Regional Quantity, Productivity and Efficiency Measures of the Swiss Health Care System

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1. Introduction

In Switzerland, there are substantial differences in per capita health care costs across cantons yielding large regional disparities in premiums paid for mandatory health care insurance.

The scope of the present paper is to first break down the cantonal cost differences into quantity and price effects and thereby to analyze to what extent cost differences are due to high prices or to large quantities. Since health care schemes comprise a variety of different health care services, quantity and price measures must be calculated and expressed as quantity and price indices. To our knowledge, such a procedure has never been conducted in Switzerland.

In a next step, the resulting output indices are combined with input indices to calculate cantonal productivity measures for all health care services together and for the subset of hospital services, respectively.

Finally, data envelopment analysis (DEA) is applied to construct efficiency measures and to separate pure technical inefficiency from possible scale inefficiencies of the cantonal hospital services.

In Switzerland, productivity and efficiency analysis of the health care sector have been undertaken by Steinmann and Zweifel (2003) as well as by Fillippini and Farsi (2004). These studies, however, focus on hospital services alone and on the assessment of hospitals as service producing entities. A spatial perspective, on the other hand, is found in many international studies, where input is often measured as public expenditure (see, for example, Afonso, Schuknecht and Tanzi, 2005). A notable exception is Afonso and St. Aubyn (2005) who

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infer health efficiency scores for OECD countries on the base of physical inputs and outputs. The present paper adopts the physical notion of productivity and efficiency by aggregating inputs and outputs to indices and applying it to the spatial entities of Swiss cantons.

The paper is structured as follows. The next section describes the data used in the calculations and explains how it was adjusted to be in line with the purpose of the study. The results in terms of quantity and price indices, productivity measures and efficiency scores are presented in sections three, four and five. Each of these sections first gives a description of the applied method. Finally, the last section provides a conclusion.

2. Data and Data Preparation

Most of the applied financial health care data stem from the data pool of santésuisse, the Swiss health insurance association. Since santésuisse only collects information on the mandatory insurance scheme, health care services financed by private insurances are not considered in the present paper. More precisely, the invoice data *(Rechnungsstellerstatistik)* for the years 2004 and 2005 has been used. The two years have been aggregated into one period as the paper aims to identify structural differences between the cantons and no time series analysis is performed. Furthermore, owing to the many non-existing hospital categories in very small cantons, the semi-cantons Appenzell Ausser- and Innerrhoden as well as Ob- and Nidwalden have been merged with St. Gallen and Lucerne, respectively.

2.1 Selection of Health Services

Table 1 exhibits the various health care services included in the assessment and their cost shares relative to total cost financed by the mandatory insurance scheme for the years 2004 through 2005. With this selection, around 18 of a total of 20 billion Swiss francs per year are included. The remaining two billion encompass a variety of services that each feature small cost shares below one percent and the cost of which can not easily be divided into prices and quantities (see section 3 below).

Table 1: Cost Shares of Health Care Services 2004–2005

health care service	cost share
inpatient hospital services	0.24
general practitioners, ambulatory services	0.23
pharmacies	0.14
outpatient hospital services	0.14
nursing homes	0.07
medical practitioners, pharmaceuticals	0.07
physiotherapists	0.02
laboratory services	0.02
home care *(SPITEX)*	0.02

2.2 Health Care Services across Cantonal Borders

In order to calculate per capita results, special attention needs to be given to the determination of the cantonal population figures. santésuisse generates two sets of statistics, one from the perspective of the insured person *(Versicherungsstatistik)* and one from the care provider's perspective *(Rechnungsstellerstatistik)*. Since only the latter allows inferring prices and quantities for inpatient hospital services, all results are derived from this statistic. However, when using these figures, it must be remembered that care providers such as hospitals and medical practitioners not only offer services to the resident population but also across cantonal borders. Dividing the cantonal cost of care providers by the number of the resident population, therefore, yields biased per capita results. For example, per capita measures would be too high for a canton that provides medical treatment for a large proportion of patients from outside the canton and, consequently, exhibits a positive net export balance in health care services. To correct this bias, a matrix of inter-cantonal service flows is used to convert the resident population into the "medically cared for population". Per capita measures, then, are calculated as cost and quantities per medicated population.

