Explaining individual health expenditure in the presence of health insurance: An extended Box-Cox indirect censoring model

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Abstract

In this paper we extend the Box-Cox indirect censoring model (Chaze, 2005) in order to simultaneously analyze healthcare consumption and insurance deductible choice in Switzerland. One original feature of this study is the focus on both the insurance deductible effect on healthcare demand and role played by GP density in the formation of this demand. We find that health insurance leads to interesting indirect effects on healthcare demand. For instance, individuals living in high-premium regions tend to increase their deductible, which in turn incites them to consume less healthcare. We also show that individuals facing higher regional health hazards opt for lower deductibles, ending up consuming more healthcare. Finally, we find evidence of presence of both moral hazard and induced demand.

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1 Introduction

In this paper, we focus on two prominent characteristics of healthcare demand. The first one is that in the presence of health insurance, the individual has an incentive to consume more than what he would without coverage. This concept is referred to as static ex-post moral hazard in the literature (see Zweifel and Manning, 2000, for a review) and is due to the fact that health insurance alters the individual's budget constraint by reducing healthcare price. The empirical identification of moral hazard requires observing some degree of heterogeneity in individual health insurance coverage. The problem is then that individuals tend to choose their health insurance coverage according to their projected healthcare consumption and this self-selection confounds the effect of moral hazard. One exception is the RAND Health Insurance Experiment where individuals were randomly assigned to health plans in order to neutralize self-selection (see Manning et al., 1987; Newhouse and the Insurance Experiment Group, 1993). With nonexperimental data, the endogeneity of health insurance has to be dealt with either by making theoretical assumptions (Gardiol et al., 2005) or by means of an adequate econometric method (see for instance Goldman, 1995; Schellhorn, 2001; Mello et al., 2002; Lehmann and Zweifel, 2004; Deb et al., 2006). These references illustrate the wide variety of models that have been applied in practice, showing as many solutions as there are different types of insurance contracts and healthcare data available.

The second prominent feature of healthcare demand we consider is that the physician is part of the formation of patient demand. There is wide agreement on this fact but the nature of the physician's role is still highly controversial. One school sees him acting as a perfect agent, providing his patients with unbiased information and allowing them to freely make their own consumption decision (Feldstein, 1973; Mooney and Ryan, 1993). An opposite point of view is held by other authors who see the physician persuing his own objectives and altering patient preferences in his own interest (Evans, 1974). The latter behavior is referred to as physician induced demand in the literature (see McGuire, 2000, for a detailed review). One popular identification strategy of physician induced demand is through an income effect: when a physician's market share is reduced, he may induce a higher demand in order to maintain his income level (Pauly, 1980). If one uses the regional density of General Practitioners (GP) as an indicator of physician market share, one might conclude that physician induced demand is present if higher GP density coincides with higher healthcare demand.

Most studies about physician induced demand have been criticized due to the lacking of important control variables. In particular, Phelps (1986) heavily criticized one study (Cromwell and Mitchell, 1986, performed at market level) for not having taken health insurance into account, which is a relevant factor as it alters the price of healthcare. The importance of health insurance is also acknowledged by Zweifel and Manning (2000) who note that it increases the degree of delegation to the physician in the patient's consumption decision process. This is important because higher delegation to the physician means that inducing demand is facilitated.

The Swiss Social Health Insurance (SHI) provides us with useful heterogeneity as identical contracts are available which only differ in their deductible and premium. In order to exploit this heterogeneity we develop an extension to a selection model, the Box-Cox indirect censoring model (Chaze, 2005), allowing it to simultaneously analyze individual healthcare expenditure and insurance deductible choice. Its formulation does not include healthcare expenditure in the deductible equation since health insurance choice is made prior to healthcare consumption. The endogeneity of the deductible variable in the healthcare expenditure equation thus only arises from unobservable factors common to both equations. We handle this with a correlation parameter between their error terms, in the spirit of the specification chosen by Schellhorn (2001) in his analysis of the effect of SHI deductible on physician visits. We use here data from the Swiss Household Income and Expenditure Survey over the period 2000-2005 and add sub-cantonal regional variables for GP density, health status, average SHI premiums and other relevant geographical factors. Our model aims at testing for the presence of both moral hazard and induced demand, the SHI deductible being used to directly identify the former and as a control variable in the identification of the latter.

Section 2 gives an overview of the Swiss health system and Section 3 presents the econometric model we have developed. Section 4 provides information on both the dataset and variables used, Section 5 presents the results. Section 6 concludes.

2 Overview of the Swiss health system

In this section we briefly present the main features of the Swiss health system. Unless otherwise specified, the figures concerning health system cost and financing (SFSO, 2005) and health insurance (FOPH, 2004) which are given here relate to the year 2003.

In 2003, total health care system costs amounted to CHF 49.9 billions. This represents 11.5% of GDP, which places Switzerland second only to the USA in the ranking of OECD countries. Moreover, the general context is one of a steady rise in cost by 23.3% over the period 2000-2005. Since the GDP only increased by 15.7% during the same period, expansion of the health sector cannot be fully financed by economic growth, which puts the whole system under great pressure. As regards the health price index, it rose slightly less rapidly (+3.4%) than the general price index (+4.2%). Even though the health price index generally tends to underestimate price increases due to technological advancement, it seems that the rise in health system cost is mainly caused by an increase in quantity consumed.

Inpatient care (47.7%) represents by far the most important part of total cost. Outpatient care comes second (29.4%) while health goods (12.6%), which include medicines, comes third. The other components are administrative costs (4.8%), auxiliary services such as lab tests (3.1%) and prevention (2.3%).

