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On the Dynamics of Physician Density
Theory and Empirical Evidence
for Switzerland*

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June 2002

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Abstract

This paper analyzes the geographical distribution of physicians across the 26 cantons of Switzerland from 1960 to 1998. We use a dynamic location model to explain physicians' choice for their practices by considering market characteristics and medical infrastructure. Our panel data analysis indicates that physicians avoid areas where physician density has reached a certain level. Also, specialists' services may sometimes be substituted for those provided by general practitioners. These results do not support the common reproach that the unequal geographic distribution of physicians necessarily reflects market failure. Finally, as physician densities converge over time, a more equal distribution in the cantons results.

JEL Classification: I11, I18, L23, C33

Key Words: physician density, market failure, health policy, convergence analysis, panel data

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1 Introduction

How do medical doctors choose where to practice? Why are there many physicians in certain areas of a country and few in others? Why does this differ also with respect to different physician types? What are the economic and social consequences of an unequal distribution? Is there need and room for policy intervention to affect the distribution of physicians across different regions of a country? Does an unequal distribution reflect market failure in health care markets due to the asymmetric information between doctors and patients? These and related questions have challenged economists, for quite a while, and there is now an increasing demand from policy makers to better understand the underlying mechanisms.

These issues are relevant for several reasons: For most countries health is a special good in the sense that everybody should have access to health care. Therefore, that access is often seen as a constitutional right. From this point of view a shortage of physicians as well as their unequal distribution of physicians geographically and according to different physician types should be avoided. On the other hand, it is often argued that the health costs per capita increase with the number of physicians.[1] Not only are physicians important suppliers of health services, but it is widely held that they may also be able to affect the amount of services their patients consume by using their superior knowledge.[2] The possibility that physicians could induce demand to serve their own interests, may call for policy intervention.

The following papers focus on physicians' location decisions. Kristiansen and Førde (1992) use cross-section data from Norway to test the hypothesis that the location of internship and residency training affects the doctor's work choice. In accordance with other studies, they find that the location of postgraduate training influences later location choices. Of consideration is also where the spouse was reared and the age of the physician, as central areas are preferred with increasing age.

Chomitz et al. (1998) analyze how changes in the incentive system for medical school graduates in Indonesia affect their location decisions. From their revealed, as well as stated preference analyses, they find that changes in incentives significantly affect the choice of a doctor's workplace.

Hurley (1990), investigating the role of income in physicians' practice decisions, considers specialty, community size and the mode of a physician's first practice as site dimensions.

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1 See Schmid (1984).
2 See Folland et al. (2001).

According to his simulations with U.S. longitudinal survey data of medical school graduates from 1960, physicians seem to respond to financial incentives. He concludes that income-based policies may, therefore, be effective for redistribution.

Bolduc et al. (1996) assess the effect of various incentive measures introduced in Québec to influence the geographical distribution of physicians. They use data about the initial practice choice from newly trained general practitioners from 1976 to 1988. According to the multinomial probit analysis, the region-specific incentive measures reduced geographical inequalities in the distribution of general practitioners.

Foster and Gorr (1992) use annual state-level data from the U.S. from 1965 until 1982 to assess the impact of federal policies from the 1960s and 1970s that aimed to increase physician supply and reduce spatial inequalities. They use a dynamic physician growth model, which they separately apply for general practitioners and specialists. Both physician types differ in their location choices. Also, the results suggest that federal policy was not so effective.

Physician densities vary also substantially among the different regions in Switzerland. This unequal geographic distribution and the positive correlation between the number of physicians and health care costs is often seen as evidence for demand inducement and therefore, market failure. Nevertheless, no specific policies have been implemented in Switzerland to reduce these inequalities. This stands in contrast to, e.g., the U.S. and Canada, where policy interventions[3] aim to eliminate the unequal distributions commonly associated with market failure. On the other hand, according to Newhouse et al. (1982), unequal distributions across geographic areas may well be consistent with well-functioning markets.

The aim of our paper is to investigate the extent to which physicians' location decisions are affected by market mechanisms and whether unequal distribution is necessarily caused by market failure. Therefore, we analyze the evolution of physician growth across the 26 Swiss cantons from 1960 to 1998. Based on Foster and Gorr (1992), we use a dynamic location choice model incorporating region-specific market characteristics as well as factors reflecting the medical and social attractiveness. We investigate whether agglomeration and attractiveness forces dominate competition effects and whether general practitioners and

[3] Possible policy measures include restricting the number of postgraduate training and practice sites in most popular areas, compensating medical school graduates with shorter compulsory service, improving career opportunities or financial incentives for working in remote places. Because physicians prefer to work where they are trained, another policy is to locate medical schools and postgraduate training sites in the less popular regions (see Hurley, 1990).

specialists differ in their behavior. In addition, we analyze whether large differences in physician densities among the cantons will persist or whether convergence will occur. The latter would indicate that physicians' power to induce demand may not be as strong as usually believed.

The new aspects of the paper are the analyses of the evolution of physician densities in Switzerland over a long period by incorporating market forces as well as structural characteristics. Our year-specific estimates allow assessment of the relative impact of these factors over time. Finally, convergence analysis provides additional insights about the long-run behavior of physician densities in Switzerland.

From our panel data analysis we find that competitive forces dominate. Physicians avoid areas where physician density has reached a certain level. Furthermore, specialists' services are often substitute for those provided by general practitioners, forcing them to locate in places with lower population growth. These findings do not support the commonly made reproach of demand inducement caused by market failure. Finally, we show that physician densities converge over time.

The paper is structured as follows: Section 2 describes the evolution of physician densities and related policy issues in Switzerland. Section 3 outlines the underlying theoretical model. The data and the econometric model are explained in section 4. Section 5 contains the analysis, and section 6 concludes. Some supplementary statistics can be found in the appendix.

2 Physician Density in Switzerland

Similar to most other countries, Switzerland has been experiencing rapidly rising health care cost in the last 40 years. In 1996, a Swiss person consumed health care services of 2'499 US$ on average, which is the highest per capita consumption after the U.S. To contain costs in health care, competitive elements were introduced in the Swiss health system reform of 1996. The mandatory basic health insurance package determined by the Swiss government, can be bought from any health insurance company of choice.[4] To attract individuals, the health insurance companies are required to offer attractive premiums, which they may achieve by forcing physicians to provide cost-effective services. In addition, managed care plans are

[4] At the moment there are about 100 health insurance companies.

allowed and consumer incentives are introduced.[5] However, in reality, many regulations counterbalance these competitive elements. For example, health insurance companies may not adjust premiums to risk or to choose among physicians, but are forced to reimburse any mandatory service.[6] Furthermore, most physicians are still paid on a fee-for-service basis, where services are valued by tariffs negotiated between the Association of health insurers (Santésuisse) and the Swiss Medical Association (FMH). Because of this compensation policy, physicians can easily open their own practice sites since they do not generally bear large financial risks once they have a medical degree.

Because the number of physicians is regarded as a main determinant of high health care costs, we must first look at Swiss medical education. Medical school graduates, who study medicine for about seven years in a university, spend approximately another six years[7] working as assistant doctors in hospitals to be certified as FMH-physicians. This qualification is required to obtain one of the few permanent positions in hospitals thereafter as specialists. As an alternative to a hospital career, physicians can start private practice, either as generalists or as specialists.[8] The decision to specialize is usually taken after graduate school and it affects the choice of training site. When students begin their medical educations, the development of physicians in 12 to 15 years is determined. Therefore, any policy aiming to influence the number of medical students, only affects the number of physicians not earlier than after a generation.

