STUDIECENTRUM VOOR ECONOMISCH EN SOCIAAL ONDERZOEK

MODELLING THE CHANGING GEOGRAPHICAL DISTRIBUTION OF PHYSICIANS

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Abstract

An important issue facing policy makers everywhere is whether or not to intervene in order to secure an 'appropriate' geographical distribution of physicians. In this paper, data for Belgium are used to explore the argument that the speed of ajustment to regional excess demand or supply of general practitioners is too slow under 'laissez-faire'. Results show that, for the period 1974-1979, it takes 5 to 9 years to reduce half the gap between the equilibrium number and an initial number of physicians. Furthermore, the rate of adjustment seems to decrease over time.

1. Introduction

An important issue facing health policy makers everywhere is whether or not to intervene in order to secure an 'appropriate' geographical distribution of physicians [see e.g. Roemer & Roemer (1981) and Rosenthal & Frederick (1984)].

It is often asserted that 'laissez-faire' leads to a geographical maldistribution of physicians so that specific regulation is necessary. The standard argument is that the market fails because physicians, guided by their preferences for attractive locations [Fuchs (1978)], can create demand. As yet the evidence on the demand creating abilities of physicians is not conclusive [see Reinhardt (1985)], but even if it were it is not clear that this would lead to a geographical maldistribution of physicians. For the USA, Newhouse et.al. (1982) shows that demand creation is neither necessary nor sufficient to explain observed patterns of physicians' location. They show that standard location theory, and assuming that the market does not fail does the explanatory job very well.

In this paper, the focus is on another argument for market failure and regulation, namely that the speed of adjustment to regional excess demand or supply is so slow under laissez-faire that regulation could beneficially speed up this process of adjustment to temper regional disequilibria.

Data for Belgium are used to explore this argument. In Belgium, location of physicians is not regulated and no special government programs guide regional distribution of physicians. Since patients have free choice of any doctor and physicians are free to locate wherever they want, it provides an excellent case to investigate where 'laissez-faire' in this respect leads to.

In Belgium, it is not all 'laissez-faire' in the health care sector. Paragraph 2 contains some institutional background on the Belgian health care system. In paragraph 3 typical location patterns for physicians are discussed and verified with the Belgian data. In paragraph 4 the concept of an equilibrium number of physicians is explained. The econometric specification is dealt with in paragraph 5. Finally, results are discussed.

2. Health care organization in Belgium

Since the early sixties nearly all Belgian citizens are covered by compulsory health insurance. The collection of health insurance contributions, predominantly pay-roll taxes, is centralised by the National Office of Social Security. Numerous mutual aid societies or sickness funds, grouped in major national associations, and under government supervision through the National Institute for Sickness and Invalidity Insurance, receive claims and indemnify their members for medical care expenses or make certain payments directly to health care providers. Medical care benefits are broader for employees that for self-employed. For employees, insurance reimburses 75 percent of official physician fees. The elderly and a few minor categories of insured are reimbursed on a 100 percent basis.

Official fees are fixed by a fee-schedule established by the National Institute for Sicknes and Invalidity Insurance after bargaining with the medical profession. As patients have free choice of doctor, the majority of general practitioners abide by the negotiated schedule. Belgium has a very high doctor to population ratio, even by European Standards (26 physicians per 10 000 population in 1982, see OECD 1985).

Hospitalisation in both public and private hospitals, is almost fully covered by the insurance program. Physicians often send their bill directly to the sickness fund and charge the patient for the co-insurance contribution. Hospitals are financed on a per diem system based on costs, although recent reforms make part of hospital income dependent upon a fixed budget. As physicians are paid separately on a fee-for-service basis, they are excluded from hospital costs.

The insurance system covers various other ancillary services ordered by physicians such as prescribed drugs, home nursing care, physiotherapy, eyeglasses, etc.

In sum, the Belgian health care system is characterised by 'public' insurance and 'private' provision of care. An excellent and more detailed description can be found in Roemer & Roemer (1981).

3. Geographical distribution of physicians

Typical observations on physicians' location patterns are:
1. the variation between areas in physician-population ratios is substantial; 2. physician-population ratios in rural areas are generally lower than in urbanized areas and 3. physician-population ratios in rural areas rise more slowly than in urban areas over time.