The health system is first financed by social insurances which contribute 40.5% to total cost. These include SHI, contributing 32.7%. The State bears 17.9% of total cost, mainly through cantonal inpatient care financing. Private health insurance (PHI, 9.0%), covers services not included in SHI. The most common private contracts offer free inpatient physician choice and better hospital accommodation, dental care coverage and reimbursement of alternative medicine. Despite these prepayment financing mechanisms, Swiss households still have to directly bear 31.6% of total cost, partly from payments for services not covered by SHI, and partly from health insurance deductibles and copayments.

SHI is of particular interest (see for instance OECD and WHO, 2006, for a detailed description). It is provided by FOPH[1]-approved insurance companies which are barred from making a profit on this business (but may offer for-profit PHI as well). All SHI insurers cover the same range of care related to illness, accident[2] and maternity as defined by the law. In particular, diagnostic services and treatments are reimbursed based on a non-exclusive list, exceptions being maternity, preventive and dental treatment services. The latter are covered only in case of serious illness. Restrictions apply to pharmaceuticals, complementary medicine and non-medical services such as physiotherapy. Hospital care is reimbursed at shared ward tariff. SHI is compulsory for all Swiss residents, with free choice of insurer, and the latter barred from refusing any new applicant. Premiums are not risk-related but set according to regions which correspond either to whole cantons or up to three parts thereof. That is why a compensation mechanism based on age and gender of the insured has to be applied at the end of the year in order to readjust the risk structure of the insurer. It may finally be noted that cantonal subsidies are granted to individuals with low or middle/low income in order to reduce their SHI premiums.

49.7% of the insured have an ordinary SHI contract which allows free choice of provider, requires payment of a monthly per-capita premium and comes with an annual deductible of CHF 230 (CHF 300 since 2004). A 10% copayment is also necessary for most types of care until an annual cap is reached. The ordinary contract premium is quite expensive: CHF 269[3] on national average with great cantonal disparity, ranging from CHF 198 for Uri to 390 for Geneva. The law makes it possible to reduce premium in return for a higher deductible. The set of deductible levels offered has been adapted several times since the current system came into force in 1996. Table 1 presents the ordinary and optional deductible values which have been available.

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[1] Federal Office of Public Health.

[2] Only for individuals without employee accident insurance.

[3] This is the average premium for adults aged 26 and over, as young adults aged 18 to 25 can obtain a premium reduction while studying.

Table 1
Evolution of the SHI deductibles

Period	Deductible level Ordinary	Optional				
1996-2003	230	400	600	1200	1500	
2004	300	400	600	1200	1500	
2005+	300	500	1000	1500	2000	2500

In 2003, 42.0% of the insured had opted for contracts with optional deductible. Less popular insurance contracts are also available as another means to reduce premium. These are provider-limiting including HMO[4] contracts (8,2% of the insured) and non-claim bonus insurance (0.1%). Interestingly, SHI basic and optional deductible contracts considered together amount to 91.7%. This means that in practice the vast majority of the insurance contracts differ only in their premium and deductible level.

Finally, Switzerland is a country with wide geographic disparities in the supply of care due to its highly decentralized health system. Cantonal number of GPs for 1000 inhabitants ranged from 0.44 (Nidwald) to 0.76 (Aargau) in 2003 (Obsan, 2007). This heterogeneity in density of GPs and individual deductible choice makes it possible to identify the effect of both health insurance coverage and healthcare supply, which is an interesting feature of Swiss data.

3 An extended Box-Cox indirect censoring model

In order to address potential endogeneity of the deductible in individual healthcare consumption, we extend the Box-Cox indirect censoring specification (Chaze, 2005) by adding an ordered probit for the choice of deductible. The extended model thus relies on the following three equation system:

$$\begin{cases} y_{1i}^* = \beta_1' x_{1i} + \gamma_1' y_{3i} + \sigma_1 u_{1i} \\ y_{2i}^* = \beta_2' x_{2i} + \gamma_2' y_{3i} + u_{2i} \\ y_{3i}^* = \beta_3' x_{3i} + u_{3i} \end{cases} , \tag{1}$$

This system defines three latent variables: y_{1i}^* corresponds to the level of healthcare consumption, in a transformed scale in order to address nonnormality, y_{2i}^* corresponds to the participation decision (consuming or not) and y_{3i}^* corresponds to the choice of deductible. In this system, x_{1i}, x_{2i}, x_{3i} are

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[4] Health Maintenance Organization.

vectors of exogenous covariates, and β_1, β_2, β_3 their associated parameter vectors. y_{3i} is the observed deductible chosen by individual i, with γ_1 and γ_2 the corresponding parameters in the first two equations. Finally, σ_1 is a standard error parameter and u_{1i}, u_{2i}, u_{3i} error terms. Note that the last two equations contain no standard error parameter as we apply the standard identifying restriction of unit variance for probit equations.

The endogeneous deductible level y_{3i} is determined by equation:

$$y_{3i} = D_{ik} \quad \text{if} \quad c_{i,k-1} \leq y^*_{3i} < c_{ik}, k = 1..K_i, \tag{2}$$

where D_{ik} is the k^{th} ranked choice of deductible available to individual i for the observation period, K_i is the number of choices available for that period, and c_{ik} are threshold parameters, with $c_{i0} = -\infty$, $c_{i1} = 0$ (identifying restriction) and $c_{iK_i} = +\infty$. Note that in order to keep notations simple, since each individual is only observed once in the sample, we use index i to account for the fact that individuals face different choices from year to year.