Table 1: Average physician densities for Switzerland

	General practitioners		**Specialists**	
Year	**Per 100,000 persons**	**Persons per generalist**	**Per 100,000 persons**	**Persons per specialist**
1960	42	2,479	38	3,649
1970	36	2,915	41	3,914
1980	43	2,429	60	2,275
1990	56	1,824	80	1,549
1998	60	1,694	105	1,184

Figure 1 shows the evolution of physician densities over the considered period, both for general practitioners and specialists, with their own practice sites and averaged over all 26

5 A choice of deductibles is given. For further details, see e.g. Schellhorn (2001) or Domenighetti and Crivelli (2001).

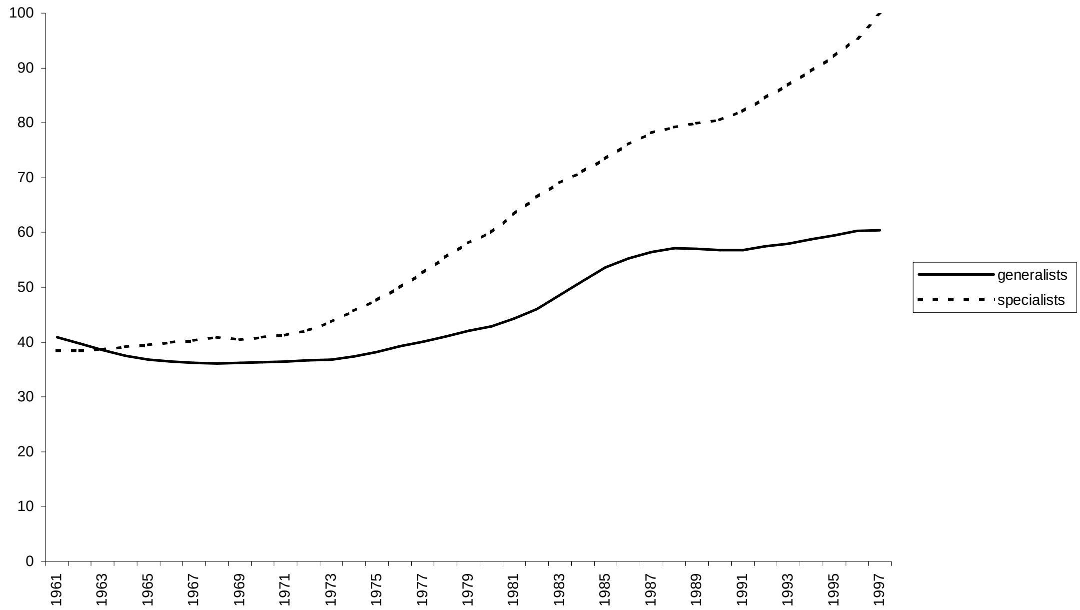
6 Except for managed care plans, e.g. HMOs where care is provided through a specific network of health care providers. However, these plans insure only about 7.5% of the Swiss population.

7 The exact length of time spent depends on the field of specialization. For further details see the regulations of the Swiss Medical Association FMH under http://www.fmh.ch/fmh.

8 A general practioner needs to have the minimum training time of two years as an assistant doctor to open a private practice.

cantons of Switzerland. In 1960, the two series started at similar levels. On average, 42 general practitioners serve 100,000 persons or one general practitioner treats 2,479 persons, whereas for the specialists the numbers are 38 physicians per 100,000 persons or 3,649 persons per physician, respectively (Table 1).

Figure 1: Physician densities from 1960 to 1998 (per 100,000 persons)

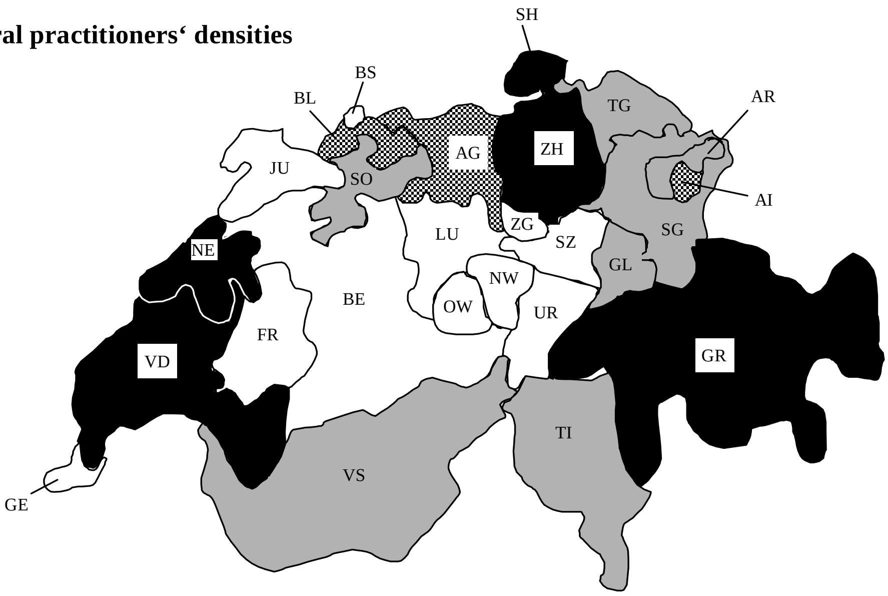


Until 1975 the physician density had been considered too small, since it was below the number recommended by the World Health Organization.[9] While physician density remained rather stable, the Swiss economy flourished and social security systems expanded. Due to easier access to medical schools, the number of medical students tripled between 1960 and 1974,[10] resulting in an increase in the number of physicians 15 years later. General practitioners and specialists grew by 93% and 241%, respectively, but the population had increased only by 32% from 1960 to 1998. Because the number of specialists had grown faster than that of general practitioners increased, densities differ substantially from each other in 1998, when 105 specialists but only 60 general practitioners served 100,000 persons on average. Similar developments have been observed in the U.S. and in Canada.[11]

9 Neue Zürcher Zeitung (NZZ), 15.11.1974, Nr. 492.
10 The requirement to study Latin at high school had been eliminated.
11 See Bolduc et al. (1996).

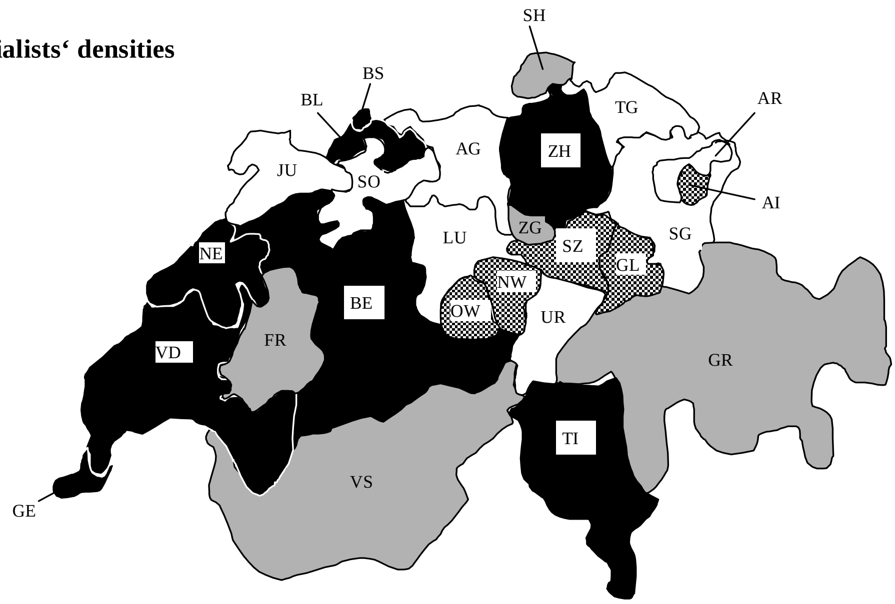
Figure 2: Physician densities for the Swiss cantons in 1998

General practitioners‘ densities



very high: 68-75 physicians per 100‘000 persons
high: 60-67 physicians per 100‘000 persons
low: 53-59 physicians per 100‘000 persons
very low: 47-52 physicians per 100‘000 persons

Specialists‘ densities



very high: 117-285 physicians per 100‘000 persons
high: 94-116 physicians per 100‘000 persons
low: 62-93 physicians per 100‘000 persons
very low: 41-61 physicians per 100‘000 persons

Since 1980, the physician density, especially of specialists, has been regarded as too high.[12] Nevertheless, access to medical education was not constrained until 1998. Interventions were limited to information campaigns held at high schools to inform potential medical students about a possible oversupply of physicians. Today, however, most universities apply an aptitude test to control the number of medical students.

