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ORIGINAL PAPER

Lead me not into temptation: drug price regulation and dispensing physicians in Switzerland

Maurus Rischatsch

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Abstract While most countries separate drug prescription and dispensation to ensure independent drug choice, some allow this combination to increase pharmaceutical access in rural areas or to increase the utilization of pharmacist skills. A drawback of this approach is that dispensing physicians or prescribing pharmacists may be incentivized to increase their own profits through the prescription of cost-inefficient drug packages, leading to an increase in pharmaceutical spending. Switzerland constitutes an interesting example of where dispensing and non-dispensing physicians coexist, permitting a comparison of their prescribing behavior. The present study shows that drug margin optimization is possible under the current drug price regulation scheme in Switzerland. Using drug claims data, empirical findings indicate a 5–10 % higher margin per dose for dispensing physicians compared to pharmacists. Cost per dose is 3–5 % higher when dispensed by physicians instead of pharmacists.

Keywords Physician dispensing · Prescribing behavior · Pharmaceutical pricing · Physician agency

JEL Classification I10 · I11 · C11 · C54

Introduction

By law, in order to prevent financial incentives affecting the way prescriptions are issued, many countries separate drug prescription and drug dispensation. Critics accuse combined providers—dispensing physicians or prescribing pharmacists—of being influenced by personal profit considerations when choosing a drug brand and/or drug quantity. South Korea constitutes one example of where physician dispensing and pharmacy prescribing was allowed until 2000, but was separated thereafter to tackle inefficient drug allocation and consumption, as discussed by Soonman [14].

The advantage of combining drug prescription and dispensation is that it permits increased pharmaceutical access in rural areas or allows greater use of pharmacists' skills, as discussed by Tonna et al. [15]. The former is the reason why physician dispensing is allowed in some Swiss jurisdictions, while the latter explains why pharmacy prescribing was introduced in the United Kingdom, where patients face long waiting periods to see a doctor (see Pearson et al. [12]). According to Emmerton et al. [5], pharmacist prescribing was successfully introduced for similar reasons in the United States, Canada, and New Zealand. More recently, the introduction of advanced-practice pharmacies in California to tackle a physician shortage has been strongly debated. Whatever the reason for combining prescription and dispensation, policy makers should keep in mind the potential disadvantages of combining these two activities.

Such potential disadvantages of combining drug prescription and dispensation emerge for different reasons. Providers serve as agents for their patients, making diagnoses and prescribing the most adequate drugs and drug quantities. If they act as perfect agents, they make the same decisions as their patients would given all relevant information (see Zweifel et al. [17], Chap. 8). However, the relationship between drug providers and their patients (or insurers where health insurance covers drug expenditure) is characterized by a strong information asymmetry.

M. Rischatsch (✉)
Department of Economics, University of Zurich, Zurich, Switzerland
e-mail: maurus.rischatsch@econ.uzh.ch

Economic incentives may seduce them to deviate from their role as perfect agents, leading to a misallocation of resources. Therefore, it is important to investigate if dispensing physicians and prescribing pharmacists show a different prescribing behavior to their colleagues who do not have the right to dispense or prescribe, respectively. Further, it is necessary to explore if the incentive due to the pharmaceutical pricing mechanism is strong enough to lead them into temptation to optimize their own drug margins.

In most countries, health care markets are heavily regulated, and public authorities administrate pharmaceutical prices. In some countries like Switzerland, drug prices are regulated at the manufacturer level, and so-called logistic margins are added to cover the cost of drug distribution. Logistic margins are often composed of two components: a per-package contribution and a price-dependent contribution proportional to the manufacturer price. In Switzerland especially, the per-package component is under considerable strain because it permits dispensing physicians to increase their own profit by prescribing the same drug quantity in smaller packages.

The objective of the work described in this article was to investigate whether combining drug prescription and dispensation leads to margin optimization activities under a pharmaceutical pricing mechanism that includes a per-package component. The article is structured as follows. The "Institutional background" section describes the health care system and pharmaceutical pricing scheme employed in Switzerland. The "Theoretical drug margin optimization" section examines theoretical margin optimization by dispensing physicians. The "Modelling approach" section introduces the econometric modeling approach and outlines how drug margin optimization is measured empirically. The "Data" section reports the used drug claims data, and the "Estimation results" section presents the results of the estimation, which elicit empirical evidence for dispensing physicians' margin optimization activities. Finally, the "Conclusions and discussion" section concludes the paper by discussing the implications of these results for improving drug price regulation in Switzerland.

Institutional background

In Switzerland, health care is financed through lump sum premiums that are independent of income. Purchasing health insurance is mandatory for all citizens, while low-income individuals are subsidized through premium reductions. Every year, an individual can choose one of six deductible levels ranging between CHF 300 and 2,500 (1 CHF $\approx$ 1.1 USD at 2011 exchange rates) for the following year. A higher deductible is rewarded with a lower premium and is in general chosen by healthier individuals. When the annual health care expenditure exceeds the deductible, the insured individual must bear a co-payment of 10 % up to a total payment of CHF 700. For expensive brand-name drugs with at least one bioequivalent generic competitor, the co-payment rate was increased from 10 to 20 % in January 2006, which was the case for all brand-name drugs investigated in this study. But because the market shares of the brand-name drugs dropped significantly after the introduction of the higher co-payment rate, the brand-name producers were forced to reduce their prices, so the higher co-payment rates were abolished.

New pharmaceuticals have to be approved by Swissmedic, an independent epidemiological institute. After the authorization, the Federal Office of Public Health (BAG) decides—based upon the three criteria of effectiveness, safety, and adequacy—if the drug should be placed on the positive list of drugs that have to be reimbursed by health insurers. The BAG is in charge of pharmaceutical pricing through direct price regulation, as discussed by Bauer [2]. The manufacturer price (P) constitutes the maximum price at which producers are allowed to sell their products to dispensing physicians, pharmacists, and wholesalers. While brand-name drugs are priced with the aid of an international price reference system, generic drug prices are set in comparison to the bioequivalent brand-name drug. In a first step, the BAG negotiates with the drug producer about the manufacturer price for the smallest package provided, which is called the reference price (P^*) in the following. Once both parties have agreed on P^*, the manufacturer prices for larger package sizes and dosages are determined following the manufacturer price relation defined by the BAG. As shown in the left panel of Fig. 1, the BAG discounts larger packages to make them cheaper for patients in need of large quanties of drugs.[1]

A so-called logistic drug margin (M) based on P is paid to pharmacies, dispensing physicians, and wholesalers to cover the cost of drug distribution and storage. The logistic drug margin is a combination of a fixed per-package margin (m_f) and a variable capital margin (m_v) that is calculated as a percentage of P so that $M = m_\mathrm{f} + m_\mathrm{v}P$. The per-package margin increases in increments that depend on the manufacturer price category. The capital margin m_v is 12–15 % for drugs cheaper than CHF 800 and 8–10 % for prices between CHF 800 and 1,800. For prices above CHF 1,800, distribution costs are fully reimbursed through a per-package margin of CHF 240. The logistic drug margin function is shown in the right panel of Fig. 1, restricted to the relevant domain for this study.[2] The boxplots depicted

[1] Compare Table 4 in the "Appendix".