2.3 Subsidies for Inpatient Hospital Services

In Switzerland, public hospitals are subsidized by the cantons. Therefore, health insurances only finance a part of total inpatient hospital costs. By the same token, santésuisse data do not reflect the full costs and must be complemented by cantonal subsidies. Table 2 shows that these subsidies – as a fraction of the total costs – add up to more than 50 percent in all cantons.[1] Moreover, the shares vary substantially from canton to canton, with less than 60 percent in the cantons Basel-Land, Schwyz and Uri and more than 70 percent in Jura, Geneva and, distinctively, Neuchâtel.

Due to the differing subsidy shares, the price indices also vary strongly when calculated with net prices without cantonal subsidies or with gross prices including subsidies. In the following it is concentrated exclusively on full cost measures.

3. Price and Quantity Indices

3.1 Methodology

In order to calculate price and quantity indices the cost of each health care category must be expressed as the product of price and quantity. For all out-patient services, the distinction of price and quantity is already given by the Swiss medical tariff scheme *(Tarmed)* which has been in force since 2004. The scheme assigns each medical service a number of tax points *(Taxpunkte)* which, in our study, are taken as quantities. The medical costs are then determined by multiplying tax points by so called tax point values *(Taxpunktwerte)*. Tax point values differ from canton to canton and serve as prices in our index calculations.

No comparable system is in force yet for inpatient hospital services. Instead, we chose a hospital day per hospital category[2] as a quantifiable unit. This is the smallest standardized quantity that can be inferred from the santésuisse data pool. The corresponding price for each hospital class can then be calculated as the cost per inpatient hospital day. The same procedure is applied to nursing homes.

1 The data on subsidies are taken from: FEDERAL STATISTICAL OFFICE, Nettofinanzbedarf der Kantone und Gemeinden für die Krankenhäuser (2004 and 2005). A more comprehensive description of the full cost calculation, particularly with respect to private hospitals, is given in SCHLEINIGER, SLEMBECK and BLÖCHLIGER (2007).

2 There are ten different hospital categories considered. Together with the eight remaining services of table 1 the indices are based on a basket with 18 distinct services.

Table 2: Cantonal Subsidies for Inpatient Hospital Services as a Share of Total Costs

Canton	abbreviation	subsidy share
Basel-Land	BL	0.58
Schwyz	SZ	0.58
Uri	UR	0.59
Basel-Stadt	BS	0.60
Zurich	ZH	0.60
Solothurn	SO	0.60
Thurgau	TG	0.60
St. Gallen, Appenzell Ausser- and Innerrhoden	SG AR AI	0.60
Aargau	AG	0.61
Glarus	GL	0.62
Vaud	VD	0.62
Fribourg	FR	0.62
Zug	ZG	0.63
Lucerne, Ob- and Nidwalden	LU OW NW	0.64
Grison	GR	0.64
Ticino	TI	0.65
Schaffhausen	SH	0.65
Valais	VS	0.66
Bern	BE	0.68
Jura	JU	0.71
Geneva	GE	0.72
Neuchâtel	NE	0.77

Finally, it is assumed that prices for pharmaceuticals and for laboratory services are the same in all cantons. Thus, the quantities can be determined by setting the prices equal to one in all cantons.

With these price specifications, the cantonal price indices presented below vary because of different tax point values and due to different implicit prices of inpatient days in hospitals.