In general, the Swiss political system grants a large amount of sovereignty to its 26 cantons. Because each is, among other issues, responsible for its own health care system, it is rather difficult to implement a unified policy for them all, a fact which leads to additional heterogeneity among them. Figure 2 and Table 5 in the appendix show physician densities of all Swiss cantons in 1998. It is obvious that physician densities differ among the cantons with a much higher variation for specialists. For general practitioners, densities vary between 47 and 75 physicians per 100,000 persons; for specialists the numbers lie between 41 and 285. Western and southern Switzerland account for the highest number of specialists. City cantons, e.g. Basel-Stadt (BS) and Geneva (GE), or cantons with university hospitals[13] seem to attract more specialists. The total number of hospital beds per canton has generally had a positive effect on the supply of physicians, especially of specialists.[14] Where tourism plays an important role (e.g. the cantons GR, TI and VS), physician densities seem higher as well, and this is particularly true for general practitioners.

3 Theory

The geographic distribution of physicians can be studied by analyzing the location choice process of physicians.[15] As it often is difficult to obtain relevant information to empirically determine the underlying processes, a more feasible way is to consider the aggregate outcome of these location decisions, i.e., to look at the distribution of physicians in different regions and to relate them to their determinants.

There exist two main categories of physicians' location choice models: The static model approach, where distribution of physicians is estimated at a given point in time, and dynamic framework, which takes into account variations over time. According to Foster and Gorr

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12 The issue became a public concern when the Council of Swiss Universities (Schweizerische Hochschulkonferenz) initiated a study, conducted by Gilliand and Eichenberger (1981), about future development of the physician population.

13 There is not a university in every Swiss canton. Six have a university hospital, i.e. Basel-Stadt (BS), Bern (BE), Fribourg (FR), Geneva (GE), Waadt (VD) and Zurich (ZH).

14 Data source: Federal Department of Statistics.

15 See also Timmermans and Golledge (1990).

(1992), the main factors which affect the location of a physician's practice are the population in a region, its professional climate, its social environment, and market conditions.

A region's population is a direct measure of market size. Physicians are expected to be sensitive to changes in population growth.[16] Professional climate refers to possible interaction with colleagues, sufficient access to hospitals and other medical facilities. The attractiveness of professional climate positively affects the supply of physicians. Also influencing the location choice of physicians are social amenities, such as educational facilities, entertainment and recreational opportunities, as well as shopping facilities. The better the social amenities, the more physicians are attracted to a region.

We denote these three determinants, which all have a positive effect on the supply of physicians in an area, as agglomeration and attractiveness effects. Besides these effects, there exist market conditions which affect physician growth negatively. When the supply of physicians reaches a certain level in a region, the competition effect might become strong. Income potential and the number of practice opportunities for new physicians decrease. Therefore, new physicians do not enter this market anymore but are more likely to open practice sites in regions with lower level of physician density, and physicians then become more equally distributed.

In the context of geographic distribution of physicians, the issue of supplier-induced demand (SID) and the implicitly underlying market failure is often addressed. SID refers to the ability of physicians to generate demand in response to fee changes, declining market shares, or changes in labor-leisure relations.[17] Academic and also policy disagree on its definition, and disagreement increases when talking about tests for providing empirical evidence and measuring SID.[18] If physicians are indeed able to induce demand, competition effects may not be relevant and agglomerative forces are dominating.

Regardless whether SID is present or not, there exist two opposite forces. To test which of these forces is stronger, an empirical investigation is necessary. If the data show that competition effects are dominating, SID might not be so relevant. However, if we find dominating agglomerative effects, we cannot differentiate whether this is caused by a weak competition effect or by SID.

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[16] Besides population growth, there exist additional factors that may affect demand for physicians' services (e.g., aging of population, increase in level of education and income, changing environmental factors like stress at work or pollution), which are not explicitly considered here.

[17] De Jaegher and Jegers (2000) assume that physicians are constrained by patient information in inducing demand.

4 Data and model

For the analyses of physicians' location choices we use annual data of the 26 cantons of Switzerland from 1960 through 1998.[19] The data include physicians working in a practice as general practitioners or as specialists and are provided by the Federal Department of Statistics. Not included are assistant doctors and specialists working only in hospitals.

According to the theory outlined above, we estimate a simple dynamic physician growth and locational behavior model, i.e.,

$$\begin{aligned}\overline{\text{GPHYS}}_{jit} = \quad & \alpha_1 + \alpha_2 \text{L.DENS}_{jit} + \alpha_3 \text{L.DENS}_{jit}{}^2 + \alpha_4 \overline{\text{L.GPOP}}_{it} + \alpha_5 \text{MEDUNI}_i \\ & + \sum \gamma_{t'} D_{t'} + \varepsilon_{it},\end{aligned} \tag{1}$$

where j=G,S (general practitioner, specialist), i=1,…,26, t, t'=1960,…,1998.

The dependent variable, physician growth ($\overline{\text{GPHYS}}$), is calculated by using a three-year moving average to smooth for annual variations. As explanatory variables three indicators for agglomeration, attractiveness and competition effects are considered.

L.DENS is physician density at the start of the period for calculating $\overline{\text{GPHYS}}$. The sign of its coefficient is ambiguous, since L.DENS captures two opposing mechanisms. Reflecting agglomerative forces, the coefficient of L.DENS is expected to be positive. However, with increasing competitive forces the coefficient of L.DENS is expected to be negative. To allow for nonlinearity, we include the square of L.DENS in the estimation.

$\overline{\text{L.GPOP}}$ is population growth and is calculated again by using a three-year moving average and by taking the lagged value. We expect $\overline{\text{L.GPOP}}$ to influence general practitioners and specialists differently. Specialists are typically multiproduct firms, i.e., they not only provide special treatments, but they also sell services normally delivered by general practitioners. Because specialists are unique providers of certain services, they usually first settle in larger cities. The ability to produce multiple services allows specialists to compete with general practitioners. These substitution elements discourage general practitioners from settling in larger cities, that are typically characterized by higher population growth rates. Therefore, we

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[18] See, e.g., Labelle et al. (1994) for an overview.

[19] The panel is not balanced, since physician data for the two split cantons Nidwalden and Obwalden are not available before 1967. Furthermore, in 1978 the canton Jura was created; it had previously be included in the canton Bern.

expect $\overline{\text{L.GPOP}}$ to enter into the model with a positive sign for specialists and a negative sign for general practitioners.[20]

MEDUNI is a dummy variable taking the value of one if the canton has a university hospital.[21] It is a supplementary indicator to L.DENS and captures a region's medical attractiveness. Furthermore, MEDUNI accounts for potential differences in the cantons' policy measures, which may differ depending on the existence of a university with a medical faculty. A positive coefficient of MEDUNI indicates that the presence of a university hospital attracts more physicians, which is further evidence for the presence of agglomerative forces. In case of a negative sign, the competition effect dominates.

Finally, we include a yearly dummy variable ($D_{t'}$) as another explanatory variable into the estimation to pick up other year-specific effects. $D_{t'}$ takes on the value of one if t'=t, zero else.

In addition to the simple case as described by equation (1), we specify an extended model that allows us to estimate time-varying parameters. For this purpose, we multiply L.DENS with the yearly dummy variable ($D_{t'}$). The other variables are defined as in equation (1).

$$\overline{\text{GPHYS}}_{jit} = \alpha_1 + \sum \eta_{t'} \text{L.DENS}_{jit} D_{t'} + \alpha_2 \overline{\text{L.GPOP}}_{it} + \alpha_3 \text{MEDUNI}_i + \sum \gamma_{t'} D_{t'} + \varepsilon_{it}\,, \qquad (2)$$

where j=G,S (general practitioner, specialist), i=1,…,26, t, t'=1960,…,1998.