[2] Compare Table 3 in the "Appendix".

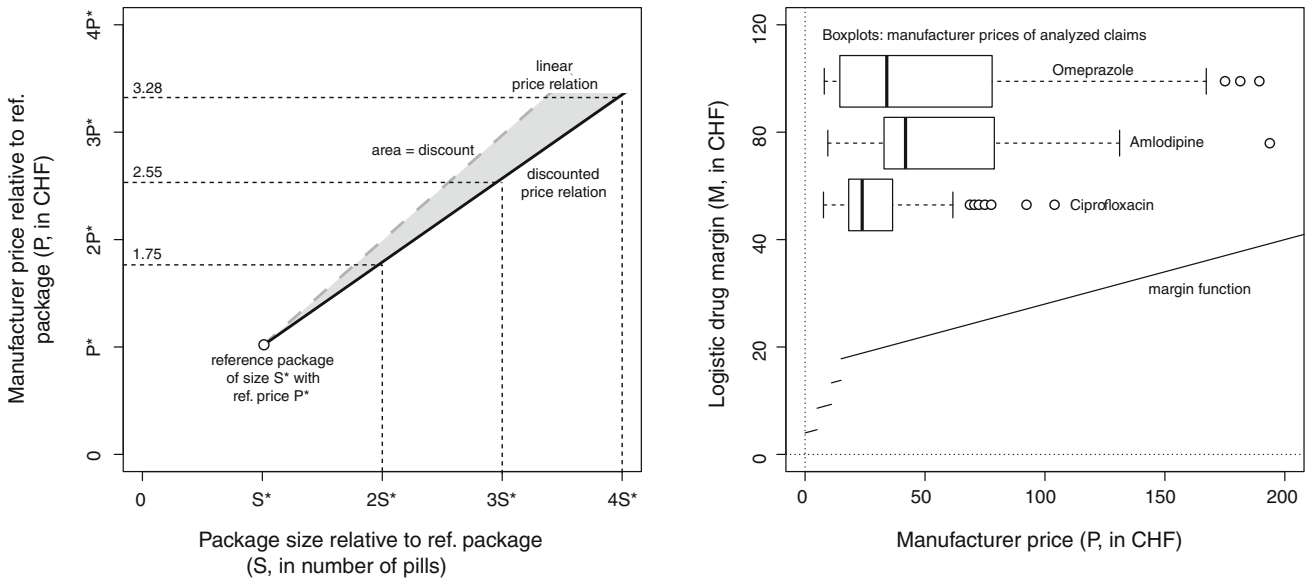

Fig. 1 Relationships of the manufacturer price to package size of a particular drug (*left*) and to the logistic margin function (*right*) used in Switzerland

in Fig. 1 show the distribution of observed manufacturer prices in the analyzed drug claims data.

The final price paid by either patients or health insurers is the sum of P and M, which is, for the sake of simplicity, called the drug cost (C) in the following. In fact, only C is observed in the drug claims data analyzed in this study. The total (unofficial) drug margin may differ if dispensing physicians or pharmacists are able to buy drugs below P. Further, how the drug margin M is split between producers, wholesalers, pharmacists, and dispensing physicians is not regulated; it is determined by bargaining between the market participants. Therefore, neither the BAG, the insurers, nor the patients know exactly how much profit the drug providers make from drug dispensing, as discussed in Rischatsch et al. [13]. In addition, pharmacists are allowed to charge payments directly to the patient for checking the medication and assessing the accuracy of the treatment, as well as to cover the cost of recording the medication. It is strictly forbidden for dispensing physicians to charge these fees, because they are reimbursed for these services through the fee-for-service system. If not explicitly prohibited by the physician, pharmacists are allowed to substitute brand-name drugs with generics, receiving a share of the insurer's cost savings to promote generic substitution, as outlined in Drabinski et al. [4]. In general, the prescription form explicitly mentions the drug brand in addition to the number of packages, the package size, and the dosage per pill. The fact that the drug name and the number of packages is stated on the prescription form discourages pharmacists from undertaking this substitution because the patient must be convinced to accept the substitute. Readers interested in a more detailed discussion of the Swiss pharmaceutical market are referred to Hunkeler [6, 7] for a historical review.

Theoretical drug margin optimization

In this section, before the empirical analysis is presented, the theoretical optimization problem—i.e., determining the choice of package size that maximizes logistic margin—is discussed. This provides the foundation for further analysis. All quantities are treated as continuous, even if they are discrete in practice (e.g., reducing the package size by one pill is impossible in practice).[3] The section ends with an illustrative example in which price data are used to demonstrate the extent to which profit can be increased by replacing larger packages with smaller ones (compare Fig. 2 and Table 5 in the "Appendix").

The prescribing process starts with the diagnosis and indication of the required chemical substance. Given that the patent protection has expired and generic drugs are available, the prescriber chooses a drug brand. Assuming that the total dosage (D_t) and the dosage per pill (D) are diagnosis specific and cannot be changed without consequences for the patient's health, D_t and D are given and are not part of the choice process. Therefore, the prescriber finally decides on the package size (S) and, implicitly, on the number of packages (N). Acting as a perfect agent on

[3] This is not the case in some countries, where drugs are sold by patient-specific package sizes containing the exact number of pills needed.