3.2 Results

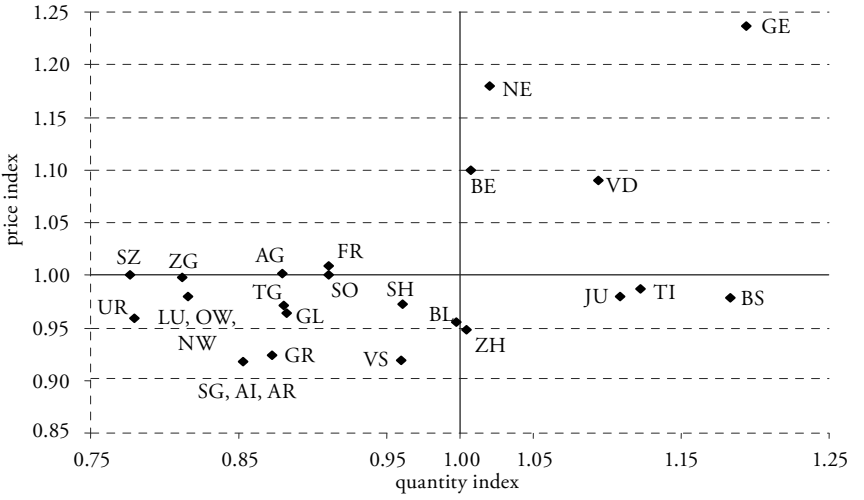
Table 3 displays the Laspeyres price index, the Paasche quantity index per capita and, the product of the two indices, the value index per capita for all considered mandatory health care services.[3] Note again, that the calculations are based on gross costs including cantonal subsidies to hospitals. The results, therefore, depict the economic view as opposed to the narrower insurers' perspective.

Table 3: Price, Quantity and Value Indices of all Mandatory Health Services 2004–2005

Canton	price index	quantity index	value index
UR	0.9595	0.7795	0.7479
SZ	1.0003	0.7763	0.7766
SG AI AR	0.9188	0.8534	0.7841
LU OW NW	0.9799	0.8157	0.7993
GR	0.9238	0.8724	0.8060
ZG	0.9983	0.8123	0.8109
GL	0.9645	0.8830	0.8516
TG	0.9711	0.8808	0.8554
AG	1.0016	0.8797	0.8811
VS	0.9199	0.9605	0.8836
SO	1.0007	0.9115	0.9122
FR	1.0091	0.9114	0.9196
SH	0.9730	0.9609	0.9350
ZH	0.9483	1.0048	0.9528
BL	0.9554	0.9980	0.9535
JU	0.9796	1.1086	1.0859
BE	1.1000	1.0070	1.1076
TI	0.9872	1.1226	1.1082
BS	0.9784	1.1830	1.1574
VD	1.0898	1.0938	1.1921
NE	1.1800	1.0206	1.2043
GE	1.2363	1.1938	1.4759

3 The applied method belongs to the so called group of star methods, because all observation are compared to an artificial mean, which, in the present case, stands for the national mean of all cantons. For a taxonomy of multilateral indices, see HILL (1997).

Figure 1: Price-Quantity Diagram of Mandatory Health Services 2004 and 2005



Again, the large differences between the cantons are striking. The range of the value index amounts to 73 percentage points; with per capita costs in Uri only half as high as in Geneva. Furthermore, the variance of the quantity index is more than twice as large as the price index variance, indicating that per capita cost differences can, for a substantial part, be explained with different quantities per capita. However, the price variance is far from zero and thus also contributes to the cantonal cost differences.

The particulars of each canton can best be discerned in the price-quantity diagram depicted in figure 1. The diagram clearly shows the relative position of each canton and the clusters of cantons with similar price/quantity indices.

Starting with high cost cantons, Geneva and, to a lesser degree, Vaud, both exhibit (per capita-) quantities and prices well above the Swiss average. Neuchâtel, Berne, Basel-Stadt, Ticino and Jura also have high costs. However, while in Neuchâtel and Berne this is due to the high prices, in Basel-Stadt, Ticino and Jura it is the large quantities which are largely responsible for the high costs.

At the other end of the price-quantity spectrum, we have the eastern Swiss cantons of Grison and St. Gallen together with Appenzell. These exhibit low costs due to both low prices and small quantities. The central Swiss cantons Uri, Schwyz, Lucerne with Unterwalden and Zug have low costs too, but solely due to quantities distinctively below average.

More generally, figure 1 also shows a positive correlation of prices and quantities across cantons. The combination of high prices and little quantities or low prices and large quantities does not exist.