Table 2 summarizes the description of our data.

Table 2: Description of data

Variable	**Description**
i	Index of canton: i=1,…,26
t, t'	Year of observation: t, t'=1960,..,1998
j	Type of physician: G=general practitioner, S=specialist
GPHYS_{jit}	Physician growth in %
$\overline{\text{GPHYS}}_{jit}$	3-year moving average of physician growth in % $(\text{GPHYS}_{jit-1}+\text{GPHYS}_{jit}+\text{GPHYS}_{jit+1})/3$
L.DENS_{jit}	Lagged physician density (number of physicians for 100'000 persons)
$\overline{\text{L.GPOP}}_{it}$	Lagged 3-year moving average of population growth in %
MEDUNI_i	Dummy variable=1 if canton has a university hospital, =0 else
$D_{t'}$	Dummy variable=1 if t=t', =0 else

[20] See Newhouse et al. (1982).
[21] See footnote 13.

5 Analysis

We estimate the simple model of equation (1) by applying different estimation techniques to check for robustness of our results. The GLS estimation (A) with heteroscedastic error structure and cross-sectional correlation allows for differences in the variance as well as a correlation among the 26 cantons. The GLS estimation (B) relaxes not only the assumption of noncross-sectional correlation, but of nonautocorrelation as well. Finally, the fixed effect model estimation (C) captures differences among the cantons, for which we do not directly control, in the constant term.[22]

Table 3: Physician growth in the simple model (1963-1997)

	General practitioners			Specialists		
	GLS[a]		Fixed Effect[b]	GLS[a]		Fixed Effect[b]
Variable[c]	(A)	(B)	(C)	(A)	(B)	(C)
L.DENS	0.007	-0.001	0.043	-0.075***	-0.054***	-0.096**
	(0.016)	(0.038)	(0.108)	(0.003)	(0.007)	(0.049)
L.DENS^2	-0.001***	-0.000	-0.001	0.000***	0.000***	0.000*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
$\overline{\text{L.GPOP}}$	-0.123***	-0.036	-0.196*	0.386***	0.407***	0.376**
	(0.036)	(0.057)	(0.104)	(0.048)	(0.086)	(0.151)
MEDUNI	-0.059	-0.082		0.801***	0.645***	
	(0.056)	(0.140)		(0.061)	(0.192)	
Constant	0.154	-0.137	0.589	4.123***	3.500***	5.360***
	(0.411	(0.962)	(1.259)	(0.158)	(0.327)	(1.589)
N	805	805	859	805	805	855
Log Likelihood	-620.371	-551.246			-644.742	
F			3.58***			1.99***

*,**,*** Coefficient different from zero with an error probability of 10%, 5%, 1%.

[a] We apply two GLS-estimation methods: (A) heteroscedastic error structure with cross-sectional correlation, (B) heteroscedastic error structure with cross-sectional correlation and autocorrelation. For the GLS estimations only 23 cantons are included, since for the cantons Jura, Obwalden and Appenzell Innerrhoden data is not available for all the time periods and therefore, the panel is not balanced.

[b] The within estimator for the fixed-effects model allows the disturbance term to follow an AR(1) process. The sizes of R-squares are: within=0.14, between=0.20 and overall=0.29 for general practitioners; within=0.08, between=0.33 and overall=0.13 for specialists.

[c] Time dummies are included into the estimation.

Table 3 shows that agglomerative forces are at work for general practitioners, since the coefficient of L.DENS is positive in two of three cases, though never statistically significantly different from zero.[23] This holds as long as L.DENS is of small size. However, the negative

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[22] Given that our sample includes all cantons in Switzerland and is therefore not a random sample, the fixed effects model specification is appropriate. In addition, given the results from a modified version of the Durbin-Watson test, we allow the disturbance term to follow an AR(1) process (see also Bhargave et al. 1982).

[23] Even though the coefficients of L.DENS and L.DENS^2 are not significantly different from zero, LR-tests showed that including them into the model is preferred.

coefficient of L.DENS squared provides evidence that the agglomeration effect weakens with higher density levels: when density reaches approximately 23 general practitioners per 100,000 persons, the competition effect is dominating even for estimation (C).[24] For the specialists, the coefficient of L.DENS is negative, whereas the coefficient of L.DENS squared is positive but almost zero. Therefore, the competition effect seems to dominate the agglomeration and attractiveness effects for the specialists during the entire observed period, which stands in contrast to the results from general practitioners.

The population growth of former periods $\overline{\text{L.GPOP}}$ negatively affects the growth of general practitioners, but it has a positive effect on specialists' growth rate. These findings seem to confirm our hypothesis that specialists' services are a substitute of general practitioners' services.

As to MEDUNI, it positively affects the specialists' growth rate, indicating that agglomerative forces are present. But it has a negative, though nonsignificant effect, on the growth rate of general practitioners. Due to the substitution elements between specialists and general practitioners, the latter seem discouraged from settling in cantons with university hospitals.[25]

To get year-specific coefficients for the density variable, we estimate the extended model according to equation (2) by applying two GLS estimation methods, a fixed effects model estimation as well as yearly OLS-regressions.[26] Figure 3 and Figure 4 graphically represent the year-specific estimates for L.DENS interacted with the time dummies.[27] At first sight, we observe the coefficients of L.DENS to vary over the years, and this variation is clearly higher for general practitioners. Looking at the evolution over time, the parameter estimates for specialists appear to be more stationary over time.[28] Finally, the different estimation methods provide similar results for most of the years.

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[24] To determine the level of L.DENS where the competition effect is dominating, we differentiate equation (1) $\left(\frac{\partial \overline{\text{GPHYS}}}{\partial \text{L.DENS}} = \alpha_2 + 2\alpha_3 \text{L.DENS} = 0\right)$ and solve for L.DENS.

[25] Note that we do not report any results for the fixed effects estimation since MEDUNI is constant over time and therefore dropped.

[26] The main advantage of yearly OLS-regressions is that it produces yearly estimates for all the variables included in our model. However, our results are somehow restricted since the number of cross-section units varies between 23 and 26 cantons (Table 7 and Table 8 in the appendix).

[27] Note that we loose the first three observations (years 1960, 1961 and 1962) as well as the last one (year 1998) due to our construction of lagged moving average growth variables.

[28] Regressing the coefficients against time and a constant term yields negative and significant results for all the models of the general practitioners and no significant results for specialists, except for model (C), where there is also a negative and significant time trend.

From the year-specific estimates, which we include in Table 6 of the appendix, we see that the coefficients of the interacted L.DENS variables are not significantly different from zero for all the years and all the estimation methods. As outlined earlier, a positive sign of the coefficient tells us that the agglomeration and attractiveness effects dominate. We find evidence for such an outcome for general practitioners during the late 1960s but not for specialists. This time period is characterized by economic growth and a perceived undersupply of physicians. A negative sign of L.DENS interacted with the time dummies is evidence for dominance of the competition effect, which leads to a more equal distribution in the long run. Our results suggest that such a mechanism is at work: For general practitioners, we find evidence for this effect from the 1970s on, while for specialists it seems to exist in most periods, so already since the beginning of the considered time period.