Physicians' location patterns in Belgium correspond well to these typical observations. The country is subdivided in 43 administrative areas, called 'arrondissements', for which various data on full-time equivalents have been collected by Leroy (1983). This purely administrative subdivision is certainly not an ideal stratification as perhaps none of the arrondissements is continuous within region. There are but two reasons to use the data nevertheless. Their mere availability and the absence of alternatives is one. A subsample of fairly contiguous regions for Belgium would consist of very few observations as the country is highly urbanised. The second reason is that the same data are often used to argue that the distribution of physicians is suboptimal. In this paper the data are merely used for explanatory purposes.

In table 1 and table 2 the geographical dispersion of general practitioners and specialists in 1974, 1976 and 1979 is presented by the frequency distribution of the number of physicians per 1000 population.

From these tables and summary statistics it follows that the variation in physician-population ratios between areas is substantial. The variation is, of course, somewhat less for general practitioners than for specialists. Some areas have twice as much GPs per population as others, whereas the range dramatically expands for spe-cialists to as much as twenty times the lowest value of specialists per population. In spite of the general increase in physician-population ratios over time, variation between areas did nod decrease.

The well-known fact that physician-population ratios in urbanised areas are generally higher than in rural areas is confirmed by the statistics shown in table 3. In this table average physician-population ratios are given for the seven major urban areas (Antwerp, Brussels, Bruges, Charleroi, Ghent, Liege and Namur) in comparison to the average ratios of the remaining areas. GP and specialists ratios are higher in urban than in other areas. In particular, the specialists tend to concentrate into urban areas.

From the same table the third typical observation can be made, namely that physician-population ratios rise faster in urban areas than in non-urban areas over time. For GPs the difference in increase is very small, but specialists clearly follow this general trend.

These typical patterns of location are consistent with predictions from standard location theory, as shown by Newhouse et.al. (1982) without any special assumpton on physician behaviour.

4. The equilibrium number of general practitioners

The major purpose of this paper is to explore whether or not physicians are influenced by regional excess demand or supply for their services when they decide were to locate their practice and to provide an estimate of the speed of adjustment.

Only the location of GPs is considered here explicitly. GPs in Belgium generally abide by the official fee schedule negotiated annually between the National Institute for Sickness and Invalidity Insurance and physician representatives. Individual GPs act as price-takers. Specialists on the other hand generally charge higher fees than the official fee-schedule and are price-makers or price searchers rather than price-takers. A model for specialists would be far more complex as it should take pricing behaviour into account as well. This is not attempted here. Consequently, regional markets of GP care may be framed in a standard demand and supply schedule for price-takers.

Suppose that for each area there is a regional quantity demanded of GP care determined by the standard variables namely its own use price, prices of substitutes, prices of complements, income and tastes, summarised by the vector of variables Y.

In the short-run a given number of price-taking GPs (NS) in the area supply their services up to the point that their full marginal cost, inclusive the marginal value of their labor time, is no longer compensated by the price they set for additional service. Short-run aggregate supply in the region would be the horizontal sum of their marginal cost schedules and supplied output would depend upon factor prices, the number of physicians and technological parameters. Say X is the vector of supply variables except the number of physicians itself.

Because most GPs have a solo practice in Belgium, this supply curve might well be backward bending as it almost entirely depends upon the individual labor supply curves.

In a regional market where patients pay a net price (PN) and physicians operate at a gross price (PG) - the difference (R) being their party reimbursement - equilibrium is defined by

$$Q = s(PG) = d(PN) \text{ and } PG = PN+R$$

where s(.) is the supply function, d(.) the demand function, Q the equilibrium quantity of GP care.

With a given number of physicians in the short run (NS) a situation of excess demand (figure 1), or excess supply (figure 2) is more likely than equilibrium if prices cannot adjust to regional conditions.

Equilibrium might be obtained not by flexible prices but more slowly through changes in the number of physicians through exit and entry in the regional market. A proper increase or decrease in the number of physicians to N* in regions with excess demand or supply might eventually bring this market with fixed prices in equilibrium.

The equilibrium number of physicians (N) will then be the solution of

$S(N^*,X) = d(Y)$

or

$N^* = n(Y,X)$ [1]

Note that if the marginal effect of physicians on quantity supplied is positive, the sign of the marginal effect of a supply determinant on the equilibrium number of physicians is the opposite of that of the marginal effect of the determinant on quantity supplied. The sign of the marginal effect on the equilibrium number of a demand determinants is similar to that of its marginal effects on quantity demanded (1).