4. Productivity Measures

4.1 Methodology

Generally, productivity measures the ratio of physical output to physical input. While input clearly stands for production factors, the notion of output is more ambiguous, particularly with respect to health care services. Ultimately, health care aims to improve the patient's state of health. However, such a concept of output is difficult to assess. FILIPPINI and FARSI (2004, p. 4) discuss a series of alternative output measures for hospital services, such as number of patient days, cases treated and DRG-adjusted cases.[4] STEINMANN and ZWEIFEL (2003, p. 364) call these measures managerial output as opposed to the social output of improved health condition[5]. With the available data, the present study is confined to the use of managerial output and, as noted before, in the case of inpatient treatment, to clinical days per hospital category.

When determining productivity it must be remembered that most production entities use multiple inputs and produce more than one output. One way to tackle this problem is the use of index numbers as productivity measures[6]. Productivity, then, is calculated as the ratio of a quantity output index to a quantity input index.

Regional output indices for all mandatory health services have already been calculated and presented in section 3 of this paper as Paasche quantity indices. It remains to determine the corresponding Paasche input indices. Ideally, an input index is determined by partitioning the total cost of each health care service into its factor shares. Then, the factor cost must be further divided into factor prices and quantities. Unfortunately, the limited data available makes it difficult

4 DRG stand for diagnostic related groups. With DRG adjustment, the cases treated can be weighted according to their standard average cost. In Switzerland, DRG are not yet in use in all cantons. Therefore, the santésuisse data do not allow its application.

5 For a conceptual review of health indicators, see ETCHES, FRANK, DI RUGGIERO and MANUEL (2006).

6 An overview of index numbers as productivity measures is given in COELLI, RAO, O'DONNELL and BATTESE, chapter 4.

to implement such a procedure without compromising. On the other hand, the relative scarcity of data poses no problem for factors or inputs with equal prices across all cantons. In this case, the price of the factor or input is selected one for all regions and the quantities are determined accordingly. The assumption of nationally equal prices seems plausible for capital inputs, but not for labor inputs where cantonal price or wage differentials must be taken into account. With these guidelines in mind, the various health care services are handled as follows.

For hospitals and nursing homes the labor cost share is inferred from the health statistics of the Federal Statistical Office. For the two years 2004 and 2005 the cost share amounts to 68 percent[7]. The regional wages for the medical and nursing staff are taken from the Swiss earnings structures survey.[8] The results show wage differences of up to fifteen percent between cantons. For the remaining hospital costs, an equal input price across all cantons is assumed and no further distinction is made.[9]

As mentioned before, the out-patient health services are subject to a standardized medical fee system, which is based on the idea of a time tariff. Hence, the tax point values, interpreted as prices when calculating output indices, can also be taken as wage indicators.

Finally, pharmaceuticals are again assumed to exhibit equal input prices in all cantons.

4.2 Results

Figure 2 depicts the individual productivity of all cantons. It shows a productivity range from 0.82 in Geneva to 1.10 in Zurich, which indicates that the health care system in Zurich is one third more productive than in Geneva, i.e., with a given input, it produces one third more output. Because of its high output price index (see section 3), the low productivity of Geneva does not come as a surprise. Note that productivity can also be expressed as the ratio of the Laspeyres input price index to the Laspeyres output price index.[10] In the case of Geneva, the input

7 Federal Statistical Office, Krankenhausstatistik und Statistik der sozialmedizinischen Institutionen 2004 and 2005, tables K1 and K3.

8 Federal Statistical Office, Schweizerische Lohnstrukturerhebung 2004.

9 It would be preferable to treat land cost separately, since land prices obviously vary across cantons. However, there is no information on the share of land cost available.

10 This is explained by the equality of the product of Laspeyres input price and Paasche input quantity index on one side and Laspeyres output price and Paasche output quantity index on the other side. Both products yield the same value index.

price index is slightly above average and thus only compensates for a small part of the high output price index. As a consequence, productivity remains low.