Figure 3: Estimated paths of L.DENS coefficients for general practitioners

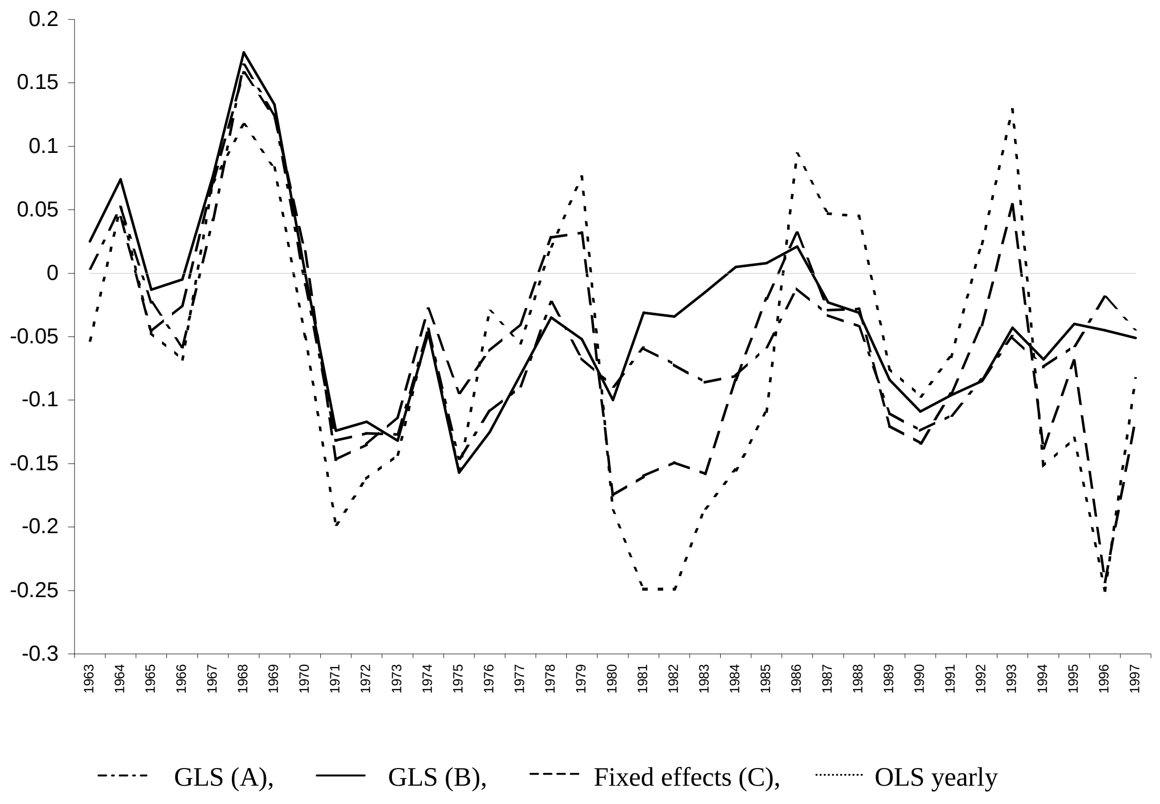
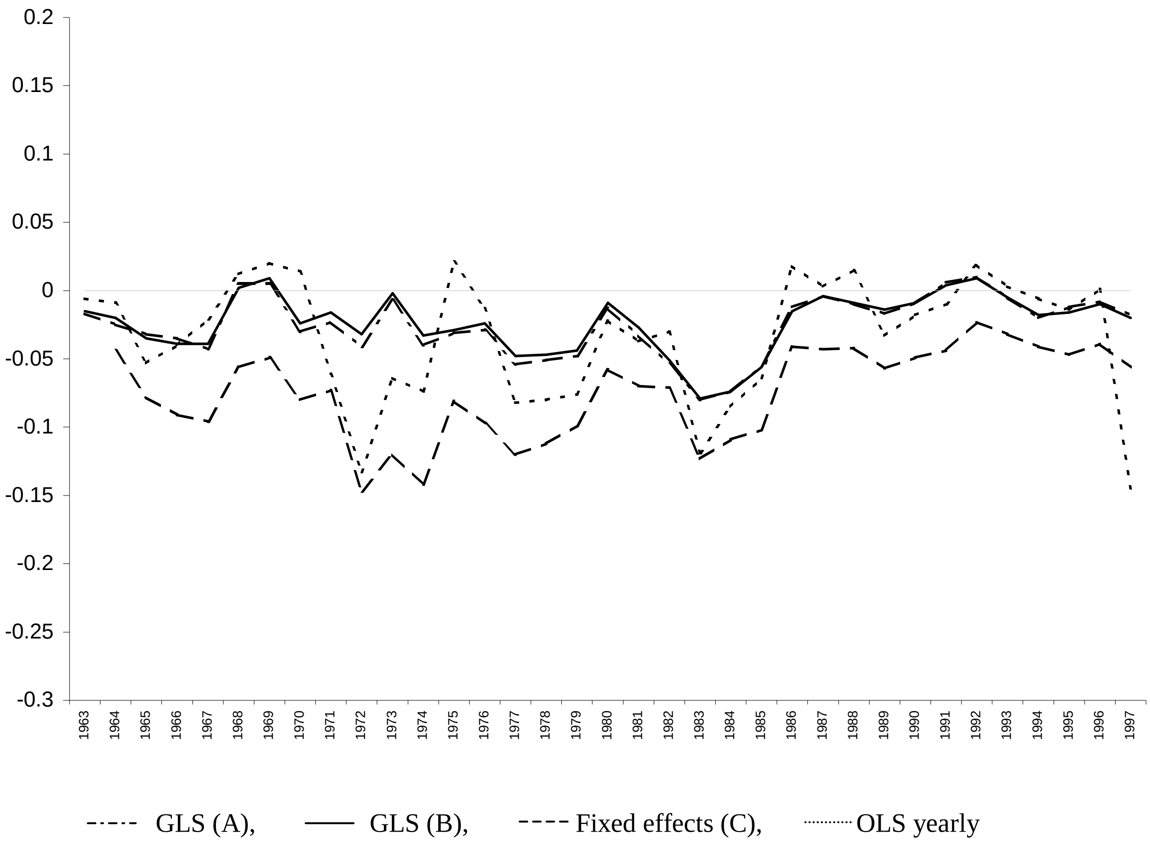


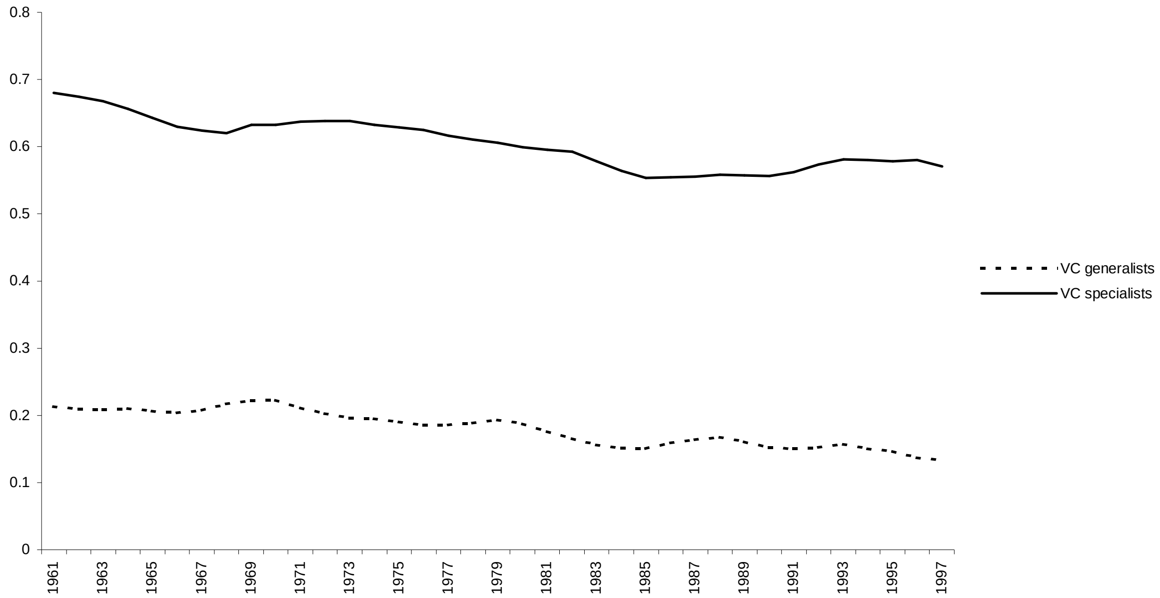
Figure 4: Estimated paths of L.DENS coefficients for specialist physicians



The results of the other explaining variables of the extended model are as follows (Table 6). As to population growth, we find again negative coefficients for general practitioners and significantly positive ones for specialists, confirming our theoretical predictions. In addition, the existence of a university hospital negatively influences the growth rate of general practitioners, whereas it attracts specialists.