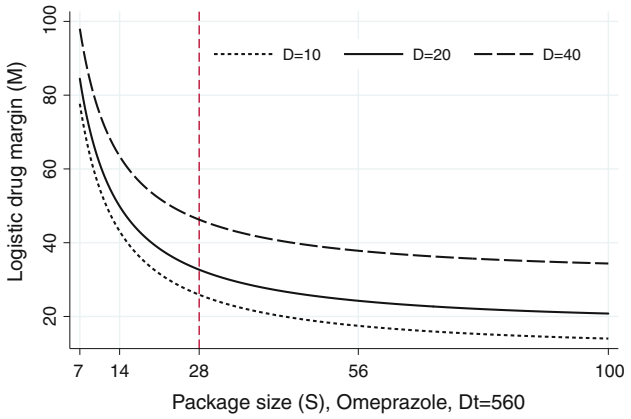

Fig. 2 Drug margin as a function of package size for given D_t and D values

behalf of the payer, the prescriber chooses the cheapest combination of S and N. However, the financial interests of dispensing physicians or prescribing pharmacists are in conflict with cost-efficient drug provision. They can optimize their own drug margin by solving the following optimization problem:

$$\max_{N,S} M|D_t, D = N \cdot [m_f + m_v \cdot P(S|D)] \quad \text{s.t.} \quad N \cdot S \cdot D = D_t. \tag{1}$$

Again, the quantity D_t denoting the total dosage to be prescribed is assumed to be constant. Further, supplier-induced demand is neglected in this study because this work is focused on *how* dispensing physicians prescribe a *given* quantity of drugs. This simplification is line with the empirical analysis, because the estimation equation controls for the prescribed drug quantity. Readers interested in supplier-induced demand in health care are referred to McGuire [10].

Modeling drug price regulation in Switzerland, the manufacturer price (P) for a given dosage per pill (D) is assumed to have the following functional form:

$$P(S|D) = p_1(D) \cdot S + p_2(D) \cdot S^2, \tag{2}$$

where p_1 and p_2 represent the per pill contribution to the package price (depending on D) with $p_1 > 0$ and $p_2 < 0$. The latter incorporates the discounting of larger packages. Both the per-package component (m_f) and the capital component (m_v) of the logistic drug margin depend on the manufacturer price. In this study, the share of analyzed drug claims that have prices in the domain where a change in price category is considerable (see Fig. 1) is negligible. Therefore, m_f and m_v are assumed to be constant. Nevertheless, one should keep in mind that the increase in drug margin achieved through the prescription of small packages could be offset by the application of a lower manufacturer price category and therefore price per package and capital margin.

Combining Eqs. 1 and 2, and substituting the quantity constraint directly into the resulting equation, the optimization problem then reads

$$\max_S M|D_t, D = \frac{D_t}{DS} \cdot \left[m_f + m_v(p_1 S + p_2 S^2)\right]. \tag{3}$$

Taking the first derivative of the drug margin with respect to the package size and re-arranging the expression leads to

$$\frac{\partial M}{\partial S} = \frac{D_t}{DS}\left(-\frac{m_f}{S} + m_v p_2 S\right) = N\left(-\frac{m_f}{S} + m_v p_2 S\right) < 0. \tag{4}$$

Equation 4 shows that the logistic drug margin decreases strictly monotonically with package size, leading to the corner solution with the prescription of the smallest package available.[4] Equation 4 unveils the role pharmaceutical pricing plays in the optimization problem. The first term in the parentheses of Eq. 4 shows that margin optimization is stimulated through the per-package component, while the second term reveals the role of large package discounting, which provides an incentive to prescribe smaller packages and increase the manufacturer price per pill, which in turn translates into a higher logistic margin.

Conclusion 1 The design of the regulated logistic drug margin in Switzerland permits dispensing physicians to increase their own profits by reducing package size so that a higher number of packages can be prescribed. Margin optimization is possible because of the per-package component of the logistic drug margin and the discounting of large packages.

The second derivative shows that $\partial^2 M/\partial S^2 = N(m_f S^{-2}) > 0$. Thus, the dispensing physicians' margin optimization effort is more effective in the lower domain of S.

Conclusion 2 The less cost-efficient the package is, the stronger the incentive to deviate and reduce the prescribed package size.

Illustrative example

Estimating all necessary parameters from pricing data, the relationship between the logistic drug margin and the package size for a given total dosage can be plotted using Eq. 3. Figure 2 visualizes how the logistic drug margin changes with the package size used to prescribe 560 mg of omeprazole (sold under the brand-name drug) in January 2006. The most frequently prescribed package during the study period corresponds to the one with 28 pills and 20 mg per pill. Therefore, we assume a patient in need of

[4] The corner solution for the illustrative example given in the next subsection is represented by the package containing seven pills (see Fig. 2).

20 mg per day for 28 days. In this case, the cheapest prescription would be the one package described above. Then, drug margin amounts to CHF 33 and the drug cost is CHF 126.[5] On the other hand, two packages with 14 pills each could be prescribed. This leads to a drug margin of CHF 50 (+52 %). Prescribing four packages with seven pills each leads to a drug margin of CHF 85 (+158 %).

The example shows that the current price regulation permits dispensing physicians to more than double their profit for the same drug quantity by simply dispensing them in smaller packages. Thus, Swiss drug price regulations have great potential for conflicts of interest if drug prescription and dispensation are combined. Additional examples are given in Table 5 in the "Appendix".

Modeling approach

This section outlines the strategy for estimating drug margin optimization empirically. The "Drug margin and cost measurement" subsection discusses the two dependent variables that are used to estimate optimization activity and its effect on pharmaceutical expenditure. The "Potential margin and cost drivers" subsection discusses the explanatory variables included in the regression analysis, while the "Model specification" subsection discusses the estimated econometric model.

