MODELLING THE DEVELOPMENT OF A PROFESSIONAL GROUP IN A MACROECONOMIC ENVIRONMENT
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1. Introduction

The following analysis was done as part of a project that was carried out by the Austrian Federal Institute of Health Affairs on behalf of the Austrian Government. A time horizon of one and a half year had been planned for the whole project whose subject was the analysis of the supply and demand of medical doctors in Austria. As a result an outlook to the year 2010 of the doctors to be expected from the educational system as well as of the need for doctors had to be produced. This presentation is concentrating on the demand side.

The general form of the title was chosen because this model may be applied in a modified form to investigate the development of other professional groups especially in the public sector. Everywhere where the government wants to guarantee a certain service to the population, that has to be financed by public means, the methodology described below is applicable.

2. Goals of the Study

When the demand part of the model was designed it was intended to reach three objectives.

1. Model the need of the patient
2. Incorporate economic relations
3. Consider the development over time.

The first point refers to the fact that it is quite often the "needs" of doctors or the interests of the health insurance that determine the demand of doctors. Therefore great care was taken to represent the needs of the consumer, the patient. Secondly, in most industrialized countries the health sector is a highly regulated sector trying to guarantee "health" to everybody.

Although the consumption of "health" by the patient does usually not depend on the price of the product or the amount of money available it is obvious that in many areas of the health service sector financing problems do arise. One example in Austria as well as in Germany is the discussion about the inclusion of care taking in the health insurance. Another example is the trend among Austrian doctors to cancel their contracts with the health insurance in order to bring income in line with performance. As The Economist sums it up in its 25th May issue there are three major principles underlying the structure of most health services in the OECD countries, division of providers and purchasers (usually health authorities) of health, encouragement of competition among providers of health, flow of money from the patient. These arguments proof that economic relations do play an important role.

As a third point in the construction of the model attention is drawn to the development over time. A situation may be misjudged easily if only the present status quo is analyzed.

In Austria studies were made with the aim to analyze parts of the health care sector. Fleissner (1977) constructed a model simulating the health care system in Austria. However, this was no attempt to produce a forecast. Another study (cf. Mandl 1982) used Markoff Chains to forecast the supply of doctors. The need of doctors was not explicitly modelled. At my institute studies on the supply of doctors for the population were made in 1979 and 1983. These studies included great details concerning the medical system in Austria, geographical distributions as well as different types of hospitals.

3. Dependent and Explanatory Variables

The present study tries to meet the three points mentioned above by simulating the need for medical doctors in an econometric model. To this end in each of the submodels different age groups enter as an indicator of the health status of the population and determine the utilization rate of the different health services. Based on the utilization rate expenditures are determined which enter the equation for the number of doctors. The model is very simple mainly because it was very difficult to obtain data. However, although it seems possible to expand and modify the present version of the model it shows quite well relations as well as the development of the system. Actually the model consists of three parts, a fact that on one side is due to the data situation but that conforms also to reality. The three submodels describe

1. doctors with an own practice and a contract with the major Health
Insurance

2. doctors working in hospitals
3. dentists.

Figure 1 shows the relations in the model for doctors with an own practice and a contract with the Health Insurance. The reasoning behind the model of the outpatient care sector is the following. Demographic characteristics of the population are the major factors influencing patient contacts. To a smaller extent patient contacts are also influenced by expenditures in that sector represented by an ambulatory price care index.

Figure 1: Doctors with Own Practices

Figure 1a: Practitioners

Patient contacts determine the share in GDP of expenditures in the ambulatory sector and as the final result doctors are determined by expenditures and the number of doctors in the previous period. In addition the share of practitioners in the total number of doctors is explained by the population and the share of the previous period. The described system is given by four equations for patient contacts, share of expenditures in GDP, doctors and share of practitioners, that are described in section 9.