The dominating competition effect indicates that physician densities became more equal from 1960 to 1998. To check whether physician densities between the 26 cantons really converge, we apply two convergence measures commonly used in growth theory.[29] σ-convergence looks at the spread of values during a time period and shows whether the different cantons or regions converge despite shocks and disturbances. β-convergence looks at the impact of the level of a variable *y* on its growth rate by applying regression analysis. For convergence, the coefficient of the level of *y* must be negative, i.e. cantons with lower levels grow faster. However, β-convergence is only a necessary but not a sufficient condition for convergence. A higher average growth rate of underdeveloped regions does not imply that the spread of *y* has diminished as well. Therefore, σ-convergence, as well as β-convergence, has to be present.

Figure 5: Variation coefficients of physician density from 1961 to 1997



For each year, we calculate the variation coefficient of physician densities (VC_t), which normalizes the standard deviation with the mean. Figure 5 shows VC_t of physician density from 1961 to 1997. The cantons differ substantially regarding the types of physicians, since VC_t for specialists is always much greater than VC_t for generalists. However, both types of physician densities seem to converge among the cantons. To test for σ-convergence, we compare VC_{1961} (starting period) to VC_{1997} (last period). For both types of physicians VC_t diminishes over time, indicating that convergence is present. In addition, we test σ-convergence in a trend model by regressing VC_t against the time. Again, the presence of σ-convergence is confirmed, as the coefficient of time is significantly negative for both cases (Table 4).

Finally, we test for β-convergence by regressing the growth rate of physician density against the starting level of physician density. In both cases, the coefficient is negative, although it is statistically significant only for specialists. However, if we calculate the growth rate of physician density by using a moving average containing five years instead of three years, both coefficients of the level of physician density become significantly negative (Table 4).

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[29] See e.g., Barro and Sala-i-Martin (1992), Schmidt (1997).

Table 4: Convergence measures for physician density between the Swiss cantons (t-value in parenthesis)

	General practitioners	Specialists
σ-convergence		
VC_{1961}	0.2137	0.6804
VC_{1997}	0.1334	0.5705
Coefficient of trend model[a]	-0.0023 (-86.71)	-0.0031 (-63.41)
β-convergence[b]		
Coefficient of level of physician density, 3 years moving average	-0.0050 (-0.50)	-0.0112 (-3.05)
Coefficient of level of physician density, 5 years moving average	-0.0259 (-3.91)	-0.0152 (-4.81)

[a] The trend model is estimated according to the equation: $VC_{jit} = \alpha_1 + \alpha_2 t + \varepsilon_{it}$.

[b] β-convergence is estimated according to: $GDENS_{jis} = \alpha_1 + \alpha_2 L.DENS_{jit} + \varepsilon_{it}$, where GDENS is the growth rate of physician density, j= general practitioner, specialist, i=1,…,26 and t=1961,…1997.

Even though there still exist significant differences among the density levels of the different Swiss cantons, we conclude that the physicians' distribution has become less unequal over the years. This finding is somehow consistent with our former findings about the existence of competitive forces, that induce physicians to move from most medically populated areas.

6 Conclusions

The focus of this paper is on whether physicians' location choices are affected by market mechanisms and whether an unequal distribution of physicians necessarily reflects market failure. We analyzed the evolution of physician densities in Switzerland from 1960 to 1998. We used a dynamic location choice model that incorporates region-specific market characteristics and factors reflecting medical and social attractiveness. We investigated whether agglomeration and attractiveness forces dominate competition effects and whether the behavior of general practitioners and specialists differs.

From our analysis, we find that physicians choose locations based on market characteristics and forces. Specialists are attracted to areas that offer a good professional climate and a high population growth. However, competition effects are dominating agglomerative forces over the whole observed period. In addition, our results show that specialists are able to substitute services provided by general practitioners. Being unique providers of certain services, specialists settle first in larger cities and force general practitioners to locate in regions characterized by lower population growth. The observed unequal geographic distribution of physicians, therefore, does not necessarily reflect market failure. Finally, we show that the physician densities of the 26 Swiss cantons converge over time, resulting in a more equal distribution.

Notwithstanding the rather large existing literature on physician behavior, more research is needed, and this holds true particularly for Switzerland. In relation to market failure, for instance, most of the numerous studies focus on how much services are induced by physicians. As Labelle et al. (1994) outline, however, the important question is about the consequences of demand inducement for consumers' utility, i.e., what are the effects of induced services on the health status of the patients. Also, there exists political pressure that health insurance companies may no longer be forced to sign contracts with every physician of their canton, thus introducing more competitive elements into the Swiss health care market. On the other hand, the recent introduction of aptitude tests for medical studies at most Swiss universities may reduce pressure from the supply side. All these circumstances will certainly further affect the distribution of physicians, and some of these issues will be addressed in future research.

7 Appendix

Table 5: Physician densities for the Swiss cantons in 1998

Canton		Generalists		Specialists	
		Per 100,000 persons	Rank	Per 100,000 persons	Rank
AG	Aargau	50	23	84	17
AR	Appenzell Ausserrhoden	65	6	77	19
AI	Appenzell Innerrhoden	48	24	41	26
BL	Basel-Land	63	8	117	8
BS	Basel-Stadt	58	13	285	1
BE	Bern	58	13	130	5
FR	Fribourg	47	25	95	12
GE	Genf	56	20	254	2
GL	Glarus	65	6	57	22
GR	Graubünden	75	1	94	13
JU	Jura	58	13	88	15
LU	Luzern	57	18	81	18
NE	Neuenburg	69	4	122	6
NW	Nidwalden	47	25	55	23
OW	Obwalden	57	18	44	25
SH	Schaffhausen	72	3	108	9
SZ	Schwyz	54	22	54	24
SO	Solothurn	62	10	86	16
SG	St. Gallen	61	12	89	14
TE	Tessin	63	8	122	6
TG	Thurgau	58	13	62	21
UR	Uri	58	13	63	20
VD	Waadt	73	2	162	3
VS	Wallis	62	10	101	11
ZG	Zug	56	20	105	10
ZH	Zürich	68	5	145	4