Drug margin and cost measurement

Logistic drug margin optimization by dispensing physicians is investigated here by comparing the margin-per-dose (MPD) values of dispensing physicians and pharmacies. Aggregating the MPD at the patient level instead of comparing MPD values at the prescription level accounts not only for margin optimization during individual physician visits but also over time. If the drug brand used by a patient changes over time, observations are treated separately. On the one hand, this controls for different manufacturer prices. On the other hand, aggregation is less problematic because it is likely that the change is due to a change in the drug seller (e.g., a change from a physician to a pharmacy). However, if the resulting aggregated observation is not completely attributable to physician nor pharmacy dispensing, the observation is treated as physician dispensing if two-thirds of D_t is sold by a physician. The MPD for the aggregated observation n is then given by

$$\mathrm{MPD}_n = \sum_i \left(m_f^i + m_v^i P_i\right)/D_t^i, \tag{5}$$

with $D_t^i = S_i D_i$ for all individual observations i belonging to the same physician, patient, and drug.[6]

Drug cost per dose (CPD) is used to measure the effect of physician dispensing on drug expenditure. The CPD values aggregate the cost for the insurer. They are calculated as

$$\mathrm{CPD}_n = \sum_i \left(m_f^i + (1 + m_v^i)P_i\right)/D_t^i, \tag{6}$$

where $m_f^i + (1 + m_v^i)\ P_i$ represents the drug cost of a single prescription i, as above.[7]

It is important to keep in mind that, even if there is a positive correlation between combined drug provision and CPD, combined drug provision may be more cost-efficient due to savings elsewhere, e.g., generic substitution (see Rischatsch et al. [13]). However, assessing the overall cost efficiency of physician dispensing is not the objective of this study. Readers interested in this topic are referred to Trottmann [16].

There are many factors that affect the outcome variables. While some of them are under the prescriber's control, others are not. Inferences may be confounded if the latter are omitted. The next subsection discusses the covariates included in the regression analysis.

Potential margin and cost drivers

Drug margin optimization is tested in this work using a dummy variable that indicates whether the drug was dispensed by a physician (PD = 1) or a pharmacist (PD = 0). A statistically significant and positive correlation between PD and MPD points at margin optimization activities and dispensing physicians acting as imperfect agents on behalf of the payers.

As mentioned above, there are several factors affecting the margin-per-dose and cost-per-dose values. General practitioners (GPs) may face patients with different needs than specialists. Hence, a dummy for GP is included to control for these differences. Moreover, physicians who prescribe some substances very rarely may be less informed about available package sizes and dosages. Even if the investigated drugs are blockbusters, information may affect MPD and CPD without being correlated with margin optimization activities. Including the number of prescriptions might be problematic because it can be correlated with margin optimization. In contrast, the number of patients (NPA) a physician served during the study period is independent of the optimization effort if one assumes that the patient number is given exogenously and that

[5] The logistic drug margin is calculated neglecting value added taxes.

[6] N_i cancels out of the equation because prescriptions of different packages at the same time are treated as separate observations.

[7] Again, additional fees and taxes that are either small or do not differ between combined and separated providers are neglected.

supplier-induced demand is absent. Furthermore, a higher demand for a specific substance may result in a larger drug portfolio in private-practice pharmacies. Having different packages available permits drugs to be prescribed more cost-efficiently.

Patients' health insurance plans are used to control for heterogeneity among patients. In Switzerland, citizens can choose between different deductibles every year (see the "Institutional background" section). The choice of a high deductible correlates with the patient's expectation of a low need for health services in the following year. Patients with, for example, chronic diseases most likely choose the lowest deductible. Therefore, it is important to distinguish between these groups, because patients in need of a high total dosage can be provided with more cost-efficient packages due to price discounts for large packages. Hence, patient latent health status is modeled using dummy variables for different deductible categories. The lowest deductibles of CHF 300 or 500 serve as the reference category. Patients with a deductible of CHF 1,000 or 1,500 are grouped into medium deductible patients (DEDM), and those with the highest deductibles of CHF 2,000 or 2,500 are represented by the high deductible category (DEDH). Additionally, individuals opting for a health maintenance organization (HMO) contract and physicians working in HMO practices are expected to be more cost-aware, increasing cost efficiency. The same might be the case for gatekeeping-insured people (GATE). To control for demographic effects, patient age (AGE) and gender (MALE) are included. The RUR dummy captures differences between urban and rural practices, and the FRIT dummy incorporates differences between French/Italian- and German-speaking areas.

The aggregation at each patient level requires a time indicator that allows us to control for price changes over time, which directly affect MPD and CPD values. Therefore, for every aggregated observation (n), the share of prescriptions pertaining to each year is calculated, and two share variables are included in the regression—one for 2006 (Y06) and one for 2007 (Y07), where 2005 constitutes the reference category.

Rischatsch et al. [13] show that financial interests encourage dispensing physicians to substitute brand-name with generic drugs. In contrast to optimizing drug choice, the present study is interested in how the combination of prescription and dispensation affects package choice when a particular drug is chosen. Therefore, drug-specific constants (DSCs) are included to control for different manufacturer prices across pharmaceuticals. The brand-name drug constitutes the reference drug. Omitting drug choice would underestimate the dispensing physicians' MPD due to a higher market share of generics with lower logistic drug margins. Again, the present study is interested in separating out such effects. Further, DSCs control for additional unobserved drug-specific effects.

The estimation equation can be written as

$$\begin{aligned} y = {} & \beta_0 + \beta_1 \mathrm{PD} + \beta_2 \mathrm{GP} + \beta_3 \mathrm{NPA} + \beta_4 \mathrm{DEDM} \\ & + \beta_5 \mathrm{DEDH} + \beta_6 \mathrm{HMO} + \beta_7 \mathrm{GATE} + \beta_8 \mathrm{AGE} \\ & + \beta_9 \mathrm{MALE} + \beta_{10} \mathrm{RUR} + \beta_{11} \mathrm{FRIT} + \beta_{12} \mathrm{Y06} \\ & + \beta_{13} \mathrm{Y07} + \beta_{14} \mathrm{DSC1} + \beta_{15} \mathrm{DSC2} + \beta_{16} \mathrm{DSC3} \\ & + \beta_{17} \mathrm{DSC4} + \varepsilon, \end{aligned} \tag{7}$$

where $y \in \{\mathrm{MPD}, \mathrm{CPD}\}$, and ε denotes the error term.

Model specification

The estimation of MPD and CPD values using ordinary least squares (OLS) regression can be problematic because the data are non-negative and such data are often heavily skewed. In this case, it is not appropriate to assume normally distributed errors, and doing so may lead to meaningless negative predictions. A possible solution to this problem is to transform the dependent variable and perform an OLS regression on the transformed variable. The model proposed by Box and Cox [3] can be used to find the optimal transformation. The Box–Cox transformation of the dependent variable leads to the estimation equation $(y^{\lambda} - 1)\lambda^{-1} = x\beta + \varepsilon$, where λ is estimated simultaneously with β. In the limiting case where λ is zero, the left-hand side of the expression reduces to $\ln(y)$. The disadvantage of the Box–Cox model is that the β's are not interpretable without performing a re-transformation to the raw scale. In the presence of heteroscedasticity, this can be problematic and lead to biased estimates.