Figure 2: Doctors in Hospitals
The model for hospital doctors, as shown in figure 2, is quite similar. Age groups determine the number of patients in hospitals, that explain expenditures in the inpatient care sector, expenditures together with the number of hospital beds per year influence the number of physicians needed in hospitals. The two age groups used in this sector are people younger than 45 year and those older than 60 years. According to reality one may think that it is about at the age of 60 that people start to change their habits concerning medical consultation. On the other side there is the fact that the population development is similar among age groups to the age of 45 and thereafter. In a later version it will be tried to eliminate this minor inconsistency.

The model for dentists is slightly different because different data are recorded in this sector. The link between variables is shown in figure 3. Contacts of dentists are explained by population groups and by personal income. It is a remarkable difference to the services of other specialists that in the dental sector it is more often the case that people have to pay for the services. Actually, there is a difference in the development of dentists and other specialists that may be partly due to the difference in the structure. In the model of dentists patient contacts determine the costs to the health insurance. Here costs are used instead of expenditures. However, these are only costs to the insurance not global costs. In this situation it was decided to explain the need for dentists directly by patient contacts. Therefore costs do not enter any further equation, they are a separate result.

Figure 3: Dentists

4. Availability of Information

The present model was developed in a process of constant feedback with reality and availability of data and it is able to describe the major relations in the demand system of doctors. Some improvement could be made by considering more detailed data that had not yet been available. It would be interesting to include more explanatory variables such as health indicators accounting for nicotine and alcohol consumption, overweight or environmental pollution, all signs of civilization sicknesses. In addition it would be helpful to grasp in a more stringent form the contacts between doctors and patients, that is include home visits by doctors or actual number of visits in practices. Finally a further improvement could be obtained by including more details on economic variables.

The data that were used are taken from two main sources:

1. National Authorities including
   1.1. the Central Statistics Agency and
   1.2. the coordinating body of the health insurance

2. OECD.

Data on population, patient contacts or doctors were taken from national sources. Data on expenditures and price indices were taken from OECD (1990). OECD data are mainly designed in order to make comparisons between countries who all have different reporting schemes, and not to do country specific studies. Maybe in a later version of the model it will be possible to include more...
There exists another minor problem with data that I would like to mention briefly. The data concerning hospitals start only in 1982, which results in a very short series. All other data start in 1967 or 1968 such that a time period of about 20 years is considered.

As indicated already earlier the variables that are modelled in the system, that is the endogenous variables, are the patient contacts of doctors in practices, hospitals or of dentists, the corresponding expenditures or costs and the necessary number of doctors. The variables that are not modelled in the system but for which exogenous assumptions are made are the population groups, the index of private consumption in the ambulatory sector, the number of hospital days and the personal income. For the future development of the population group the forecast by the Austrian Central Statistics Agency is used, for the other variables assumptions based on the historical developments had to be made.

5. Methodology and Programming Steps

The methodological process of constructing the model consisted of three essential steps.
1. Estimation of equations
2. Solution over the historical period
3. Forecast

Under point 1 several versions of individual equation were tested to ensure that they describe real world phenomena and that they are reasonable in their statistical properties. Once a set of equations was selected the equations were put together in one system. In the second step the equations were estimated simultaneously and solved over the historical period. Usually the simultaneous estimation did not differ much from the single equation estimation because the system is very simple. The fit over the historical period is a very valuable test of the performance of the equations. It shows how well the estimated equations fit the values in the past. After this step the exogenous variables were introduced and the system was used to produce a forecast over the period 1990 to 2010.

The steps in implementing the described procedure using the SAS* software correspond to the methodological steps and include some additional ones.
1. Reading raw data into SAS data files
2. Estimation of equations
3. Solution over historical period
4. Forecast
5. Graphics

According to this grouping five sets of programs exist that each perform a specific task. In the first group the preparation of data is done. Raw data are read into permanent SAS data files for later use in the other groups. Group 2 includes estimation programs where several versions of individual equations are tested. In each program of the third group several equations are put together into one system whose equations are estimated simultaneously and that subsequently is solved over the historical period. Group 4 includes programs where the models tested in the third group are used for forecasting. In group 5 the results are put in a graphical form.

