patients they will face from past visits, causing them to store the drugs that best match their clientele.

Policy implications

Assessing the welfare effect of PD is not within the scope of this study. It would require an analysis of frequencies and volumes of drug prescriptions as well as patient preferences with regard to drug suppliers.[17] Nonetheless, the previously discussed results allow us to assess potential savings through generic substitution due to PD.

The marginal effect (ν) of PD on the likelihood of a generic prescription (not shown in Table 5) measures the expected change in market share due to PD. We assume that the relative market share for generic provider within the market for generics remains unaffected by the generic substitution. Then, potential savings (S) due to PD can be calculated according to

$$S = \sum_i S_i = \sum_i \nu \cdot n_i \cdot (\bar{p}_i^b - \bar{p}_i^g), \tag{6}$$

where n_i indicates the total number of prescribed packages per category i depending on dosage and pills per package. The average patient prices for brand-name and generic drugs are denoted by $\bar{p}^b$ and $\bar{p}^g$, respectively.

In the case of omeprazole, the market share for generics increases by 4 %-points due to PD ($\nu = 0.04$). In our sample, total expenditure for omeprazole are CHF 19,247,704 and savings due to generic substitution through PD are CHF 773,100 or 4 % (see Table 6 in the Appendix). For amlodipine ($\nu = 0.15$), the market share for generics increases by 15 %-points, resulting in savings of CHF 1,211,677, which equals 10 % of total cost.[18] In comparison, potential savings for ciprofloxacin ($\nu = 0.06$) are lower with CHF 87,997 (1.85 % of CHF 4,751,284). In sum, the findings show that generic substitution through PD leads to a remarkable decrease in drug expenditure which is unlikely to be compensated by supplier-induced demand since Swiss health insurers have began to closely monitor physician's drug bills. Trottmann (2011) finds that generic substitution through PD has a negative effect on drug expenditure, which is not overcompensated as a result of supplier-induced demand. Nevertheless, a thorough analysis of possible welfare implications, which is beyond the scope of this paper, is an interesting topic for future research. For a further discussion see also Rischatsch (2012).

Conclusions

This research analyzes the role of physicians' and patients' financial incentives in the choice between generic and brand-name drugs. Prescribing the generic alternative takes more effort

[17] Cost containment through cheaper generic drugs could be (over) compensated through unnecessarily prescribed drugs.

[18] To facilitate the calculation, all models are estimated without an interaction of PD and GP. Further, one has to keep in mind that the brand-name drug went off patent in the first month of the study period. This contributes to a strong effect of PD because physicians with dispensing rights are targeted by sales activities and are immediately informed about market entry of new generic drugs.

on the part of the physician for two main reasons: First, she needs to acquire information about new drugs which enter the market only after patent expiration of the brand name. Second, she needs to convince the patient that the cheaper generic is not of lower quality. The physician is willing to make this effort only if the benefit from choosing the generic is sufficiently high. Generic drugs have higher benefit because of three reasons, namely financial benefits, agency towards the patient, and agency towards insurers. The influence of these three components is estimated using a large set of drug claims data from Switzerland.

Regarding financial incentives, this data is ideal for analysis because some – but not all – Swiss physicians have the right to dispense drugs on their own account. Physicians with this privilege derive a significant part of their income from the sale of drugs, causing financial incentives associated with drug dispensing to be substantial. PD is found to be associated with a higher likelihood of prescribing generic drugs, which is likely due to a higher contribution to physician income in comparison with that of brand-name drugs (Hypothesis 1; see also Table 2). A limitation of our analysis is that we are unable to separate this effect from other differences between dispensing and non-dispensing physicians. In particular, information costs for prescribing generic drugs might be lower for dispensing physicians as they are targeted by sales representatives and may therefore be better informed about availability and prices of drugs than their non-dispensing colleagues. Additionally, dispensing physicians have to finance and manage storage, tying up capital and causing opportunity costs.