Besides Geneva, the cantons Neuchâtel, Bern and Vaud also clearly exhibit below average productivities. On the other side of the range, the cantons Zurich, St. Gallen with Appenzell, Valais, Grison, Basel-Land, Jura and Uri have relative high productivity. The eleven regions in between, from Solothurn to Basel-Stadt, all feature productivity rates close to average with small deviations of less than two percent.

Figure 2: Productivity of Mandatory Health Services 2004–2005[11]

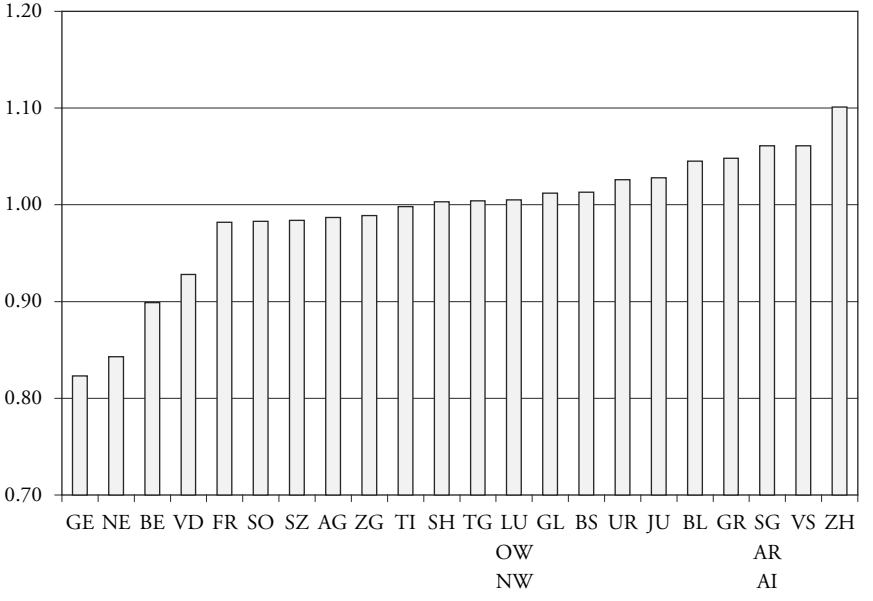
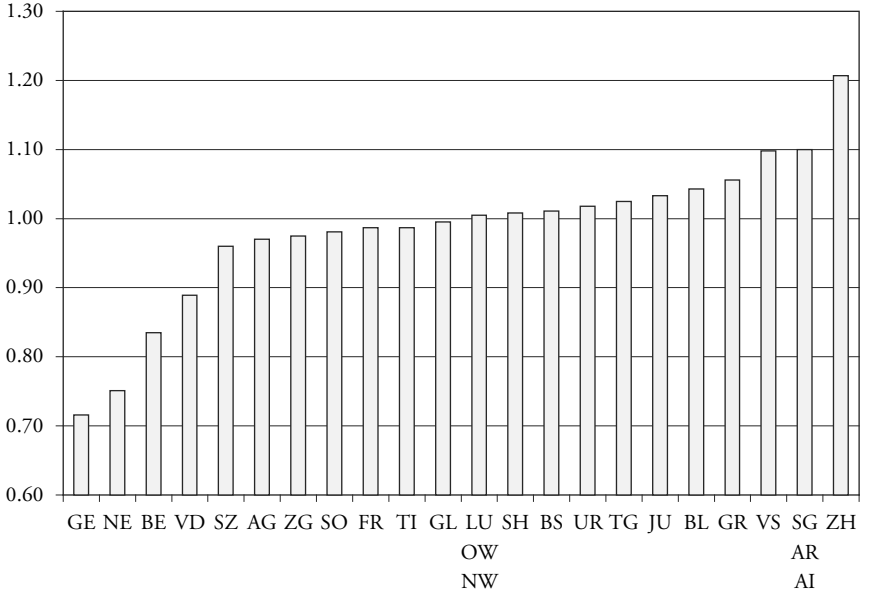


Figure 3 shows the results for the subset of – inpatient and outpatient – hospital services. The picture remains similar to figure 2 but is more pronounced. The productivity of Zurich and Geneva now diverge by almost 0.5 index points. In contrast to Zurich with input hospital prices 5 percent above average, input prices in Geneva are exactly on par with the national average and, hence, do not compensate for high output prices.