5. Econometric specification and estimation

In a specification of equation [1] for the purpose of estimation using regional data, prices are dropped from the equation as the variation in prices between regional markets presumably is neglectable. A linear equation is used so that [1] is approximated by

(1) As $q=s(n^*,X)=d(Y)$ it follows that $S_n dn^* + S_x dX = d_y dY$ from which $\frac{dn^*}{dX} = -\frac{Sx}{Sn}(dY=o)$ and $\frac{dn^*}{dy} = \frac{dy}{Sn}(dX=o)$

$$N_t^* = X_t b + Y_t a \qquad [2]$$

with N* a K x 1 vector of the (unobservable) equilibrium number of physicians in period t in the K regions, X a K x S matrix of K regional observations on S supply determinants, Y a K x D matrix of K regional observations on D demand determinants and b and a are vectors of parameters of dimension S x 1 resp D x 1.

In table 5 the variable definitions, means and standard deviations used in the estimations are given. These variables correspond to typical demand and supply determinants for primary care [see e.g. Carrin & De Graeve (1986)].

The issue at hand is whether or not excess demand or excess supply in regional markets will guide entering physicians and if so at what speed disequilibria will be reduced. A partial adjustment model is used to answer this question.

Consider the following partial adjustment model

$$N_t - N_{t-\theta} = \lambda_\theta \, (N_t^* - N_{t-\theta}) + \mu_t \qquad [3]$$

with $N_t - N_{t-\theta}$ a K x 1 vector os observed adjustments in the K regions in the number of physicians from period t- to period t, $N_t^* - N_{t-\theta}$ a K x 1 vector of 'desired' adjment in the K regions over the same perod, λ_θ a scalar and μ_t a K x 1 vector of normally distributed error terms with zero expectancy and constant variance.

If λ_θ is different from zero and smaller than one, disequilibria will disappear over time without special policies for geographic distribution of physicians. The ratio λ_θ/θ will give some indication of the speed of adjustment, provided λ_θ is constant over time.

Substitution of [2] in [3] yields the following reduced form equations suited for estimation by ordinary least squares

$$N_t = (1-\lambda_\theta) N_{t-\theta} + \lambda_\theta X_t b + \lambda_\theta Y_t a + \mu_t \qquad [4]$$

Regional data on the physician per population ratio for 1974, 1976 and 1979 are available from the work of Leroy (1983). Consequently, equation [4] can be estimated separately for the two year interval from 1974 tot 1976 and for the three year interval from 1976 to 1979 using the cross-section data on regions.

Inequality of time intervals does not allow direct pooling of the two series. However, assuming that

$$\lambda_{\theta} = \theta\lambda_{1} \qquad [5]$$

or that annual adjustment is constant over the period covered by the data, both sets of cross section data can be pooled.

Substituting [5] in [3] and using [2] leads to

$$N_{t} - N_{t-\theta} = -\lambda_{1}\theta\, N_{t-\theta} + \lambda_{1}\, \theta\, X_{t}b + \lambda_{1}\, \theta\, Y_{t}a + \mu_{t} \qquad [6]$$

where θ is known and λ_{1}, a and b are vectors of parameters to be estimated.

6. Estimation results

In table 6 the estimation results for equation [6] are summarised. Column [1] and column [2] are ordinary least squares estimates for the period 1974/1976 and the period 1976/1979. As one might expect heteroscedasticity with cross-sections of this type, Glesjer tests [see e.g. Maddala (1979) p.262] were run. They did not reveal serious heteroscedasticity problems.

The lagged physician per 10000 population ratio (GP) has the expected negative sign and is highly significant in the first period (0.3 %) but less so in the second period (11 %). The coefficients are small and seem to decline over time. The coefficients for the period 1974/1976 is substantially larger than for the period 1976/1979. The implied periods of adjustment are long (2). Using the 1974/1976 coefficient it takes about 5.5 years to halve the gap between the equilibrium number and an initial number of physicians, and about 10.9 years to reduce the gap with three quarters. Adjustment takes even longer with the 1976/1979 coefficient: 8.9 years to halve a gap and 17.7 years to reduce it with three quarters.

Specialists (SP) appear to be complementary to general practitioners rather than substitutes. This is consistent with the findings of Carrin & De Graeve (1986), analysing the demand for gp care in Belgium.

Mortality (MORT) has a positive effect on the physician-populaqtion ratio. As an important part of care over a person's lifecycle is near the time of death, mortality is expected to have a positive effect on the demand for care and the physician-population ratio. The effect is highly significant (3 %) for the first period but not for the second period.

Density (DENS) and income (INC) are not robust. The coefficients switch signs over periods and are statistically not significant.

The share of elderly (AGE) in the population has a negative but insignificant coefficient. This is contradictory to usual findings, i.e., that age increases the demand for gp care.