Finally, observed healthcare consumption (i.e. real expenditure) is determined by equation:

$$y_{1i} = \begin{cases} T^{-1}(y^*_{1i}) \text{ if } y^*_{2i} > 0 \\ 0 \qquad\qquad \text{otherwise} \end{cases}. \tag{3}$$

where T represents the standard Box-Cox transformation (Box and Cox, 1964), defined by

$$T(y) = T(y;\lambda) = \begin{cases} \frac{y^\lambda - 1}{\lambda} & \text{if } \lambda \neq 0 \\ \log(y) & \text{if } \lambda = 0 \end{cases}. \tag{4}$$

The vector of error terms u_{1i}, u_{2i}, u_{3i} is assumed to follow a standardized trivariate normal distribution, with correlations ρ_{12}, ρ_{13} and ρ_{23}. This trivariate normal must however be truncated in order to ensure that, whatever λ, y^*_{1i} remains in the validity domain of T^{-1}. We therefore define the following bounds:

$$B_{1ik} = \begin{cases} -\frac{1}{\sigma_1}\left(\frac{1}{\lambda} + \beta_1' x_{1i} + \gamma_1 D_{ik}\right) & \text{if } \lambda > 0 \\ -\infty & \text{if } \lambda \leq 0 \end{cases}, \tag{5}$$

$$B_{2ik} = \begin{cases} +\infty & \text{if } \lambda \leq 0 \\ -\frac{1}{\sigma_1}\left(\frac{1}{\lambda} + \beta_1' x_{1i} + \gamma_1 D_{ik}\right) & \text{if } \lambda > 0 \end{cases}. \tag{6}$$

and

$$c^*_{ik} = \begin{cases} -\infty & \text{if } k = 0 \\ c_{ik} - \beta_3' x_{3i} & \text{if } 1 \le k \le K_i - 1\,. \\ +\infty & \text{if } k = K_i \end{cases} \tag{7}$$

The joint density of u_{1i}, u_{2i}, u_{3i} becomes:

$$f(u_{1i}, u_{2i}, u_{3i}) = \begin{cases} \frac{1}{\Delta_i}\phi(u_{1i}, u_{2i}, u_{3i}; \rho_{12}, \rho_{13}, \rho_{23}) & \begin{array}{l} \text{if} \quad B_{1ik} < u_{1i} < B_{2ik} \\ \text{and } \; c^*_{i,k-1} < u_{3i} < c^*_{ik} \end{array} \\ 0 & \text{otherwise} \end{cases} \tag{8}$$

where

$$\Delta_i = \begin{cases} 1 - \sum_{k=1}^{K_i} \Big[\Phi(B_{1ik}, c^*_{ik}; \rho_{13}) - \Phi(B_{1ik}, c^*_{i,k-1}; \rho_{13})\Big] & \text{if } \lambda > 0 \\ 1 & \text{if } \lambda = 0 \\ \sum_{k=1}^{K_i} \Big[\Phi(B_{2ik}, c^*_{ik}; \rho_{13}) - \Phi(B_{2ik}, c^*_{i,k-1}; \rho_{13})\Big] & \text{if } \lambda < 0 \end{cases} \tag{9}$$

Note that ϕ and Φ represent density and cumulative of the standardized multivariate normal (with dimension given by the number of arguments).

Under these assumptions, the model can be estimated by maximum likelihood. The (limited information) log-likelihood may be written as:

$$\begin{aligned} \log L = \sum_{i=1}^{n} \Big\{ & (1 - y_{2i}) \log P(y_{1i} = 0 | x_i) \\ & + y_{2i} \log P(y_{1i} > 0 | x_i) f(y_{1i} | y_{1i} > 0, x_i) \Big\}, \end{aligned} \tag{10}$$

where $y_{2i} = 1(y^*_{2i} > 0)$.

The probability of no consumption is given by:

$$\begin{aligned} P(y_{1i} = 0 | x_i) = \sum_{k=1}^{K_i} \Big\{ & \;\Phi(-\beta_2' x_{2i} - \gamma_2 D_{ik}, c_{ik} - \beta_3' x_{3i}; \rho_{23}) \\ & - \Phi(-\beta_2' x_{2i} - \gamma_2 D_{ik}, c_{i,k-1} - \beta_3' x_{3i}; \rho_{23}) \Big\} \end{aligned}, \tag{11}$$

and the conditional density of positive consumption by:

$$
\begin{aligned}
P(y_{1i} > 0|x_i)f(y_{1i}|y_{1i} > 0, x_i) = {} & \frac{1}{\sigma_1 \Delta_i} y_{1i}^{\lambda-1} \sum_{k=1}^{K_i} \phi(u_{1ik}) \\
& \times \left[\Phi\left(\frac{\beta_2' x_{2i} + \gamma_2 D_{ik} + \rho_{12} u_{1ik}}{\sqrt{1-\rho_{12}^2}}, \frac{\beta_3' x_{3i} - c_{i,k-1} + \rho_{13} u_{1ik}}{\sqrt{1-\rho_{13}^2}}; \rho_{23|1} \right) \right. \\
& \left. - \Phi\left(\frac{\beta_2' x_{2i} + \gamma_2 D_{ik} + \rho_{12} u_{1ik}}{\sqrt{1-\rho_{12}^2}}, \frac{\beta_3' x_{3i} - c_{ik} + \rho_{13} u_{1ik}}{\sqrt{1-\rho_{13}^2}}; \rho_{23|1} \right) \right], \quad (12)
\end{aligned}
$$

where:

$$
\begin{aligned}
u_{1ik} &= \frac{T(y_{1i}) - \beta_1' x_{1i} - \gamma_1 D_{ik}}{\sigma_1}, \\
\rho_{23|1} &= \frac{\rho_{23} - \rho_{12}\rho_{13}}{\sqrt{1-\rho_{12}^2}\sqrt{1-\rho_{13}^2}}.
\end{aligned}
$$

Finally, even though the estimated model makes it possible to understand how healthcare demand (and insurance choice) arises, the main interest lies in the untransformed variable y_{1i}. y_{1i} being a limited dependent variable, two different expectations can be computed, namely the unconditional expectation $\mathrm{E}(y_{1i}|x_i)$, which involves both positive and zero expenditures, and the conditional expectation $E(y_{1i}|y_{1i} > 0, x_i)$, which relates only to positive expenditures. We present the formulas for computing these expectations along with the probability of consuming, conditionally on a set of covariates in Appendix A.