11 All results shown in figures are numerically presented in tables A1 and A2 in the Appendix.

Figure 3: Productivity of Hospital Services 2004–2005



The ranking of the other cantons with low productivity, i.e. Neuchâtel, Bern and Vaud, remains unaltered when compared to the results in figure 2. The same pattern also applies to the six cantons with high productivity. The only deviation is the slight change in the order of the cantons with near average productivity. The similarity of figures 2 and 3 follows from the applied procedure assessing quantity indices. The application of the medical tax point system for input as well as output measures of out-patient services implies that regional productivity differentials mainly arise due to corresponding differences in hospital services. Figure 2, therefore, produces a smoothed picture of figure 3.

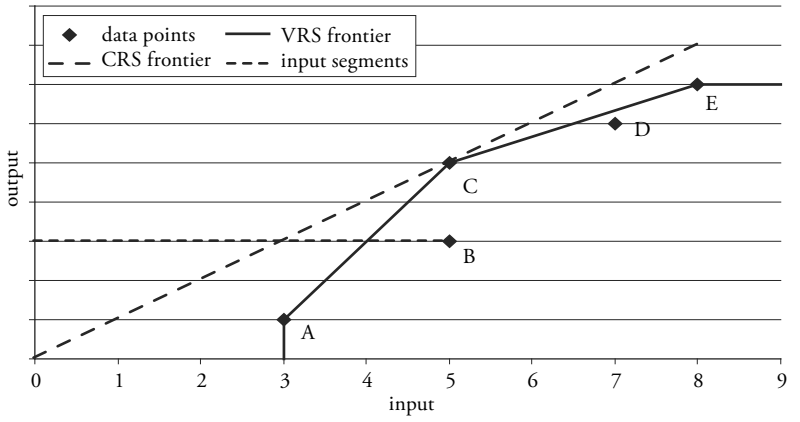
5. Efficiency Measures

5.1 Methodology

Productivity is by definition a size standardized measure. When further analyzing the regional differences in productivity, the question arises to what extent these variations can be explained by the differing size of the surveyed cantonal units, i. e. are economies of scale causing the productivity differentials? But the

discussion on economies of scale focuses on production entities, and it doesn't seem realistic to consider the entire health scheme of a canton as such an entity. However, unlike some of the other areas of the health sector, public hospitals are run and coordinated by the cantons and, therefore, can be regarded as a service generating unit. Consequently, the following efficiency analysis is restricted to hospital services alone.

Figure 4: Data Envelopment Analysis with Constant and Variable Returns to Scale



The applied method is data envelopment analysis (DEA), which constructs efficient frontiers from given observations.[12] First the data sample is depicted in an input-output diagram as illustrated in figure 4.[13] Under the premise of constant returns to scale (CRS), a linear efficient frontier is drawn from the origin to the observation with highest productivity (point C in figure 4). With this assumption, all other units are considered less efficient. Alternatively, an efficient frontier with variable returns to scale (VRS) is drawn as the convex envelope of the sample. In this case, A and E are also efficient. The inefficiencies of B and D can be broken down further into scale inefficiencies and pure technological inefficiencies.

Efficiency scores are measured either input or output oriented. The input oriented efficiency measure expresses the fraction of actual input that is necessary