6. Development of the System

Table 1 : Adjusted R2 of estimated equations

<table>
<thead>
<tr>
<th>Doctors with an own practice:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FKSN</td>
<td>0.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEAMN</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATOTSZ</td>
<td>0.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital doctors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSP</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEICN</td>
<td>0.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARZAK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dentists:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FZ</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COSZN</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZAHN</td>
<td>0.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The variables given in the table are the endogenous variables estimated by 2SLS.
In order to show some of the results table 1 gives the adjusted R² for the estimated equations.

The model for doctors with an own practice is the part for which most data exist. This is a carefully tested model that is also reasonable in its statistical properties. The model for hospital doctors was not an easy part because it is not very well supported by data. In the case of dentists it is remarkable that the yearly growth rate of patient contacts is smaller than that of dentists. This fact explains to some extent the "weak" fit of the variable ZAHN.

The presentation of the estimation results is restricted to the major variables, that is doctors in the three areas. Figure 4 to 6 show actual versus fitted values for the three groups of doctors. For doctors with own practice the turning point between 1968 and 1980 is not very well captured. It may be conjectured that the development of actual values was a result of a policy concerning doctors under contract with the major Health Insurance. Actually, considering all doctors with an own practice no similar development may be discerned. The development of expenditures does not follow a similar curve, therefore the fit in this period is weak. However, up from 1980 the fit seems acceptable although there exists some underestimation. This graphic is very interesting because it shows the strong upward swing in the number of doctors during the last ten years. During that time a new contract came into effect that regulated the number of doctors cooperating with the health insurance. The graphic suggests in which direction the system might go if the present development continues.

Figure 4:

Medical Doctors In the Ambulatory Sector
Actual versus fitted

The data for doctors in hospitals show an almost linear development. The two population groups that indirectly determine the need for doctors in hospitals are people between 0 and 45 and those older than 60 years. These two age groups represent quite well the development of patient contacts over the considered period whereby the older age group has a much bigger influence than the younger one. Expenditures per head of the population show some minor fluctuations that are obviously due to changes in the population. As can be seen total expenditures depict, according to the other variables in that module, an almost linear development.

Finally, the need for hospital doctors is described by expenditures and yearly hospital days. By including the total number of hospital days it was tried to take a measure of efficiency into consideration. Over the considered period hospital beds were decreasing indicating a gain in efficiency. In the past it happened that parts of a hospital had to be closed because not enough staff was available to keep the station running. This was obviously a very inefficient policy that hospital administrations are trying to reduce. In addition, substitution between the hospital and ambulatory sector is also a means of reducing the number of hospital beds thus increasing the efficient
usage of hospital facilities. Therefore, by including patients, through the
costs, and hospital days two opposing trends come into effect. Patient contacts
rather increase the need for hospital doctors whereas an increase in efficiency
tends to lower the need for doctors.

Figure 5:

In the case of dentists the development of patient contacts is well
described by the two population groups, younger and older than 60 years, and a
variable for personal income. The last variable was included because in the case
of dentists not every treatment is covered by the insurance. The importance of
this variable is supported by the estimated parameters which in the case of
dentists give a higher weight to the younger age group than to the older one.
Costs for the insurance per head of the population are well explained by patient
contacts. Finally the need for dentists is not entirely explained by patient
contacts, showing that there must exist some other factor for the explanation of
the equation of dentists. However, patient needs determine the general trend,
they do not capture some fluctuations that are present in the development of
dentists.

Figure 6:
7. Outlook to the year 2010

With respect to utilization rates past values indicate that in the ambulatory sector patient contacts are about 10 times as high as in the hospital sector. This trend is expected to continue into the future. The difference in absolute values of the utilization rates is the reason why the difference in growth rates is not obvious. Comparing the exact numbers patient contacts in the hospital sector show the highest mean growth rate of 2.1% per annum over the forecasting period compared with a 1.9% growth in the ambulatory sector. Expressed in patient contacts dentists show the lowest increase with a yearly growth rate of 1.5%. The exact figures of patient contacts in the ambulatory sector, in hospitals and for dental services are given in table 2.