4 Data and variable definitions

The micro dataset is obtained by pooling monthly cross-sectional samples from the Swiss Household Income and Expenditure Survey (SHIES) over the period 2000-2005. This nationally representative survey of private households provides information on household income and consumption as well as many personal and household characteristics. The advantage of pooling is that it not only produces a large sample of 20'940 households but also enables us to account for price evolution.

In order to insure homogeneous demand functions, we use the SFSO yearly consumer price index for healthcare (reference period 2000) to deflate all health-related monetary variables (healthcare expenditure, SHI deductible and average regional SHI premium), while the SFSO general price index is used to compute real income and relative price of healthcare. With regard to the latter, it should be stressed that the true individual price depends on insurance coverage and therefore the relative price index only accounts for part of the price effect.

We measure healthcare consumption as the sum of all individual health expenditures over a one month period. It may be noted that SHIES data relates to total cost (including co-payments from insurance companies) and not out-of-pocket expenditure which is unavailable because of reimbursement delay. Moreover, it is not possible to distinguish between covered and uncovered healthcare. One advantage of SHIES data is that most healthcare expenditures appear at individual level, with only 10.4% being reported at household level. Our approach is to allocate the latter to household members proportionally to observed healthcare expenditure. For income, we resort to a proxy for permanent income computed as the sum of all household expenditures, except motor vehicles purchases and healthcare expenditures, divided by an equivalence scale to account for household composition.[5]

As regards compulsory health insurance, SHIES records the deductible level and premium paid. Individual premium will not be considered in this study since it depends mostly on the choice of deductible. Along with individual healthcare expenditure, the deductible is our second dependent variable as it measures individual health insurance coverage. It appears that 7.1% of the individuals did not give any information on their insurance deductible and that 6.6% reported deductible values which are in fact not offered by health insurers. Even though we did not find any significant difference in terms of health expenditure between these groups, we applied a simple imputation method in order to reduce any potential bias. After correcting for obvious typos we imputed the closest standard deductible to the individuals reporting a value not offered. Whenever a reported value fell exactly between two standard values, we randomly assigned the upper or lower closest standard value. Finally, we have not included any variable related to additional health insurance as the survey does not make it possible to properly observe this.[6] Moreover, such a variable might be endogenous (see for instance Barros et al., 2008) and without adequate treatment might bias the estimation.

Other variables are household type (8 categories) and various personal characteristics: nationality (2), education (3) and socio-professional status (8). Furthermore, we randomly draw one individual aged 18 or over from each household in order to obtain an independent sample. We do not consider children who have very different consumption patterns and different deductibles. After eliminating the observations with missing values we get a sample of

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[5] The equivalence scale factor is computed as the square root of the sum of the number of adults and half the number of children.

[6] In the SHIES, additional health insurance premiums are mixed with those of accident insurance.

19'973 individuals.

In order to account for supply-side factors, the density of general practitioners is a key covariate in this study. We compute it at sub-cantonal level according to the 2004 health insurance premium regions. [7] . This regional level allows for finer analysis as the largest cantons are split into up to 3 parts, which makes for more homogeneity. For consistency, all other geographical variables are defined at the same regional level. We use three measures of regional health status, namely the prevalence of deaths caused by communicable and non-communicable diseases and accidents. In the absence of information about individual health status, these variables are used as controls. Another geographical variable is the regional average insurance premium (of the basic insurance contract for individuals aged over 26) which will only be used in the deductible equation. Indeed, this variable strongly influences deductible choice but is only marginally linked to individual healthcare expenditure. Finally, we also use two variables related to place of residence: degree of urbanization (4 categories) and linguistic region (3 categories with Italian and Romansh speaking regions grouped).

5 Results

The extended Box-Cox indirect censoring model developed in section 3 is applied to the analysis of individual healthcare expenditure in Switzerland. Explanatory variable selection has been performed by putting all possible covariates (see section 4) in all three equations of the model. A priori exclusions are the average regional health insurance premium which was only included in the deductible equation (see section 4) and binary variables indicating the month of survey excluded from the deductible equation because insurance choice was made prior to the survey. Our selection process removes one variable in one equation at each step until all remaining variables are significant at the 5% level. We then select the best model according to Akaike's information criterion.

The estimated parameters of the model are shown in Appendix B. We can see that even though λ is found to be small, the logarithmic transformation is rejected at the 5% level. As for ρ_{12}, it is not significant, i.e. there is no correlation between the decision to consume and the quantity consumed. This

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[7] These regions (43 overall) are homogeneous throughout all insurers only since 2004. We have maintained these geographical units constant over all the period considered, which is not perfect but still provides us with a very good proxy of high, middle and low premium regions.

result is consistent with the two-part model assumption [8]. Note that ρ_{23} is clearly significant while ρ_{13} is not. The endogeneity of the deductible is thus only found to affect the selection equation. On the other hand, the deductible appears to affect only the quantity consumed (i.e. γ_1 significant) and not the decision to consume (γ_2 not significant). As expected, the sign of γ_1 is negative: the higher the deductible, the lower the healthcare expenditure.

At this point we consider each equation separately. In what follows, it is important to keep in mind that these parameters represent direct effects of the corresponding covariates. Such an analysis helps us to understand the role played by the explanatory variables but is partial as the correlations between the different equations are ignored. The overall effect of each covariate on healthcare consumption will be presented later on.