Finally productivity or workload (WKL) has a negative and significant (1 %) effect on the physician-population ratio as expected.

In column [3], [4] and [5] results of pooled equations with various restrictions on coefficients are reported. Table 7 summarises the analysis of covariance. Column [3] are the results if all coefficients except the intercept and the adjustment parameter are assumed equal. The hypothesis that coefficients except

(2) Solving the linear difference equation implied in a partial adjustment model yields to $n_t - n^* = (n_o - n^*)(1-\lambda)^t$

intercept and adjustment parameter are equal over time is not rejected at the 1 % level [F(6,70)=.54].

Column [4] has the results if all slope coefficients are assumed equal. The hypothesis of equality of slope coefficients is not rejected at the 5 % level but rejected at a a level of 10 %. This indicates that the adjustment parameter is decreasing over time.

Finally column [5] are results of a pooled regression with all coefficients assumed equal. The hypothesis of homogeniety of coefficients is however rejected [F(1,77)=18.92].

From the above, specification [3] seems to be the most suited for further analysis.

Conclusions

In this paper a partial adjustment model is estimated using cross-section data on 'arrondissements' in Belgium for 1974, 1976 and 1979 to assess whether or not general practitioners take excess demand of excess supply for their services into account when they decide of locate themselves in a certain area. Furthermore, an estimate of the speed of adjustment of physician numbers is provided.

Estimation results indicate that adjustment takes place in the hypothesized direction.

However, the adjustment of the physician-population ratio under the Belgian policy of 'laissez-faire' is slow. It takes 5 to 9 years to reduce half the gap between an equilibrium number and an initial number of physicians and 11 to 18 years to reduce the gap to 25 %.

Adjustment speed seems to decrease over time. For the period 1974/76 annual adjustment was estimated at 12 percent, whereas for the period 1976/79 at 7.5 percent.

If more recent data become available, it would be a worthwile excercise to reestimate the equations to see if these results are robust.

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Table 1. Frequency distributions
General practitioners per 10 000 pop.

Class limits	1974	1976	1979
4-5	2	-	-
5-6	4	2	-
6-7	14	6	1
7-8	10	12	4
8-9	6	10	11
9-10	5	7	8
10-11	1	4	5
11-12	1	2	6
12-13	-	-	5
13-14	-	-	2
14-15	-	-	1
Total	43	43	43
Mean	7.39	8.28	10.02
St.dev.	1.51	1.51	1.92
Min	4.34	5.29	6.75
Max	11.20	11.89	14.32

Table 2. Frequency distributions of specialist per 10 000 pop.

Class limits	1974	1976	1979
0-2	2	1	1
2-4	11	8	8
4-6	16	16	8
6-8	8	12	14
8-10	2	2	5
10-12	2	2	4
12-14	1	1	1
14+	1	1	2
Total	43	43	43
Mean	5.73	6.22	7.02
St.dev.	3.43	3.56	3.94
Min	0.88	1.43	1.21
Max	20.40	22.02	24.88

Table 3. GPs per 10 000 population: urban vs. other areas

Urban (n=7)	1974	1976	1979	1974-79
mean	8.95	9.78	11.60	+2.65
std.dev.	1.62	1.61	1.94	
Other areas (n=36)				
mean	7.09	7.99	9.71	+2.62
std.dev.	1.49	1.49	1.92	

Table 4. Specialist per 10 000 population urban vs. other areas

Urban (n=7)	1974	1976	1979	1974-79
mean	10.83	11.58	13.01	+2.18
std.dev.	4.24	4.60	5.15	
Other areas (n=36)				
mean	4.74	5.18	5.86	+1.12
std.dev.	3.25	3.32	3.66	

Table 5. List of variables

		Year	Mean	St.dev.
GP	number of general practitioners	1974	7.39	1.51
	per 10 000 population	1976	8.28	1.51
		1979	10.02	1.92
SP	number of specialists	1974	5.73	3.43
	per 10 000 population	1976	6.22	3.56
		1979	7.02	3.94
MORT	deaths per 1 000 population	1976	12.36	2.14
		1979	11.67	1.93
DENS	1 000 population/square kilometer	1976	.469	.960
		1979	.466	.930
INC	median income per tax report in	1976	.234	.028
	in 100 000 francs	1979	.336	.024
AGE	percentage retired, widows	1976	15.12	3.70
	and handicaped	1979	15.24	3.63
WKL	average number of contacts	1976	8.90	1.63
	in 1 000 per GP	1979	8.88	1.82