The generalized linear models (GLMs) approach serves as an alternative. The great advantage of these models is that no re-transformation to the raw scale is required after the estimation (see Manning [8], Manning and Mullahy [9]). A GLM is defined through its link function $g(\cdot)$ and the distributional family of the dependent variable $F(y)$. The link function defines the relation between the expected outcome $E[y|x]$ and the linear predictor $x\beta$, so that $g(E[y|x]) = x\beta$. The most prominent functions are the logarithmic $\ln(y) = x\beta$ and the inverse $y^{-1} = x\beta$ link function. The optimal link function depends on the data and can be found using the Box–Cox model discussed previously. The distributional family $F(y)$ defines the relation between the mean and variance of the dependent variable. Manning and Mullahy [9] recommend that the test proposed by Park [11] should be used to find the optimal mean-variance relation for the data at hand. In this study, the gamma family in combination with the logarithmic link function is found to fit the data best.

The GLMs in this study are estimated using the Bayesian approach. The joint posterior $K(\theta|D)$ is computed

by Bayes theorem and links the observed data (D) with the researcher's expectations about the unknown parameters (θ), so that

$$K(\theta|D) = \frac{L(D|\theta) \cdot k(\theta)}{L(D)}, \tag{8}$$

where $L(D|\theta)$ is the likelihood of observing D given θ, $k(\theta)$ is the prior about θ, and $L(D)$ is the normalizing constant. The denominator is independent of θ and can be dropped, resulting in $K(\theta|D) \propto L(D|\theta) \cdot k(\theta)$, which is the product of the likelihood times the prior distribution.

For the gamma GLM, the likelihood is given by $\Gamma(\mu\tau, \tau)$, where Γ denotes the gamma distribution with its scale and shape parameters. The logarithmic link function enters the model as $\ln(\mu) = X\beta$, where X is the covariate matrix. Thus, $\theta = \{\beta, \tau\}$ are the unknown parameters of interest. Here, τ is the likelihood's precision parameter, which is equivalent to the inverse of the variance ($\tau = \sigma^{-2}$) and is assumed to have a gamma prior, i.e., $\tau \sim \Gamma(a_\tau, b_\tau)$. Physician-specific estimates (β_p) are obtained by specifying a hierarchical structure for the Bayes model such that β is replaced by $\beta_p = \bar{\beta} + \delta_p$, where $\bar{\beta}$ represents the population mean effect of β and δ_p represents the difference in the effect between physician p and the population mean, with $E[\delta_p] = 0$. Normal priors are assumed at the lower hierarchical stage, so that $\bar{\beta} \sim N(\mu_{\bar{\beta}}, \tau_{\bar{\beta}})$ and $\delta_p \sim N(0, \tau_\delta)$, and the hyperprior for τ_δ at the upper level of hierarchy is assumed to be gamma distributed with $\tau_\delta \sim \Gamma(a_\delta, b_\delta)$. All prior and hyperprior parameters are chosen to make the priors as uninformative as possible, so that their selection does not affect the estimates. However, given the large size of the data set to be analyzed, the weight of the assumed priors diminishes, so their selection is not influential. The joint posterior is then given by

$$\begin{aligned} K(\bar{\beta}, \delta_p \forall p, \tau_\delta, \tau|D) \propto & \prod_p \Gamma(D|e^{X\bar{\beta}+X\delta_p} \cdot \tau, \tau) \\ & \times N(\bar{\beta}|\mu_{\bar{\beta}}, \tau_{\bar{\beta}}) \\ & \times N(\delta_p|0, \tau_\delta) \times \Gamma(\tau_\delta|a_\delta, b_\delta) \\ & \times \Gamma(\tau|a_\tau, b_\tau), \end{aligned} \tag{9}$$

which has no standard distribution and has to be simulated. To reduce the complexity of the model, only the coefficient pertaining to physician dispensing (PD) is modeled using a hierarchical structure.

Data

To test for margin optimization, three active pharmaceutical ingredients from therapeutic categories with high sales volumes were selected: omeprazole, amlodipine, and ciprofloxacin (see Hunkeler [7]).[8] The drug claims data were provided by a major Swiss health insurer and contain prescription-level observations between 2005 and 2007. Omeprazole is an inhibitor of gastric acid secretion and is used to treat gastric and duodenal abscesses, while amlodipine is a calcium channel blocker for treating angina and ciprofloxacin is used to treat specific bacterial infections.[9]

A first univariate comparison of logistic drug margin per dose between dispensing physicians and pharmacies shows that mean and median MPD values are higher for dispensing physicians regardless of the substance.[10] For omeprazole and amlodipine, the data reveal a negative correlation between PD and CPD.[11] This can be explained by the higher share of generics dispensed by physicians, and underlines the importance of including DSCs in the regression to separate drug choice from margin optimization.

Three additional measures permit a first impression of prescribing behavior regarding package choice. On average, dispensing physicians sold a higher number of packages to provide the median dosage per patient needed. For omeprazole, dispensing physicians prescribed 2.3 packages versus 1.9 packages by non-dispensing physicians. The values for amlodipine are 3.5 versus 3.3, and for ciprofloxacin 1.1 versus 1.0. This is in line with the average package size prescribed. On average, omeprazole was prescribed in packages containing 34.6 pills (dispensing physicians) versus 42.4 pills (non-dispensing physicians). The same tendency can be observed for amlodipine (84.5 vs. 87.6) and ciprofloxacin (12.7 vs. 14.4), which supports the hypothesis that dispensing physicians prescribe smaller packages.

Descriptive statistics for the explanatory variables are shown in Table 1. The share of sampled observations (aggregated as discussed previously, not single prescriptions) pertaining to dispensing physicians was between 39 and 52 %. Hunkeler [7] estimates a physician-dispensing rate of 33 % for all prescriptions covered by Swiss social health insurance. The high share emphasizes the important role of PD in delivering pharmaceuticals in Switzerland. GPs prescribed more than 77 % of the sampled observations. On average, physicians faced 32 patients in need of amlodipine and ciprofloxacin, and 71 patients requiring omeprazole. About 90 % of the sampled patients chose the lowest deductible category, while 3–9 % signed a medium

[8] ATC-codes: omeprazole (A02BC01), amlodipine (C08CA01), ciproflocaxin (J01MA02).