Regarding classical variables from demand theory, we find that the relative price of healthcare is not significant in any of the three equations. This result is not unexpected in the case of consumption since individuals bear only part of the price of care thanks to their insurance. In the deductible equation, the average regional premium (which is driven by health system cost and is thus correlated to healthcare price) may have canceled out the effect of the relative price index. Income is found to be a strong determinant of healthcare consumption with a positive and very significant effect. Interestingly, income is also an important factor of insurance choice: the higher the income, the higher the deductible. In theory, at least two opposite effects are at work here: some poorer individuals opt for the highest deductible in order to cope with their premium (and risk not being able to afford care when needed) while others are discouraged from doing so as they are afraid of not having enough cash in case of illness. Here the liquidity constraint appears to clearly dominate. [9]

Concerning personal and household characteristics, we find that a degree 5 polynomial of age (crossed with gender) is significant in the deductible equation. Even though lower degree polynomials would be sufficient in the other equations, we also use degree 5 for homogeneity. Because of the complexity of high power polynomials we will not discuss here either age or gender parameters and only analyze the overall effect of these variables later on. Education has a positive effect on both the selection and deductible equations. The latter result might be explained by the relative complexity of SHI, better education helping the individual to understand optional insurance contracts. Socioprofessional status and household type are also important factors as they appear

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[8] The model is still not a two-part one as the link with the deductible equation prevents separability.

[9] This result might also be partly due to premium reductions granted to poorer individuals which make high deductibles less attractive for them. However, this seems to be secondary as these premium reductions do not prevent SHI from being highly regressive (see Bilger, 2008, for instance).

in all three equations of the model. Behavioral differences according to household type appear to be particularly significant. For instance, couples tend to have lower healthcare consumption and higher deductibles than single adults and this difference is even more marked when children are taken into consideration. Finally, foreigners tend to both consume less often and have lower deductibles, probably because they are less familiar with the Swiss health system and SHI in particular.

Linguistic region reveals that Swiss Italians both consume significantly more care and have higher deductibles. This points out that local and cultural factors can play an important role as well. Degree of urbanization shows us that individuals living in an isolated town consume more frequently and that those living in a city center have lower deductibles. As expected, the average regional premium has a positive effect on deductible choice and is highly significant. This is important since this variable plays a key role in model identification. This result means that in high-premium regions, individuals have more incentive to reduce their financial burden by opting for a higher deductible. Interestingly, regional health status appears to be significant only in the deductible equation. This reveals that in regions with weaker health status individuals do not directly increase their healthcare consumption but lower their deductible to cope with higher health hazards.

Finally, GP density appears significant in all three equations of the model. This underlines the importance of supply-side effects in the analysis of demand for healthcare and health insurance. Higher supply does not only increase quantity consumed but also frequency. This increase in demand does not pass through the promotion of lower deductibles since we observe the opposite effect.

We now turn to the overall effect of covariates on conditional and unconditional expected healthcare consumption and probability of consuming. Table 2 displays this information for some selected ages and both genders, with all other covariates set at their sample means. The effect of aging appears clearly as the expected consumption at 65 is approximatively twice the one at 25. Women are also found to consume considerably more than men but this difference slightly narrows with aging. Probability of consuming follows a similar pattern.

Table 3 presents the sample means and marginal effects of the other covariates. It can be seen that the signs and significance of these results do not contradict the interpretations given above. Correlations between equations are thus not strong enough to reverse the direct effects found in the partial analysis. However, these correlations are necessary to quantify the effects of covariates on untransformed healthcare expenditure. Moreover, simultaneous analysis of both direct and overall effects proves to be instructive as well. For instance, the analysis of marginal effects shows that individuals living in high premium

Table 2
Conditional and unconditional expected healthcare consumption and probability of consuming according to age and gender

	$E(Y_1\|x)$		$P(Y_1 > 0\|x)$		$E(Y_1\|Y_1 > 0, x)$	
age	women	men	women	men	women	men
25	159.4	78.9	61.46	40.50	259.3	194.7
	(10.4)	(7.1)	(1.00)	(1.03)	(16.6)	(16.6)
35	180.6	93.3	62.41	42.55	289.4	219.3
	(8.8)	(5.6)	(0.88)	(0.84)	(14.1)	(12.7)
45	195.3	110.2	63.71	45.87	306.5	240.2
	(9.8)	(6.6)	(0.95)	(0.94)	(15.4)	(14.1)
55	231.6	132.5	67.05	49.45	345.4	267.9
	(10.8)	(7.3)	(0.92)	(0.99)	(16.3)	(14.8)
65	272.7	180.2	70.08	54.55	389.1	330.3
	(16.8)	(12.6)	(0.97)	(1.10)	(23.7)	(22.6)

Standard errors are displayed in brackets and probabilities are given in percentage.

regions consume significantly less healthcare. However, this variable has not been included in any of the two consumption equations and therefore the observed decrease in consumption is induced by an indirect effect through higher deductibles. Similarly, individuals living in regions with worse health status show greater expected consumption. It is interesting to note that these individuals cope with higher health hazards by decreasing their insurance deductible. Regional health status thus increases healthcare consumption through health insurance. This is another example of indirect effect involving health insurance. Finally, not only is GP density a very significant (positive) determinant of consumption level but it also increases the probability of consuming.

Table 3: Sample means and marginal effects

	$\bar{x}$	$E(Y_1\|x)$	$P(Y_1 > 0\|x)$	$E(Y_1\|Y_1 > 0, x)$
Education (ref: Secondary I or less)				
Secondary II	0.721	12.787	2.403	10.019
	(0.449)	(4.071)	(0.57)	(4.856)
Tertiary	0.145	15.483	3.283	10.238
	(0.352)	(5.441)	(0.756)	(6.386)
Socioprofessional status (ref: Employed)				
Selfemployed	0.071	-1.525	-0.581	0.297
	(0.257)	(12.003)	(0.709)	(19.878)

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Standard deviations/errors are displayed in brackets and probabilities are given in percentage.