Table 6. Regression results

	[1] 74/76	[2] 76/79	[3] Pooled 1	[4] Pooled 2	[5] Pooled 3
$\theta.GP_{t-\theta}$	-.1194 (.0368)***	-.0752 (.0459)	-.1270 (.0385)***	-.0899 (.0302)***	-.0574 (.0324)*
$D.\theta.GP_{t-\theta}$	-	-	.0544 (.0356)		
θSP_t	.0240 (.0171)	.0064 (.0200)	.0121 (.0132)	.0132 (.0133)	.0027 (.0145)
$\theta.MORT_t$	.0492 (.0214)**	.0057 (.0285)	.0195 (.0182)	.0173 (.0183)	.0450 (.0190)*
$\theta.DENS_t$	-.0399 (.0503)	.0287 (.0640)	.0059 (.0415)	.0039 (.0418)	-.0123 (.0462)
$\theta.INC_t$	-.9613 (1.3939)	.1071 (1.7787)	-.5159 (1.1465)	-.8259 (1.1382)	3.2710 (0.7083)***
$\theta.AGE_t$	-.0144 (.0101)	-.0080 (.0133)	-.0102 (.0085)	-.0101 (.0086)	-.0088 (.0096)
$\theta.WKL_t$	-.0653 (.0259)**	-.1340 (.0292)***	-.1135 (.0196)***	-.1149 (.0198)***	-.0870 (.0207)***
Constant	3.2234	7.0625	4.6999	4.3595	.9297
D.constant	-	-	1.9103 (.0196)***	3.0784 (0.7079)***	-
R^2	.3913	.4525	.5674	.5541	.4446
SEE	.4009	.7046	.5677	.5726	.6349
F d.f.	3.21 (7,35)	4.13 (7,35)	11.08 (9,76)	11.96 (8,77)	8.92 (7,78)

. dependent $GP_t - GP_{t-\theta}$

. D=0 for 74/76 and 1 for 76/79

. *** = 1 %; ** = 5 %; * = 10 %

Table 7. Analysis of covariance

Source	Sum of squares		df	m.sq	F
1. All coefficients unrestricted	residual Δ	23.0026 1.0647	70 6	0.3286 0.1774	0.54
2. All coefficients restricted except λ and constant	residual Δ	24.4902 0.7529	76 1	0.3181 0.7529	2.37
3. All coefficients restricted except constant	residual Δ	25.2431 6.2005	77 1	0.3278 6.2005	18.915
4. All coefficients restricted	residual Δ	31.4436	78	0.3573	

Figure 1. Regional excess demand

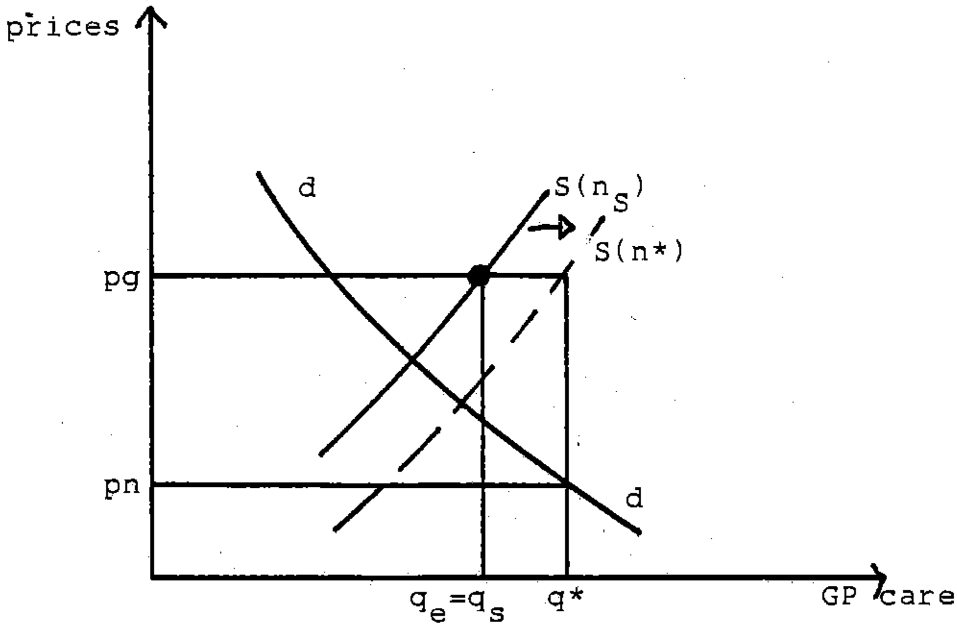

Figure 2. Regional excess supply