Table 2:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>FKSN</th>
<th>FSPN</th>
<th>FZN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>2.29</td>
<td>-</td>
<td>0.52</td>
</tr>
<tr>
<td>1980</td>
<td>2.70</td>
<td>-</td>
<td>0.83</td>
</tr>
<tr>
<td>1989</td>
<td>3.04</td>
<td>0.26</td>
<td>0.70</td>
</tr>
<tr>
<td>1990</td>
<td>3.07</td>
<td>0.26</td>
<td>0.72</td>
</tr>
<tr>
<td>1991</td>
<td>3.13</td>
<td>0.27</td>
<td>0.74</td>
</tr>
<tr>
<td>1992</td>
<td>3.34</td>
<td>0.27</td>
<td>0.80</td>
</tr>
<tr>
<td>2000</td>
<td>3.65</td>
<td>0.30</td>
<td>0.88</td>
</tr>
<tr>
<td>2010</td>
<td>4.52</td>
<td>0.40</td>
<td>1.10</td>
</tr>
</tbody>
</table>

FKSN: patient contacts/population
FSPN: hospital patients/population
FZN: dentist contacts/population

Expressed in expenditures the two considered sectors show a different picture. In absolute numbers the percentage share of expenditures in GDP of the hospital sector is located at 2.5% which is about 1/3 above the expenditure share of the ambulatory sector of 1.9% of GDP. However, it may be expected that in the future the expenditure share in GDP for hospitals will grow at a much lower rate than the share for doctors with own practices, that is at 0.7% yearly as compared to 2.3% per annum. These expected growth rates result in fairly similar expenditure shares of 2.8% in the two sectors towards the end of the forecasting period, as shown in figure 7.

Figure 7:
In other words, although it may be expected that utilization rates in hospitals grow at a faster rate than in the ambulatory sector a restrictive policy for the expenditure share of hospitals will be applied. As was mentioned earlier it is mainly in the hospital sector that the division between purchasers and providers of health services has to be well coordinated. The exact values for costs of dental services are not really comparable to the mentioned expenditures. Although patient contacts show the lowest increase among the compared utilization rates the costs for dental services are expected to increase at a yearly rate of 4%.

The analyzed variables translate into the demand for doctors in the following way. Comparing absolute numbers the need for hospital doctors is the highest of the three groups of doctors, followed by doctors with own practices and dentists. In the group of doctors with own practices dentists account for almost 1/3 in 2010, which is a high share in a group if about 22 specialists. The total number of doctors with own practices (including dentists) accounts for about 2/3 of the hospital doctors by 2010. A cumulative plot of the three groups of doctors is shown in figure 8. With respect to yearly changes dentists show the greatest expansion of 2.3% yearly until 2010. The need for doctors employed in hospitals or working in own practices shows a similar increase of yearly 1.5%.

Figure 8:

Using the obtained results two indicators were calculated showing the potential of medical care per person of the population and the work load for each of the three groups of doctors. The two statistics are shown in figures 9a and 9b, respectively.

As is to be expected from the results seen so far the potential of doctors working in hospitals, calculated as the ratio of doctors per 10,000 patients in one sector, is the highest, at a value of about 60. The figures in the ambulatory sector and for dentists are even smaller such that 2 to 3 doctors supply medical care for 10,000 persons of the population. What seems much more interesting is the fact that the potential of doctors in hospitals and with own practices is decreasing thus continuing the trend that prevailed already in the past. Opposed to that is the development of the potential of dentists which is increasing. In other words, with respect to dentists the supply of medical care will be improved for the population whereas for the other groups of doctors the supply of medical care will become worse in the sense that the same number of doctors will have to treat a higher number of patients.

The workload of doctors is defined as the number of patients per doctor. It is therefore clear that for doctors working in hospitals and own practices the workload will increase as opposed to dentists where the workload will be reduced, again a development that is a continuation of the past.
8. Conclusions and Outlook

The presented analysis demonstrates that the need for medical doctors in the hospital sector is much bigger than in the ambulatory sector. In accordance with the present reality it is the hospital sector that may cause problems in the future. The question for the policymaker is whether it is advisable to keep up the expected development of the system or whether it is preferable to find new strategies, both from a qualitative and an economic point of view. This study concentrated on the analysis of the health sector and there specifically on two groups of doctors. Improvements of the model seem to be possible by including more details such as an index on the style of living or on the environmental situation. It seems worthwhile to elaborate the modelling of the cost/expenditure effect. In this respect nominal values might be replaced by real ones. More socioeconomic factors could be taken into consideration such as income, that is used in one part already, education and profession. If data can be made available it would be interesting to work out in a better way the potential of substitution between the ambulatory and the hospital sector. Moreover, a similar analysis could be carried out using cross sectional data instead of time series.