	$\bar{x}$	$E(Y_1\|x)$	$P(Y_1 > 0\|x)$	$E(Y_1\|Y_1 > 0, x)$
Farmer	0.011	12.866	3.126	6.489
	(0.105)	(30.609)	(1.72)	(50.929)
Unemployed	0.013	-4.162	-1.907	2.444
	(0.114)	(27.882)	(1.575)	(46.377)
Student	0.016	-0.329	1.009	-5.69
	(0.124)	(27.406)	(1.56)	(45.545)
Homemaker	0.089	19.079	1.121	27.445
	(0.285)	(11.06)	(0.687)	(18.211)
Pension or other	0.207	99.067	3.909	152.209
	(0.405)	(12.379)	(0.776)	(20.339)
Foreigner	0.109	-15.969	-2.999	-12.522
	(0.312)	(4.429)	(0.593)	(5.596)
Household type (ref: Lone person)				
1 parent, 1 child	0.023	-32.812	-0.864	-52.599
	(0.151)	(19.274)	(1.234)	(31.626)
1 parent $\geq$ 2 children	0.021	-65.954	-3.967	-94.412
	(0.143)	(21.594)	(1.298)	(35.657)
Couple without children	0.313	-59.055	-3.222	-86.213
	(0.464)	(7.953)	(0.502)	(13.021)
Couple, 1 child	0.112	-89.842	-5.529	-127.974
	(0.315)	(11.544)	(0.665)	(19.074)
Couple, 2 children	0.173	-104.86	-6.064	-151.341
	(0.378)	(10.89)	(0.612)	(18.003)
Couple, $\geq$ 3 children	0.071	-128.982	-6.478	-191.133
	(0.257)	(14.813)	(0.807)	(24.616)
Other	0.028	-115.588	-8.67	-191.48
	(0.165)	(20.224)	(1.119)	(33.589)
Linguistic region (ref: German)				
French	0.22	31.572	-0.011	54.882
	(0.414)	(6.701)	(0.019)	(11.652)
Italian	0.088	53.62	-0.059	93.41
	(0.283)	(10.279)	(0.081)	(17.882)
Urbanization (ref: Countryside)				
Isolated town	0.009	33.654	5.653	29.777
	(0.094)	(13.703)	(1.975)	(15.419)
Suburb	0.469	0.596	0.011	0.978
	(0.499)	(2.841)	(0.458)	(2.647)
City center	0.266	3.634	0.38	4.382

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Standard deviations/errors are displayed in brackets and probabilities are given in percentage.

	$\bar{x}$	$E(Y_1 \mid x)$	$P(Y_1 > 0 \mid x)$	$E(Y_1 \mid Y_1 > 0, x)$
	(0.442)	(3.638)	(0.568)	(3.637)
Regional premium	246.6	-0.062	-1.817*10^{-3}	-0.098
	(52.591)	(0.026)	(2.459*10^{-3})	(0.044)
Contagious diseases	4.449	0.046	1.355*10^{-3}	0.073
	(11.47)	(0.025)	(1.886 *10^{-3})	(0.041)
Density of GPs	62.638	0.81	0.028	1.264
	(17.127)	(0.179)	(0.012)	(0.292)

Standard deviations/errors are displayed in brackets and probabilities are given in percentage.

6 Discussion

Here we develop an extension to the Box-Cox indirect censoring model (Chaze, 2005). in order to simultaneously analyze individual healthcare expenditure and insurance deductible choice in Switzerland. We use SHIES micro data over the period 2000-2005 to which we add many regional-level variables: GP density, health status indicators, average SHI premiums and other geographical information. One original feature of this study is that we focus on both the insurance deductible effect on healthcare demand and role played by GP density in the formation of this demand.

Even though deductible choice is not modeled from an economic perspective and we are primarily interested in its effect on healthcare demand, an analysis of the parameters of its equation yields meaningful results. For instance, we find that the deductible significantly increases with income, probably revealing a liquidity constraint. Another important factor is education with better educated people opting for higher deductibles. This might be explained by the relative complexity of SHI. From a policy perspective, one could recommend making better use of the choices already available by investing in better information for instance, rather than to keep changing the set of deductibles offered.

Simultaneous analysis of both direct and overall effects can prove to be insightful as well. We find that health insurance produces interesting indirect effects on healthcare demand. For instance, individuals living in high premium regions tend to increase their deductible which in turn incites them to consume less healthcare. We also find that individuals facing higher regional health hazards opt for lower deductibles, ending up consuming more healthcare.

The deductible appears to significantly affect the quantity consumed but not the decision to consume. As expected, the effect of the deductible is negative: the higher the deductible, the lower the healthcare expenditure. It is important to stress here that our measure of healthcare comprises all kinds of health expenditures, covered by SHI or not. This wide definition enables us to take into account substitutions that may arise between covered and uncovered care. In case of illness individuals with high deductibles might opt for cheaper uncovered care (instead of more expensive covered care) by having recourse to self-medication for instance. Such behavior would not affect participation but substantially decrease health expenditure, thus explaining why we do not find any deductible effect in the selection equation. Another point is that our data includes individuals with provider-limiting contracts such as HMO, without making it possible to identify them. These individuals potentially bias our estimations since they are subject to additional incentives to contain their healthcare consumption (as shown by Lehmann and Zweifel, 2004, for Switzerland). However, this should remain limited here as few individuals opted for such contracts during the period analyzed (8.3% in 2003). Finally, it is important to stress that SHIES data does not include any individual health status indicator. Nonetheless, we control for the risk factors used in SHI compensation mechanism (i.e. age and gender) as well as for socioeconomics variables which are known to be correlated to health status (i.e. income, education and socioprofessional status) as well as for many other factors. Consequently, we think that the evidence found here indicates that SHI deductible is very likely to reveal moral hazard in Switzerland, which is in line with Gardiol et al. (2005) but contradicts Schellhorn (2001). Note that the former analysis was carried out with SHI covered expenditure and the latter with physician visits.