[9] For more information, see http://www.drugbank.ca/drugs.

[10] Mean MPD (in CHF per 1,000 mg) for physicians versus pharmacies: 40.0 versus 37.6 (omeprazole), 53.1 versus 52.1 (amlodipine), and 4.1 versus 3.9 (ciprofloxacin).

[11] Mean CPD (in CHF per 1,000 mg) for physicians versus pharmacies: 101.1 versus 101.7 (omeprazole), 155.8 versus 158.5 (amlodipine), and 9.0 versus 8.8 (ciprofloxacin).

Table 1 Descriptive statistics of the covariates used

Variable	Abbrev.	Omeprazole			Amlodipine			Ciprofloxacin		
		Mean	Med.	SD	Mean	Med.	SD	Mean	Med.	SD
Physician dispensing	PD	0.39	–	–	0.45	–	–	0.52	–	–
General practitioner	GP	0.81	–	–	0.86	–	–	0.77	–	–
Number of patients	NPA	71	30	109	32	16	47	32	15	47
Medium deductible	DEDM	0.06	–	–	0.03	–	–	0.09	–	–
High deductible	DEDH	0.01	–	–	0.01	–	–	0.02	–	–
HMO insured	HMO	0.04	–	–	0.02	–	–	0.02	–	–
Gatekeeping insured	GATE	0.05	–	–	0.04	–	–	0.06	–	–
Rural area	RUR	0.25	–	–	0.27	–	–	0.25	–	–
French/Italian	FRIT	0.45	–	–	0.33	–	–	0.34	–	–
Share prescriptions (2006)	Y06	0.33	–	–	0.30	–	–	0.35	–	–
Share of prescriptions (2007)	Y07	0.41	–	–	0.32	–	–	0.37	–	–
Patient age	AGE	58	59	18	70	72	13	57	59	19
Patient sex	MALE	0.39	–	–	0.47	–	–	0.41	–	–
Share of generic drug (no. 1)	DSC1	0.38	–	–	0.31	–	–	0.34	–	–
Share of generic drug (no. 2)	DSC2	0.37	–	–	0.19	–	–	0.27	–	–
Share of generic drug (no. 3)	DSC3	0.10	–	–	0.09	–	–	0.18	–	–
Share of generic drug (no. 4)	DSC4	0.07	–	–	0.06	–	–	0.04	–	–

Mean mean values are shown, *Med.* median values are shown, *SD* standard deviations are shown

(DEDM) and 1–2 % signed a high (DEDH) deductible contract. Only 2–4 % were HMO insured and 4–6 % signed a gatekeeping contract. The average patient age was 58 (omeprazole), 70 (amlodipine), and 57 (ciprofloxacin). Between 39–47 % of the sampled patients were male. About a quarter of all practices were located in rural areas and 33–45 % were in French- or Italian-speaking areas. Prescriptions were distributed equally over the three years. The DSCs display drug-specific shares of aggregated observations where the brand-name drug is the base category.

Estimation results

Posterior summaries for the hierarchical Bayes GLM estimates are listed in Table 2. As proposed by the Box–Cox model, logarithmic link functions are applied for all three chemical agents, which has further advantages in that the coefficients can be interpreted as semi-elasticities (ξ), e.g., as the percentage change in MPD for a change from pharmacy (PD = 0) to physician (PD = 1) dispensing, ceteris paribus.

Margin comparison

In this study, PD is the variable to assess in order to determine if permitting physicians to sell drugs on their own account leads to margin optimization activities. The posterior means for PD show that the logistic margin per dose is 10.1 % higher for omeprazole, 5.6 % higher for amlodipine, and 5.2 % higher for ciprofloxacin. None of the 95 %-credibility intervals include zero, and the lowest 2.5 percentile was found for ciprofloxacin (4 %) while the highest 97.5 percentile was found for omeprazole (11 %). These values point to margin optimization activities by dispensing physicians. The upper panel of Fig. 3 depicts the Kernel densities of physician-specific semi-elasticities (ξ_p) for physician dispensing.

The estimates pertaining to the GP variable show no evidence for differences in the prescribing behavior between general practitioners and specialists. While the 95 %-credibility interval includes zero in the case of omeprazole, the interval for amlodipine is located in the positive, while the one for ciprofloxacin lies only in the negative domain. The same conclusions can be drawn for the number of patients a physician faced during the study period (NPA). Based on the credibility intervals, the effect is positive for omeprazole and ciprofloxacin but negative for amlodipine. The medium and high deductible categories (DEDM, DEDH) control for patients with better latent health status who are expected to be less likely to suffer from chronic diseases and thus have a lower likelihood of a high drug demand. Hence, they can be supplied with less cost-efficient packages due to the discounting of large packages. Indeed, there is empirical evidence supporting this expectation in the cases of omeprazole and amlodipine. For ciprofloxacin, the mean effect is not statistically