Table 6: GLS and fixed effect estimations of extended model

	General practitioners			Specialists		
	GLS[a]		**Fixed Effect[b]**	**GLS[a]**		**Fixed Effect[b]**
Variable[c]	(A)	(B)	(C)	(A)	(B)	(C)
L.DENS*D_{1963}	0.004	0.025		-0.017***	-0.015***	
	(0.016)	(0.024)		(0.004)	(0.004)	
L.DENS*D_{1964}	0.051***	0.074***	0.044	-0.025***	-0.020***	-0.044
	(0.017)	(0.025)	(0.061)	(0.004)	(0.004)	(0.037)
L.DENS*D_{1965}	-0.023	-0.013	-0.046	-0.032***	-0.035***	-0.078
	(0.016)	(0.025)	(0.072)	(0.004)	(0.005)	(0.050)
L.DENS*D_{1966}	-0.058***	-0.005	-0.025	-0.035***	-0.039***	-0.091*
	(0.016)	(0.024)	(0.076)	(0.004)	(0.004)	(0.055)
L.DENS*D_{1967}	0.042**	0.077***	0.072	-0.043***	-0.039***	-0.096
	(0.017)	(0.026)	(0.084)	(0.004)	(0.004)	(0.059)
L.DENS*D_{1968}	0.164***	0.174***	0.158*	0.005	0.002	-0.056
	(0.018)	(0.027)	(0.084)	(0.004)	(0.006)	(0.061)
L.DENS*D_{1969}	0.125***	0.133***	0.123	0.005	0.009*	-0.049
	(0.017)	(0.026)	(0.079)	(0.004)	(0.005)	(0.060)
L.DENS*D_{1970}	-0.009	0.000	0.017	-0.030***	-0.024***	-0.080
	(0.017)	(0.025)	(0.076)	(0.004)	(0.005)	(0.060)
L.DENS*D_{1971}	-0.132***	-0.124***	-0.147*	-0.023***	-0.016***	-0.073
	(0.016)	(0.024)	(0.076)	(0.004)	(0.004)	(0.058)
L.DENS*D_{1972}	-0.126***	-0.117***	-0.135*	-0.041***	-0.032***	-0.147**
	(0.017)	(0.025)	(0.075)	(0.004)	(0.004)	(0.058)
L.DENS*D_{1973}	-0.127***	-0.132***	-0.113	-0.007*	-0.002	-0.120**
	(0.018)	(0.027)	(0.085)	(0.004)	(0.004)	(0.057)
L.DENS*D_{1974}	-0.045**	-0.047*	-0.028	-0.040***	-0.033***	-0.142***
	(0.018)	(0.026)	(0.083)	(0.003)	(0.004)	(0.055)
L.DENS*D_{1975}	-0.146***	-0.157***	-0.094	-0.031***	-0.029***	-0.081
	(0.017)	(0.026)	(0.077)	(0.003)	(0.004)	(0.053)
L.DENS*D_{1976}	-0.109***	-0.125***	-0.061	-0.029***	-0.024***	-0.097*
	(0.017)	(0.025)	(0.077)	(0.003)	(0.004)	(0.051)
L.DENS*D_{1977}	-0.089***	-0.080***	-0.040	-0.054***	-0.048***	-0.120**
	(0.018)	(0.027)	(0.083)	(0.003)	(0.004)	(0.049)
L.DENS*D_{1978}	-0.023	-0.035	0.028	-0.051***	-0.047***	-0.112**
	(0.017)	(0.026)	(0.082)	(0.003)	(0.003)	(0.047)
L.DENS*D_{1979}	-0.067***	-0.052**	0.032	-0.048***	-0.044***	-0.099**
	(0.016)	(0.024)	(0.073)	(0.003)	(0.003)	(0.046)
L.DENS*D_{1980}	-0.089***	-0.100***	-0.175**	-0.013***	-0.009***	-0.058
	(0.016)	(0.024)	(0.075)	(0.003)	(0.003)	(0.043)
L.DENS*D_{1981}	-0.059***	-0.031	-0.160**	-0.033***	-0.027***	-0.070*
	(0.016)	(0.023)	(0.073)	(0.003)	(0.003)	(0.042)
L.DENS*D_{1982}	-0.072***	-0.034	-0.149**	-0.054***	-0.051***	-0.071*
	(0.016)	(0.024)	(0.076)	(0.003)	(0.003)	(0.040)
L.DENS*D_{1983}	-0.086***	-0.015	-0.158**	-0.080***	-0.079***	-0.123***
	(0.015)	(0.022)	(0.073)	(0.002)	(0.003)	(0.037)
L.DENS*D_{1984}	-0.081***	0.005	-0.084	-0.074***	-0.074***	-0.109***
	(0.015)	(0.022)	(0.072)	(0.002)	(0.003)	(0.037)
L.DENS*D_{1985}	-0.058***	0.008	-0.020	-0.055***	-0.056***	-0.102***
	(0.015)	(0.021)	(0.069)	(0.002)	(0.003)	(0.038)
L.DENS*D_{1986}	-0.012	0.021	0.032	-0.012***	-0.015***	-0.041
	(0.014)	(0.018)	(0.066)	(0.002)	(0.003)	(0.037)
L.DENS*D_{1987}	-0.033**	-0.023	-0.029	-0.004*	-0.004	-0.043
	(0.014)	(0.019)	(0.069)	(0.002)	(0.003)	(0.035)
L.DENS*D_{1988}	-0.042***	-0.031*	-0.028	-0.010***	-0.009***	-0.042

	(0.013)	(0.018)	(0.060)	(0.002)	(0.003)	(0.035)
L.DENS*D_{1989}	-0.110***	-0.084***	-0.120**	-0.017***	-0.014***	-0.057*
	(0.013)	(0.017)	(0.059)	(0.002)	(0.003)	(0.034)
L.DENS*D_{1990}	-0.124***	-0.109***	-0.134**	-0.009***	-0.009***	-0.049
	(0.014)	(0.018)	(0.062)	(0.002)	(0.003)	(0.033)
L.DENS*D_{1991}	-0.112***	-0.096***	-0.095	0.006***	0.004	-0.044
	(0.016)	(0.020)	(0.068)	(0.002)	(0.003)	(0.034)
L.DENS*D_{1992}	-0.084***	-0.085***	-0.041	0.010***	0.009***	-0.023
	(0.016)	(0.021)	(0.067)	(0.002)	(0.002)	(0.033)
L.DENS*D_{1993}	-0.050***	-0.043**	0.054	-0.005***	-0.005**	-0.032
	(0.017)	(0.021)	(0.067)	(0.002)	(0.002)	(0.031)
L.DENS*D_{1994}	-0.074***	-0.068***	-0.138**	-0.020***	-0.018***	-0.041
	(0.017)	(0.022)	(0.066)	(0.002)	(0.002)	(0.029)
L.DENS*D_{1995}	-0.057***	-0.040*	-0.069	-0.012***	-0.016***	-0.047
	(0.016)	(0.020)	(0.059)	(0.002)	(0.002)	(0.029)
L.DENS*D_{1996}	-0.019	-0.045**	-0.243***	-0.008***	-0.010***	-0.039
	(0.016)	(0.021)	(0.071)	(0.002)	(0.002)	(0.028)
L.DENS*D_{1997}	-0.044***	-0.051**	-0.115	-0.018***	-0.020***	-0.056**
	(0.016)	(0.021)	(0.071)	(0.002)	(0.002)	(0.027)
$\overline{\text{L.GPOP}}$	-0.110***	-0.022	-0.141	0.300***	0.319***	0.323**
	(0.035)	(0.061)	(0.104)	(0.047)	(0.073)	(0.156)
MEDUNI	-0.125**	-0.046		0.428***	0.351*	
	(0.062)	(0.128)		(0.044)	(0.208)	
Constant	6.735***	3.644***	3.095*	1.944***	1.942***	2.974**
	(1.012)	(1.316)	(1.778)	(0.194)	(0.205)	(1.308)
N	805	805	859	805	805	855
Log Likelihood	-628.416	-510.131		-735.851	-617.483	
F			2.86***			1.69***

*,**,*** Coefficient different from zero with an error probability of 10%, 5%, 1%.

[a] We apply two GLS-estimation methods: (A) heteroscedastic error structure with cross-sectional correlation, (B) heteroscedastic error structure with cross-sectional correlation and autocorrelation. For the GLS estimations only 23 cantons are included, since for the cantons Jura, Obwalden and Appenzell Innerrhoden data is not available for all the time periods and therefore, the panel is not balanced.

[b] The fixed effects model (C) is estimated with the error term following an AR(1) process. Note that the first year (1963) is dropped in order to get correct estimates of the group mean. The sizes of R-squares are: within=0.20, between=0.13 and overall=0.27 for general practitioners; within=0.13, between=0.25 and overall=0.14 for specialists.

[c] Time dummies are included into the estimation.