GP density not only appears to very significantly increase the consumption level of healthcare but also to have a positive and significant effect in both the selection and deductible equations. We thus find here both the selection effect found by Chaze (2005) and the consumption level effect found by Bilger and Chaze (2008). Even though such results have already been found, the better quality of the control variables has to be underlined here. Indeed, in addition to many personal and household characteristics, we also control for regional health status and, even more importantly, health insurance. Moreover, the use of SHI premium regions instead of cantons provides a finer regional level. It is for these reasons that we think our evidence on presence of physician induced demand is stronger. However, one should be cautious before concluding as a bias due to reverse endogeneity is likely to be present as well. Future improvements could involve a two-step instrumental variable method applied to the GP density variable in the model presented here. The effect of GP density on deductible choice is harder to interpret. We can remark that GP density is correlated with other supply density variables such as hospital beds and pharmacies. Therefore people living in high healthcare supply level regions might have more interactions with the health system in general and end up being better informed about SHI.

It may be noted that our approach is vulnerable to heteroscedasticity bias since we use maximum likelihood estimation (which requires full model specification) and assume homoscedasticity without controlling for it. It is unclear how and to what extent the presence of heteroscedasticity would affect our findings related to moral hazard and induced demand in particular. Addressing the issue of heteroscedasticity would require further methodological development but seems a priori feasible. A first way to do so could be by adding a set of covariates explaining the variance of healthcare expenditure. Whether this approach will be fruitful or not is first a practical issue given that the current model is already very nonlinear and involves high computational complexity. Another direction would be to consider a multi-step estimation procedure. The current model could be estimated in a first step, then its residuals used to estimate the equation of the variance, with its estimated parameters then used to correct the initial model (with possibility to iterate this procedure).

As regards the issue of endogeneity, it is interesting to note that only the correlation between the selection and deductible equations appears to be significant. This might be explained by the fact that the individuals' unobservable information about their future health at the time of deductible choice might be more of a binary nature than quantitative, given the difficulty to accurately assess future health outlays. In fact, individuals might base their deductible choice on self-assessed probability to recourse to covered care. It is also worth noting that the deductible does not appear to be significant in the selection equation. At first sight this may seem odd and raise the question whether any endogeneity is actually present. This fact, however, does not prevent endogeneity since the latter passes through the error terms of the equations.

Finally, we would like to discuss modeling of the deductible. The main issue here is that the latent variable underlying deductible choice is likely to be nonlinear. It is for this reason that we think reasonable to keep an ordered probit approach which provides us with great flexibility to address this issue [10] . As regards the specification of the deductible in the expenditure and selection equations, we have kept it linear for simplicity. This could however be changed, making it possible to test more complex interactions between deductible choice and healthcare consumption.

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[10] It may be noted, however, that this choice limits prediction as it is not possible to precisely determine what the value of a given threshold will be in the future.

A Expectations and probability of consuming

A.1 Unconditional expectation

We have (provided the integral converges):

$$\begin{aligned}
&\mathrm{E}(y_{1i}|x_i) = \Pr(y_{1i} > 0|x_i)\mathrm{E}(y_{1i}|y_{1i} > 0, x_i)\\
=&\int_0^{+\infty} y_{1i}\Pr(y_{1i} > 0|x_i) f(y_{1i}|y_{1i} > 0, x_i)dy_{1i}\\
=&\frac{1}{\sigma_1\Delta_i}\sum_{k=1}^{K_i}\int_{B_L}^{B_U}(\lambda y^*_{1i}+1)^{\frac{1}{\lambda}}\phi\left(\frac{y^*_{1i}-\beta'_1x_{1i}-\gamma_1D_{ik}}{\sigma_1}\right)\\
\times&\left[\Phi\left(\frac{\beta'_2x_{2i}+\gamma_2D_{ik}+\rho_{12}\frac{y^*_{1i}-\beta'_1x_{1i}-\gamma_1D_{ik}}{\sigma_1}}{\sqrt{1-\rho_{12}^2}},\frac{\beta'_3x_{3i}-c_{i,k-1}+\rho_{13}\frac{y^*_{1i}-\beta'_1x_{1i}-\gamma_1D_{ik}}{\sigma_1}}{\sqrt{1-\rho_{13}^2}},\rho_{23|1}\right)\right.\\
-&\left.\Phi\left(\frac{\beta'_2x_{2i}+\gamma_2D_{ik}+\rho_{12}\frac{y^*_{1i}-\beta'_1x_{1i}-\gamma_1D_{ik}}{\sigma_1}}{\sqrt{1-\rho_{12}^2}},\frac{\beta'_3x_{3i}-c_{ik}+\rho_{13}\frac{y^*_{1i}-\beta'_1x_{1i}-\gamma_1D_{ik}}{\sigma_1}}{\sqrt{1-\rho_{13}^2}},\rho_{23|1}\right)\right]dy^*_{1i}
\end{aligned}$$

A.2 Probability of consuming

$$\begin{aligned}
P(y_{1i}|y_{1i}\geq 0|x_i) = 1 - \sum_{k=1}^{K_i}\big\{&\Phi\left(-\beta'_2x_{2i}-\gamma_2D_{ik}, c_{ik}-\beta'_3x_{3i}\rho_{23}\right)\\
&-\Phi\left(-\beta'_2x_{2i}-\gamma_2D_{ik}, c_{i,k-1}-\beta'_3x_{3i}\rho_{23}\right)\big\}
\end{aligned}$$

A.3 Conditional expectation

$$E(y_{1i}|y_{1i}\geq 0,|x_i) = \frac{\mathrm{E}(y_{1i}|x_i)}{P(y_{1i}|y_{1i}\geq 0|x_i)}$$