12 See COELLI, RAO, O'DONNELL and BATTESE, chapter 6, for a short survey on the methodology.

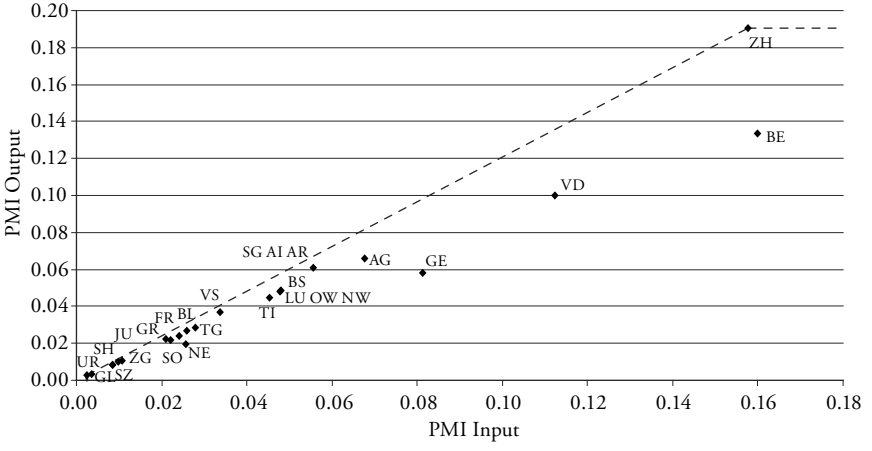
13 The example is based on COELLI, RAO, O'DONNELL and BATTESE, p. 175.

for an efficient unit of production to produce a given output. In the case of point B, the CRS efficiency score equals 3/5 and the corresponding VRS score 4/5 (see input segments in figure 4). The scale efficiency is then (3/5)/(4/5) = 3/4, indicating the remaining inefficiency due to scale effects even if production would take place on the VRS frontier.

5.2 Results

Figure 5 shows the result of data envelopment analysis for cantonal hospital services. Because the CRS and the VRS efficient frontiers almost coincide between Zurich and Uri, only the latter is plotted. As a first general result, the near coincidence of the two frontiers implies that CRS and VRS efficiency scores do not differ strongly and scale effects of regional hospital services are not very important.

Figure 5: Data Envelopment Analysis for Hospital Services 2004–2005



Zurich is the canton with the highest productivity as well as with the largest output. Therefore, the VRS frontier comprises no segment with decreasing returns to scale. By the same token, all other cantons exhibit CRS efficiency scores below one (see table 4). The lowest score of Geneva implies that with a productivity of Zurich and CRS, the same output could be produced with 59.3 percent of the actual input.

Table 4: Efficiency Scores CRS and VRS Hospital Services 2004–2005

Canton	efficiency score CRS	efficiency score VRS	scale efficiency
ZH	1.000	1.000	1.000
SG AI AR	0.911	0.916	0.995
VS	0.910	0.919	0.989
GR	0.875	0.892	0.981
BL	0.864	0.878	0.985
JU	0.856	0.895	0.956
TG	0.849	0.862	0.986
UR	0.843	1.000	0.843
BS	0.838	0.844	0.993
SH	0.835	0.881	0.948
LU OW NW	0.833	0.839	0.992
GL	0.824	0.934	0.883
TI	0.818	0.825	0.992
FR	0.817	0.832	0.982
SO	0.813	0.829	0.980
ZG	0.808	0.844	0.957
AG	0.803	0.807	0.995
SZ	0.796	0.841	0.946
VD	0.736	0.738	0.998
BE	0.692	0.693	0.999
NE	0.623	0.637	0.978
GE	0.593	0.596	0.994

Incidentally the convex VRS frontiers only exhibit two kinks at the smallest canton Uri and at Zurich. Therefore, only small cantons such as Uri, Glarus and, less distinct, Jura, Zug, Schaffhausen and Schwyz feature scale (in-) efficiencies clearly below one. The inefficiencies of the other cantons are, in large part, due to pure technological slacks. Namely the cantons of Geneva, Neuchâtel, Berne and Vaud show low efficiency scores that cannot be explained by scale effects.

6. Conclusions

Cantonal cost differentials of mandatory health care can have two causes: different prices or different quantities. The break down of the cost differentials into a price and a quantity index reveals that in fact both aspects contribute to the substantial per capita cost differentials.

Moreover, the results show a clear positive correlation of prices and quantities. Cantons with relatively high costs feature either large quantities or high prices or both, cantons with low costs, on the other hand, typically exhibit either small quantities or low prices or both. Cantons with high prices and small quantities or with low prices and large quantities do not exist.