Table 7: Yearly OLS-regressions of extended model for general practitioners

Year	L.DENS	$\overline{\text{L.GPOP}}$	MEDUNI	Constant	R^2	N
1963	-0.053	0.532	-0.829	0.096	0.072	24
1964	0.052	0.083	-0.496	-3.251	0.032	24
1965	-0.047	0.247	0.580	0.613	0.075	24
1966	-0.068	0.146	-0.525	2.394	0.045	24
1967	0.072	0.040	-0.958	-2.349	0.084	24
1968	0.117**	-0.024	-2.373***	-3.415	0.536	24
1969	0.083*	-0.087**	-1.918***	-1.870	0.516	24
1970	-0.050	-0.300***	-1.451	3.509	0.333	25
1971	-0.198***	-1.124***	-1.480	10.597***	0.513	25
1972	-0.162***	-1.526***	-1.398	9.539***	0.449	25
1973	-0.143***	-1.205***	-0.756	8.056***	0.454	25
1974	-0.044	-1.645*	-0.095	4.267	0.133	25
1975	-0.156*	-1.608*	0.399	7.615**	0.310	25
1976	-0.030	-0.402	1.344	2.848	0.084	25
1977	-0.055	0.865	0.636	4.621	0.083	25
1978	0.021	0.821	0.549	1.873	0.021	25
1979	0.076	1.026	2.345	-0.800	0.102	25
1980	-0.187*	1.695**	0.206	11.102**	0.333	25
1981	-0.249*	2.282**	0.008	14.167**	0.373	26
1982	-0.249*	2.758	-2.055	14.486**	0.294	26
1983	-0.185	-2.178	-2.563	16.875**	0.202	26
1984	-0.155**	-3.524**	-1.295	15.421***	0.410	26
1985	-0.109**	-3.707***	-0.377	12.911***	0.304	26
1986	0.094	-0.095	2.051	-1.733	0.067	26
1987	0.047	1.619	1.347	-1.075	0.107	26
1988	0.045	2.312**	0.304	-2.192	0.187	26
1989	-0.075	1.040	-0.202	4.454	0.181	26
1990	-0.097	1.034	0.208	5.417	0.205	26
1991	-0.066	0.382	0.884	4.466	0.095	26
1992	0.023	0.863	1.144	-0.182	0.063	26
1993	0.129	2.022	1.896	-8.202	0.261	26
1994	-0.152**	-0.087	0.697	11.265**	0.282	26
1995	-0.130*	-0.128	0.811	9.467*	0.294	26
1996	-0.250	-0.727	0.475	17.488	0.194	26
1997	-0.083	0.298	0.285	5.399	0.203	26

*,**,*** Coefficient different from zero with an error probability of 10%, 5%, 1%.

Table 8: Yearly OLS-regressions of extended model for specialists

Year	L.DENS	$\overline{\text{L.GPOP}}$	MEDUNI	Constant	R^2	N
1963	-0.006	0.971	-0.817	-0.833	0.088	23
1964	-0.009	1.037	-1.131	-1.435	0.105	23
1965	-0.053	2.889***	-0.232	0.547	0.323	23
1966	-0.040	1.525***	-0.368	2.482	0.216	23
1967	-0.021	1.611***	-1.289	2.253	0.275	24
1968	0.012	0.458***	-0.525	1.625*	0.526	24
1969	0.020	0.109	0.229	0.781	0.179	24
1970	0.014	-0.818***	0.614	1.917	0.501	25
1971	-0.061	1.367	2.498	2.931	0.137	25
1972	-0.133	-0.047	3.663	9.293*	0.129	25
1973	-0.064	-2.133	-0.080	9.848*	0.116	25
1974	-0.074	-0.175	-0.766	9.556	0.101	25
1975	0.021	2.506	-2.773*	4.151***	0.209	25
1976	-0.013	3.053*	-1.185	7.385***	0.194	25
1977	-0.082*	0.089	1.570	9.886***	0.245	25
1978	-0.080**	0.073	1.993	10.293***	0.229	25
1979	-0.076**	0.742	3.438**	9.375***	0.233	25
1980	-0.022	1.792**	2.605	5.038	0.152	25
1981	-0.037	1.250	2.185	7.859***	0.106	26
1982	-0.030	1.933	1.530	6.408**	0.058	26
1983	-0.119**	-1.154	4.121	14.037***	0.221	26
1984	-0.085**	0.746	2.766	9.998***	0.272	26
1985	-0.064	-0.117	1.141	9.667***	0.246	26
1986	0.018	1.186	-1.189	2.446	0.028	26
1987	0.003	0.306	-0.416	3.097	0.007	26
1988	0.015	2.432**	-0.734	-0.499	0.169	26
1989	-0.033	-0.967	1.377	5.250	0.078	26
1990	-0.018	-0.870	0.624	4.203	0.026	26
1991	-0.010	-0.485	1.060	4.348*	0.006	26
1992	0.019	-0.781	-0.317	3.032	0.091	26
1993	0.003	-0.952	0.355	4.353**	0.053	26
1994	-0.006	1.748	1.530	2.343	0.077	26
1995	-0.014	2.216*	2.154	2.712	0.180	26
1996	0.001	1.318	0.199	2.879**	0.135	26
1997	-0.145	0.682	-0.710	6.444***	0.266	26

*,**,*** Coefficient different from zero with an error probability of 10%, 5%, 1%.

8 References

Barro, R.J. and X. Sala-i-Martin (1992), Convergence, Journal of Political Economy 100 (2): 223-251.

Bhargava, A., L. Franzini and W. Narendranathan (1982), Serial Correlation and the Fixed Effects Model, Review of Economic Studies 49 (4): 533-549.

Bolduc, D., B. Fortin and M.A. Fournier (1996), The Effect of Incentive Policies on the Practice Location of Doctors: A Multinomial Probit Analysis, Journal of Labor Economics 14: 703-732.

Chomitz, K.M., G. Setiadi, A. Azwar, I. Nusye and R. Widiyarti (1998), What Do Doctors Want? Developing Incentives for Doctors to Serve in Indonesia’s Rural Areas, World Bank, Development Research Group.

De Jaegher, K. and M. Jegers (2000), A Model of Physician Behaviour with Demand Inducement, in: Journal of Health Economics 19: 231-258.

Domenighetti, G. and L. Crivelli (2001), Sécurité de l’approvisionnement en médecine de ville dans le cadre de la suppression de l’obligation de contracter, Working paper MecoP and iems.

Folland, S., A.C. Goodman and M. Stano (2001), The Economics of Health and Health Care, 3rd. ed., Upper Saddle River: Prentice-Hall.

Foster, S.A. and W.L. Gorr (1992), Federal Health Care Policy and the Geographic Diffusion of Physicians: A Macro-scale Analysis, in: Policy Sciences 25: 117-134.

Gilliand, P. and P. Eichenberger (1981), Demographie der künftigen Ärzteschaft in der Schweiz: Perspektiven und ihre Auswirkungen auf lange Sicht (Demography of Future Physicians: Perspectives and Effects in the Long-term), in: Schweizerische Ärztezeitung 62 (38): 2759-2770.

Greene, W.H. (1993), Econometric Analysis, 2nd ed., New York: Macmillan Publishing Company.

Hurley, J. (1990), Simulated Effects of Incomes-Based Policies on the Distribution of Physicians, in: Medical Care 28: 221-238.

Kristiansen, I.S. and O.H. Førde (1992), Medical Specialists’ Choice of Location: The Role of Geographical Attachement in Norway, in: Social Science and Medicine 34: 57-62.

Labelle, R., G. Stoddart and T. Rice (1994), A Re-examination of the Meaning and Importance of Supplier-Induced Demand, in: Journal of Health Economics 13: 347-368.

Newhouse, J.P., A.P. Williams, B.W. Bennett and W.B. Schwartz (1982), Does the Geographical Distribution of Physicians Reflect Market Failure?, in: Bell Journal of Economics 13 (2): 493-505.

Schellhorn, M. (2001), The Effect of Variable Health Insurance Deductibles on the Demand for Physician Visits, in: Health Economics 10: 441-456.

Schmid, H. (1984), Der Einfluss zunehmender Ärztedichte auf die Kosten der Krankenversicherung (Influence of an Increasing Physician Density on the Cost of Health Insurance), in: Schweizerische Ärztezeitung 65 (11): 497-506.

Schmidt, H. (1997), Konvergenz wachsender Volkswirtschaften (Convergence of Growing Economies), Wirtschaftswissenschaftliche Beiträge 152, Heidelberg: Physica-Verlag.

Timmermans, H. and R.G. Golledge (1990), Applications of Behavioural Research on Spatial Problem II: Preference and Choice, in: Progress in Human Geography 14: 311-354.