Table 2 Hierarchical Bayes GLM results

Posterior	Omeprazole			Amlodipine			Ciprofloxacin		
	Mean	Percentiles		Mean	Percentiles		Mean	Percentiles	
		2.5	97.5		2.5	97.5		2.5	97.5
Estimation 1: Margin per dose (MPD)									
Physician dispensing	0.10	0.09	0.11	0.06	0.05	0.07	0.05	0.04	0.06
General practitioner	0.00	−0.01	0.01	−0.02	−0.03	−0.01	0.02	0.01	0.03
Number of patients	0.02	0.01	0.02	−0.02	−0.03	−0.02	0.02	0.01	0.02
Medium deductible	0.06	0.04	0.07	0.07	0.05	0.09	0.00	−0.00	0.01
High deductible	0.08	0.06	0.11	0.09	0.05	0.14	0.01	−0.01	0.03
HMO insured	0.02	−0.00	0.04	−0.03	−0.06	−0.00	−0.02	−0.04	−0.01
Gatekeeping insured	0.01	−0.01	0.02	0.02	−0.00	0.03	0.00	−0.01	0.01
Patient age	−0.08	−0.08	−0.07	0.00	−0.00	0.00	−0.00	−0.01	−0.00
Patent sex (male)	−0.05	−0.05	−0.04	−0.07	−0.07	−0.06	−0.11	−0.12	−0.11
Rural area	−0.00	−0.01	0.01	0.00	−0.00	0.01	0.00	−0.00	0.01
French/Italian speaking	0.02	0.01	0.03	0.01	0.00	0.02	−0.03	−0.03	−0.02
Share of prescriptions (2006)	−0.03	−0.04	−0.02	−0.19	−0.20	−0.18	−0.11	−0.11	−0.10
Share of prescriptions (2007)	−0.08	−0.09	−0.07	−0.31	−0.32	−0.30	−0.14	−0.14	−0.13
Share of generic drug (no. 1)	−0.31	−0.32	−0.30	−0.16	−0.17	−0.15	−0.12	−0.12	−0.11
Share of generic drug (no. 2)	−0.36	−0.37	−0.34	−0.21	−0.22	−0.20	−0.09	−0.09	−0.08
Share of generic drug (no. 3)	−0.49	−0.51	−0.47	−0.19	−0.21	−0.18	−0.09	−0.10	−0.08
Share of generic drug (no. 4)	−0.54	−0.56	−0.52	−0.25	−0.26	−0.23	−0.15	−0.17	−0.14
Constant	3.98	3.96	3.99	4.23	4.22	4.24	1.57	1.56	1.58
Estimation 2: Cost per dose (CPD)									
Physician dispensing	0.05	0.04	0.05	0.03	0.03	0.04	0.03	0.02	0.03
General practitioner	−0.00	−0.01	0.00	0.00	−0.00	0.01	0.01	0.01	0.02
Number of patients	0.01	0.00	0.01	−0.02	−0.03	−0.02	0.01	0.00	0.01
Medium deductible	0.02	0.01	0.03	0.03	0.02	0.04	0.00	−0.01	0.01
High deductible	0.04	0.03	0.06	0.05	0.02	0.07	0.01	−0.00	0.02
HMO insured	0.01	0.00	0.02	−0.01	−0.03	0.01	−0.02	−0.03	−0.00
Gatekeeping insured	0.01	0.00	0.02	0.02	0.01	0.04	0.00	−0.01	0.01
Rural area	−0.00	−0.01	0.01	0.01	0.00	0.02	0.00	−0.00	0.01
French/Italian speaking	0.01	0.00	0.01	0.01	−0.00	0.01	−0.01	−0.01	−0.00
Share of prescriptions (2006)	−0.04	−0.04	−0.03	−0.34	−0.34	−0.33	−0.21	−0.22	−0.21
Share of prescriptions (2007)	−0.09	−0.09	−0.08	−0.52	−0.52	−0.51	−0.27	−0.27	−0.26
Patient age	−0.02	−0.03	−0.02	0.00	0.00	0.00	−0.00	−0.00	−0.00
Patient sex (male)	−0.02	−0.03	−0.02	−0.03	−0.03	−0.03	−0.07	−0.07	−0.06
Share of generic drug (no. 1)	−0.73	−0.74	−0.73	−0.38	−0.39	−0.37	−0.28	−0.28	−0.27
Share of generic drug (no. 2)	−0.78	−0.79	−0.78	−0.42	−0.43	−0.42	−0.19	−0.20	−0.19
Share of generic drug (no. 3)	−0.97	−0.98	−0.96	−0.44	−0.45	−0.43	−0.20	−0.21	−0.19
Share of generic drug (no. 4)	−0.86	−0.87	−0.85	−0.53	−0.54	−0.52	−0.31	−0.33	−0.30
Constant	5.35	5.34	5.36	5.52	5.51	5.52	2.55	2.55	2.56
Number of observations	72,488			40,749			66,236		
Number of physicians	7,314			5,919			7,675		

Model specification: Gamma GLM family (F) with logarithmic link function (g). To facilitate simulation, the two explanatory variables number of patients (NPA) and patient age (AGE) were standardized to have $E[x] = 0$, $Var[x] = 1$

different from zero. Heterogeneity in cost awareness among patients is modeled by including alternative health insurance contracts, like HMO and gatekeeping (GATE). HMO-insured patients have 2–3 % lower MPD values. However, omeprazole constitutes an exception where a positive correlation is found. The MPD of a gatekeeping-insured

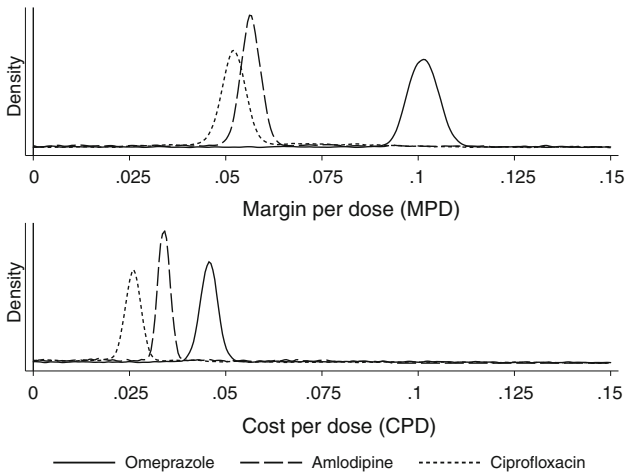

Fig. 3 Dispersion of physician-specific PD effects (ξ_p)

patient is not statistically different from that of a basically insured patient, which is also true for differences between rural and urban practices (RUR). For omeprazole and amlodipine, the MPD is higher for practices located in French- and Italian-speaking areas (FRIT) compared to German-speaking regions. However, ciprofloxacin contradicts this finding, so no clear statement can be made without performing further analysis of additional substances. Having a higher share of prescriptions in 2006 (Y06) and 2007 (Y07) decreases the MPD, as expected, due to price reductions over time. Further, elderly patients receive packages with a lower MPD, which can be explained analogously to the deductible categories. Elderly patients may receive the drugs because of chronic diseases or simply having by a higher drug demand, so they can be supplied with larger cost-efficient packages. Surprisingly, MPDs for males are significantly lower. The drug-specific constants (DSCs) have expected signs and magnitudes considering the lower manufacturer prices of generic drugs.