B Estimated parameters of the extended Box-Cox indirect censoring model

B.1 Covariate coefficients estimates and estimated nonlinear parameters

	Equation		
Variable name	Expenditure	Selection	Deductible
Log. of relative health price	-5.283	1.965	1.681
	(6.538)	(3.538)	(3.589)
Log. of equivalent income	0.519	0.346	0.244
	(0.0634)	(0.0245)	(0.0208)
Age	0.689	0.327	1.053
	(0.382)	(0.211)	(0.187)
Age^2	-0.0281	-0.0142	-0.0400
	(0.0162)	(0.00906)	(0.00799)
Age^3	0.000554	0.000292	0.000711
	(0.000326)	(0.000185)	(0.000162)
Age^4	$-5.24*10^{-6}$	$-2.84*10^{-6}$	$-6.02*10^{-6}$
	$(3.14*10^{-6})$	$(1.80*10^{-6})$	$(1.58*10^{-6})$
Age^5	$1.91*10^{-8}$	$1.06*10^{-8}$	$1.96*10^{-8}$
	$(1.16*10^{-8})$	$(6.72*10^{-9})$	$(5.89*10^{-9})$
Male	6.046	3.805	0.409
	(5.112)	(2.596)	(2.338)
Male × Age	-0.743	-0.503	-0.069
	(0.573)	(0.295)	(0.266)
Male × Age^2	0.0333	0.0220	0.00531
	(0.0243)	(0.0127)	(0.0115)
Male × Age^3	-0.000710	-0.000454	-0.000151
	(0.000489)	(0.000259)	(0.000235)
Male × Age^4	$7.23*10^{-6}$	$4.48*10^{-6}$	$1.82*10^{-6}$
	$(4.71*10^{-6})$	$(2.53*10^{-6})$	$(2.30*10^{-6})$
Male × Age^5	$-2.81*10^{-8}$	$-1.68*10^{-8}$	$-7.85*10^{-9}$
	$(1.74*10^{-8})$	$(9.49*10^{-9})$	$(8.66*10^{-9})$
Education (ref: Secondary I or less)			
Secondary II	0	0.128	0.142
	constr.	(0.0294)	(0.0261)
Tertiary	0	0.178	0.360
	constr.	(0.0396)	(0.0340)
Socioprofessional status (ref: Employed)			
Selfemployed	0.0271	-0.0258	0.177
	(0.0718)	(0.0367)	(0.0314)
Farmer	-0.0310	0.164	0.092
	(0.185)	(0.0889)	(0.0771)

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Standard errors are displayed in brackets.

Variable name	Expenditure	Selection	Deductible
Unemployed	0.0372	-0.102	-0.121
	(0.168)	(0.0813)	(0.0709)
Student	-0.0417	0.0521	-0.0182
	(0.165)	(0.0806)	(0.0708)
Homemaker	0.0762	0.0574	-0.0231
	(0.0659)	(0.0355)	(0.0308)
Pensioner or other	0.467	0.198	-0.178
	(0.0739)	(0.0401)	(0.0351)
Foreigner	0	-0.159	-0.188
	constr.	(0.0304)	(0.0267)
Household type (ref: Lone person)			
1 parent, 1 child	-0.186	-0.0479	-0.133
	(0.114)	(0.0638)	(0.0556)
1 parent, $\geq$ 2 children	-0.276	-0.208	-0.115
	(0.130)	(0.0671)	(0.0596)
Couple without children	-0.247	-0.165	0.0693
	(0.0500)	(0.0260)	(0.0223)
Couple, 1 child	-0.353	-0.284	0.0760
	(0.0776)	(0.0343)	(0.0297)
Couple, 2 children	-0.427	-0.312	0.0940
	(0.0748)	(0.0316)	(0.0274)
Couple, $\geq$ 3 children	-0.560	-0.332	0.147
	(0.0961)	(0.0417)	(0.0361)
Other	-0.405	-0.449	-0.0375
	(0.135)	(0.0578)	(0.0510)
Linguistic region (ref: German)			
French	0.204	0	0.0238
	(0.0421)	constr.	(0.0248)
Italian	0.355	0	0.129
	(0.0647)	constr.	(0.0316)
Urbanization (ref: Countryside)			
Isolated town	0	0.294	0.0548
	constr.	(0.102)	(0.0861)
Suburb	0	-0.000286	-0.0409
	constr.	(0.0236)	(0.0212)
City center	0	0.0174	-0.102
	constr.	(0.0290)	(0.0271)

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Standard errors are displayed in brackets.

Variable name	Expenditure	Selection	Deductible
Regional premium	0 constr.	0 constr.	0.00409 (0.000226)
Contagious diseases	0 constr.	0 constr.	-0.00297 (0.00102)
Density of GPs	0.00420 (0.00105)	0.00148 (0.000623)	0.00137 (0.000609)
Constant	-6.696 (3.554)	-5.543 (1.891)	-13.24 (1.679)
Insurance deductible [11]	$-2.52*10^{-4}$ $(7.44*10^{-5})$	$-2.93*10^{-5}$ $(3.96*10^{-5})$	-
Nonlinear parameters			
λ	0.00997 (0.00447)	-	-
ρ_{12}	-0.0208 (0.123)	-	-
ρ_{13}	0.00146 (0.0216)	-	-
ρ_{23}	-0.0499 (0.0208)	-	-
σ_1	1.818 (0.0369)	-	-

Standard errors are displayed in brackets.

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[11] These are the γ_1 and γ_2 parameters.

B.2 Estimates of health insurance propensity thresholds

	Threshold parameters			
	c_2	c_3	c_4	c_5
2000	.81786 (.02222)	1.36614 (.02945)	1.59044 (.03306)	-
2001	.72064 (.01996)	1.1896 (.02541)	1.37088 (.0278)	-
2002	.6459 (.01852)	1.09894 (.0235)	1.25958 (.02535)	-
2003	.5723 (.01823)	.98391 (.02254)	1.11122 (.02382)	-
2004	.50468 (.01787)	.87176 (.0221)	.99891 (.02344)	-
2005	.68381 (.02188)	.80601 (.02335)	1.78611 (.03602)	1.91813 (.03852)

Standard errors are displayed in brackets.

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