The presented methodology and reasoning were applied to one specific area but it seems possible to use it also for other areas of the public sector. Among the professional groups that might be analyzed using a similar method are
lawyers, judges and teachers. Moreover, a whole area of public services such as the public transport or the supply of energy could be analyzed using the outlined method.

9. Equations

The equations used to describe the ambulatory sector are:

\[
\begin{aligned}
    \text{FKSN} &= k_0 + k_1 \ast \text{B060} + k_2 \ast B7575 + k_3 \ast \text{AMCI} \\
    \text{TEAMN} &= a_0 + a_1 \ast \text{FKSN} \\
    \text{ATOTSZ} &= a_{t0} + a_{t1} \ast \text{TEAMN} + a_{t2} \ast \text{ATOTSZ}(t-1) \\
    \text{RPRAK} &= r_{p1} \ast \text{TOT} + r_{p2} \ast \text{RPRAK}(t-1) \\
    \text{FKSN} &= \frac{\text{FKS}}{\text{TOT}} \\
    \text{TEAMN} &= \frac{\text{TEAM}}{\text{BIPN}} \\
    \text{RPRAK} &= \frac{\text{PRAK}}{\text{ATOTSZ}}
\end{aligned}
\]

where

FKS denotes the number of patient contacts,
TEAM denotes total expenditures in the ambulatory sector,
ATOTSZ denotes the number of doctors working in their own practice excluding dentists,
PRAK denotes the number of practitioners,
B060 and B7575 denote two population groups, younger and older than 60 years, respectively,
AMCI is an ambulatory care price index based on private expenditures in the ambulatory sector,
TOT denotes the population,
BIPN denotes nominal GDP,
the index (t-1) refers to a lag of length 1 of the corresponding variable,
\(k_i, a_{mi}, a_{ti}\) and \(r_{pi}\) are estimated parameters.

The equations for the hospital sector are:

\[
\begin{aligned}
    \text{TEICN} &= t_0 + t_1 \ast \text{FSPN} \\
    \text{FSP} &= f_{sp0} + f_{sp1} \ast \text{B7575} + f_{sp2} \ast \text{B045} \\
    \text{ARZAK} &= a_{t0} + a_{t1} \ast \text{TEICN} + a_{t2} \ast \text{BEL} \\
    \text{FSPN} &= \frac{\text{FSP}}{\text{TOT}} \\
    \text{TEICN} &= \frac{\text{TEIC}}{\text{BIPN}}
\end{aligned}
\]

where

TEIC denotes the expenditures in the inpatient sector,
FSP denotes hospital patients,
ARZAK denotes the need for doctors in the hospital sector,
BEL denotes the number of hospital beds per year,
B045 denotes the population group younger than 45 years.

The equations for dentists are:

\[
\begin{aligned}
    \text{FZ} &= f_{0} + f_{1} \ast \text{B060} + f_{2} \ast B7575 + f_{3} \ast \text{AS} \\
    \text{COSZN} &= c_{0} + c_{1} \ast \text{FZN} \\
    \text{ZAHN} &= z_{p0} + z_{p1} \ast \text{FZ} \\
    \text{FZN} &= \frac{\text{FZ}}{\text{TOT}} \\
    \text{COSZN} &= \frac{\text{COSZ}}{\text{TOT}}
\end{aligned}
\]

where

FZ are the patient contacts of dentists,
AS denotes nominal personal income,
COSZ denotes the costs for the insurance
References

Fleissner, Peter (1977), Sozialkybernetik im Gesundheitswesen, Österreichische Akademie der Wissenschaften, Wien.

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