Turning to agency towards patients, we test whether physicians respond to the financial burden caused by copayment. Choosing the lower-priced generic drug serves to decrease this burden without affecting the quality of medication due to bioequivalence of the generic substitutes studied here. We find that the likelihood of receiving the generic increases for patients with a higher deductible (Hypothesis 2). In addition, the rate of coinsurance (which applies when the deductible is exceeded) was increased for certain brand-name drugs during our observation period. Although this change caused but a small additional burden per patient compared to income, it does go along with a strongly increased use of generic drugs. A likely contributor is that the government's initiative to promote generic substitution alloyed concerns about quality on the part of both prescribers and patients.

The variation in deductibles and coinsurance permits to study the interaction between physicians' financial incentives and their patient agency. Given imperfect agency on behalf of patients, dispensing physicians are predicted to respond less strongly to a hike in copayment than non-dispensing ones (Hypothesis 4). However, the evidence found in our data is mixed, failing to support the notion that drug dispensing weakens physician agency, as argued by pharmacists' lobbying groups and some Swiss politicians.

Moreover, most of the odds ratios pertaining to proxies of patient income (residence in a high-income area, purchase of extra hospital and accident insurance) suggest that wealthier patients have a higher probability of receiving brand-name drugs because the price difference between them and the generic substitute has less of an effect due to lower marginal utility of income of the wealthy (Hypothesis 3).

Consideration of the savings for insurers might provide an additional motivation for the prescription of the cheaper generic alternative (Hypothesis 5). However, this effect could be confirmed for only one drug in the econometric estimation (see Table 2 again). Nevertheless, the high willingness of non-dispensing physicians to prescribe generic drugs points to some degree of agency towards insurers. Last but not least, physicians working in managed care-type arrangements are found to prescribe more generic drugs than their colleagues, pointing to an increased cost awareness in the managed care setting (Hypothesis 6).

In sum, financial incentives, agency towards the patient, and agency towards insurers are all found to markedly influence generic substitution. Moreover, government initiatives to promote generic drugs can be effective even in the presence of weak financial incentives because they may reassure physicians and patients of the safety and high quality of generic drugs. However, if government were to try to markedly reduce generic prices, it might weaken the incentives for generic substitution, at least for dispensing physicians. The reason is that physicians' financial incentives may encourage rather than undermine generic substitution.

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Appendix

See Table 6.

Table 6 Savings due to generic substitution through PD (omeprazole, 2005–2007)

Category	Quantity	Average prices		Drug cost and changes		
i	n_i	$\bar{p}_i^b$	$\bar{p}_i^g$	TC_i	S_i	%
10 mg						
×14	546	50.15	28.62	17,197	470	2.73
×28	2,288	75.20	45.64	114,482	2,705	2.36
×56	2,583	131.12	79.88	235,796	5,293	2.24
×98	470	–	127.82	60,078	–	–
×100	3,967	219.02	128.67	575,045	14,337	2.49
20 mg						
×7	4,260	46.62	22.48	101,092	4,113	4.07
×14[a]	18,356	70.98	33.42	636,462	20,611	3.24
×28	42,518	118.64	56.53	2,627,267	105,637	4.02
×56	30,719	213.42	106.95	3,768,254	130,824	3.47
×98	5,887	–	136.54	803,801	–	–
×100	36,310	362.57	143.88	6,179,657	316,754	5.13
40 mg						
×7[a]	7,560	66.88	26.35	205,090	6,133	2.99
×28	34,868	195.00	75.82	2,927,608	166,223	5.68
×56	8,833	–	112.74	–	995,875	–
Total				19,247,704	773,100	4.02

Note Total prescribed packages (n_i), total cost (TC_i) and potential savings (S_i) per category. Prices and costs are shown in CHF.1 CHF ≈ 1.1 USD at 2011 exchange rates[a] The market share is only increased up to 100 %

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