Drug cost comparison

Regarding the effect of combining drug prescription and dispensation on pharmaceutical expenditure, the outcome variable of interest is the cost per dose (CPD) prescribed. Again, cost is defined to be equal to the sales price in this study. Other costs, such as pharmacy fees, are neglected here. If one is interested in assessing the overall cost efficiency of combined drug delivery, other potential sources for cost savings should be considered, e.g., generic substitution. The estimated semi-elasticities (see the lower panel of Table 2) signify that physician dispensing increases pharmaceutical expenditure due to inefficient package choice.

The estimated posterior means of ξ's for PD with respect to CPD are 4.6 % (omeprazole), 3.4 % (amlodipine), and 2.6 % (ciproflocaxin). Again, none of the 95 %-credibility intervals include zero, and the lowest 2.5 percentile is found for ciprofloxacin (2.0 %), while the highest 97.5 percentile is estimated for omeprazole (5.4 %). These estimates show that physician dispensing leads to a higher drug cost if only package choice is considered. However, generic substitution and other potential savings (see the discussion above) could overcompensate for these costs. In addition, even in the case of a higher pharmaceutical cost, patients' willingness to pay for easier access to pharmaceuticals may be higher than the additional cost, thus legitimizing physician dispensing. In Switzerland, a referendum in 2009 revealed that citizens are strongly in favor of dispensing physicians.

Conclusions and discussion

While most countries separate drug prescription and dispensation to ensure independent drug choice, some countries grant the authority to physicians to dispense or pharmacists to prescribe drugs on their own account. On the one hand, this approach facilitates access to pharmaceuticals in rural areas and makes greater use of pharmacists' skills. On the other hand, a drawback of combining drug prescription and dispensation is the potential for drug margin optimization by combined drug providers, which may lead to higher pharmaceutical expenditure due to inappropriate prescription of drug packages.

This study sought to answer two questions. First, what role does the pharmaceutical pricing mechanism play in setting financial incentives for dispensing physicians to conduct margin optimization? Second, is there empirical evidence for margin optimization by dispensing physicians in Switzerland? The theoretical part of the study showed that the per-package margin component incentivizes dispensing physicians to reduce package size in return for a higher quantity of packages. The findings from hierarchical Bayes GLM estimation support the expected positive correlation between physician dispensing and logistic drug margin per dose (MPD) as well as the pharmaceutical cost per dose (CPD). For MPD, the posterior means of the semi-elasticities with respect to the physician-dispensing dummy indicate that the margins are 5–10 % higher for dispensing physicians compared to the margins of pharmacists. None of the 95 %-credibility intervals include zero. The CPD is 3–5 % higher for dispensing physicians, indicating that profit considerations lead to higher drug expenditure due to inappropriate package choice. However, physician dispensing could lower pharmaceutical bills through other cost savings. Thus, the study does not allow us to put forward a general statement about the cost efficiency of combined drug provision. However, the evidence that

dispensing physicians receive higher logistic margins than pharmacists indicates that dispensing physicians are imperfect agents for their patients. Further, the analysis shows that margin optimization most likely arises because of the per-package margin component used in the drug pricing mechanism. Hence, some regulatory changes could help to mitigate inadequate package choice by dispensing physicians. First, the per-package margin should be abolished. Second, package prices should relate linearly to the dosage contained. These two changes would remove all incentives originating from the logistic margin, because—regardless of how the drug is dispensed—the same drug quantity would always lead to the same logistic drug margin. However, a drawback of the latter is that it makes large packages more expensive than they currently are, because discounts would cease to exist. However, discounting could be retained, because its effect is negligible compared to the effect of the per-package margin.

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Appendix

See Tables 3, 4 and 5.

Table 3 Logistic drug margin regulation

	Abbrev.	Unit	Price category					
			Cat. 1	Cat. 2	Cat. 3	Cat. 4	Cat. 5	Cat. 6
Manufacturer price	P	CHF	<5.00	5.00–10.99	11.00–14.99	15.00–799.99	800–1,799	≥1,800
Per-package component	m_f	CHF	4.00	8.00	12.00	16.00	60.00	240.00
Capital component	m_v	%	12–15	12–15	12–15	12–15	8–10	–

Source: Drabinski et al. [4] (1 CHF ≈ 1.1 USD at 2011 exchange rates)

Table 4 Manufacturer price relation for packages of the same drug

Discount rate	Formula	Number of pills (S)					Dosage per pill (D)			
		S^*	$2S^*$	$3S^*$	$4S^*$	$5S^*$	D^*	$2D^*$	$3D^*$	$4D^*$
		–	0.12	0.15	0.18	0.21	–	0.18	0.24	0.30
Linear price	$P = l \cdot P^*$	l = 1.00	2.00	3.00	4.00	5.00	1.00	2.00	3.00	4.00
Discounted price	$P = d \cdot P^*$	d = 1.00	1.76	2.55	3.28	3.95	1.00	1.64	2.28	2.80

P^* denotes the reference price of a drug. It is the price of the smallest available package with respect to the number of pills and the dosage per pill, and constitutes the starting point for the pricing of other packages of the same drug. Using the discount rates (d), the discounted manufacture prices are given by $P = d \cdot P^*$. Comparing the applied discounted with the hypothetical linear manufacturer prices shows that, for example, a package with 100 pills ($5S^*$) costs only 3.95 instead of 5.00 times the price of a package with 20 pills (S^*). *Source:* BAG [1]

Table 5 Example of relative changes in logistic drug margins ($D_t = 560$, $D = 20$)

Number of...		Antra MUPS		Omezol-Mepha MT		Omed		Oprazol		Omeprazole Helvepharm	
Pills	Packages	Margin	Δ	Margin	Δ	Margin	Δ	Margin	Δ	Margin	Δ
28	1	32.82	1.00	22.52	1.00	22.47	1.00	25.20	1.00	21.35	1.00
14	2	49.92	1.52	38.10	1.69	38.01	1.69	41.10	1.63	29.10	1.36
7	4	84.96	2.59	57.00	2.53	N.A.	–	N.A.	–	39.00	1.83

Logistic drug margins are shown in CHF (1 CHF ≈ 1.1 USD at 2011 exchange rates). Relative changes are denoted by Δ. Once the manufacturer prices for all available packages of a drug are defined, the logistic drug margin for each package is determined depending on the manufacturer price category, as discussed in the "Institutional background" section. The logistic drug margins shown above are those of the brand-name drug of omeprazole (see the illustrative example in the "Institutional background" section) and four of its generic competitors

N.A. not available

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