While the variance of the quantity index exceeds the price index variance, prices nevertheless differ substantially from canton to canton. This is due to different tax point values of out-patient services and particularly because of the large discrepancies of implicit hospital prices. These prices, calculated as cost per hospital day and hospital category, vary even more when expressed as gross prices, i. e. inclusive the cantonal subsidies. Unequal net prices therefore cannot be explained with regionally different subsidy figures.

High hospital prices also strongly impact on productivity. Since productivity can be expressed as the ratio of the input to the output price index, the effect of high output prices on productivity can be mitigated by high input prices. However, this is not the case for Geneva, Neuchâtel, Berne and Vaud, the four cantons with high output prices. Zurich, on the other hand, exhibits output prices below average and at the same time relatively high input prices, which renders it the canton with the clearly highest productivity.

Finally, data envelopment analysis discloses a near coincidence of the frontiers with constant and variable returns to scale. Therefore, productivity differentials, for the most part, cannot be explained by scale effects. Apart from the large canton of Zurich, there are also many small cantons with higher productivity than Geneva, Neuchâtel, Berne and Vaud.

Appendix

Table A1: Output, Input and Productivity All Obligatory Health Services 2004–2005

Canton	productivity	quantity index output	quantity index input
Aargau	0.987	0.063	0.064
Bern	0.899	0.131	0.146
Basel-Land	1.045	0.030	0.029
Basel-Stadt	1.013	0.044	0.043
Fribourg	0.982	0.027	0.027
Geneva	0.823	0.066	0.080
Glarus	1.012	0.004	0.004
Grison	1.048	0.022	0.021
Jura	1.028	0.009	0.009
Lucerne, Unterwalden	1.005	0.048	0.047
Neuchâtel	0.843	0.022	0.026
St.Gallen, Appenzell	1.061	0.063	0.059
Schaffhausen	1.003	0.009	0.009
Solothurn	0.983	0.027	0.028
Schwyz	0.984	0.011	0.011
Thurgau	1.004	0.028	0.028
Ticino	0.998	0.047	0.047
Uri	1.026	0.003	0.003
Vaud	0.928	0.099	0.106
Valais	1.061	0.037	0.035
Zug	0.989	0.011	0.012
Zurich	1.101	0.183	0.166

Table A2: Output, Input and Productivity Hospital Services 2004–2005

Canton	productivity	quantity index output	quantity index input
Aargau	0.970	0.066	0.068
Bern	0.835	0.134	0.160
Basel-Land	1.043	0.027	0.026
Basel-Stadt	1.011	0.049	0.048
Fribourg	0.987	0.024	0.024
Geneva	0.716	0.058	0.081
Glarus	0.995	0.004	0.004
Grison	1.056	0.022	0.021
Jura	1.033	0.010	0.010
Lucerne, Unterwalden	1.005	0.048	0.048
Neuchâtel	0.751	0.019	0.026
St.Gallen, Appenzell	1.100	0.061	0.056
Schaffhausen	1.008	0.009	0.009
Solothurn	0.981	0.022	0.022
Schwyz	0.960	0.008	0.009
Thurgau	1.025	0.029	0.028
Ticino	0.987	0.045	0.045
Uri	1.018	0.003	0.003
Vaud	0.889	0.100	0.112
Valais	1.098	0.037	0.034
Zug	0.975	0.010	0.011
Zurich	1.207	0.190	0.158

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SUMMARY

In Switzerland, there are substantial cantonal differences in per capita cost of the mandatory health care system. The present paper breaks these differences down into price and quantity effects revealing both, a large quantity and a somewhat smaller price variance across cantons. As a statistical fact, a positive correlation of price and quantity index results.

Dividing the inferred quantity output index by a corresponding input index yields a measure of total factor productivity. While the canton of Zurich exhibits the highest productivity, the measures in Geneva, Neuchâtel, Berne and Vaud are far below average.

Finally, a data envelopment analysis of hospital services shows little evidence for variable returns to scale implying that low productivities are, for the most part, due to pure technological slacks.