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ORIGINAL RESEARCH

Incentives of Health Care Expenditure

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ABSTRACT

The incentives of health care expenditure (HCE) have been a topic of discussion in the USA (Obama reforms) and in Europe (adjustment to debt crisis). There are competing views of institutional versus GDP (unit income elasticity) and productivity related factors of growth of expenditure. However ageing of populations, technology change and economic incentives related to institutions are also key drivers of growth according to the OECD and EU's AWG committee. Simulation models have been developed to forecast the growth of social expenditure (including HCEs) to 2050. In this article we take a historical perspective to look at the institutional structures and their relationship to HCE growth. When controlling for age structure, price developments, doctor density and in-patient and public shares of expenditures, we find that fee-for-service in primary care, is according to the results, in at least 20 percent more costly than capitation or salary remuneration. Capitation and salary (or wage) remuneration are at same cost levels in primary care. However we did not find the cost lowering effect for gatekeeping which could have been expected based on previous literature. Global budgeting 30 (partly DRG based) percent less costly in specialized care than other reimbursement schemes like open contracting or volume based reimbursement. However the public integration of purchaser and provider cost seems to result to about 20 higher than public reimbursement or public contracting. Increasing the number of doctors or public financing share results in increased HCEs. Therefore expanding public reimbursement share of health services seems to lead to higher HCE. On the contrary, the in-patient share reduced expenditures. Compared to the previous literature, the finding on institutional dummies is in line with similar modeling papers. However the results for public expansion of services is a contrary one to previous works on the subject. The median lag length of adjustment is 6.6 years or 26 quarters for countries to move half way to the eventual equilibrium in HCE/GDP-ratios in response to a shock in demand factors which indicates "hysteresis" in demand.

Keywords

Health care expenditure; OECD; System; Performance; Econometrics

INTRODUCTION

Health policy and health systems are designed to deliver health services to provide for the general population's health needs. These create health benefits (increases in longevity, QALY and decreases in Pyll and amendable morbidity etc. population health gains) and costs in form of national health care expenditures (HCEs). In the demand for health model, inputs (staff, capital, intangible assets, etc.) are turned into intermediate outputs (doctor visits, hospital days, examinations and tests, etc.) according to the production function of health. Health (utility) effects are the final outputs or results of this process [1,2].

There has been quite a considerable number and amount of research effort on cross-country studies with cross-sectional data [3-7]. The results of these studies show that national income seems to be the most important determinant of HCE expenditures. The income elasticity of demand has been estimated to be close to unity. These results were later replicated for panel data [8] and similar results appeared. In addition to this relationship, the institutional arrangements, health care prices, technology and its advances and hospital structures of health care systems should have an impact on health expenditures for health policy to be effective in this context, but they resulted much smaller in scale [8]. These studies were however limited by small sample size, supplier induced demand, omitted variables and the implicit assumption of homogenous effects of explanatory variables across countries.

On the other hand the health care country studies with panel data have most often con-

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centrated on co-integration and unit root studies for intra-country or cross-country time series data of HCE, GDP and their statistical interaction. Results on the relationship of co-integration between HCE and GDP are quite mixed (for full discussion see [9]. Some studies seem to find unit roots in HCE and GDP time series with varying findings (yes or no) of a co-integration vector present between the two [10,11] but these were quickly reversed by contradictory evidence with different test methods declaring no unit roots [12]. The same seems to apply to co-integration considerations [12]. The power of co-integration and unit root tests and their general test design seem to greatly influence results making consensus of co-integration time series, cross-country analysis of income elasticity of health care demand seemingly very difficult. One of the latest study by Dreger [13] using latest co-integration techniques find that a co-integration vector exist and that the income elasticity of health expenditures is unity (equal to one) and this result is robust to statistical testing and different model specification. The other explanatory variables controlled are medical progress, life expectancy, infant mortality and share of old age population [13].

However there is less literature on health care system characteristics on health care costs done with long panels and flexible nonlinear models. This paper aims at bringing a significant contribution to this field of study following the study on effects of institutional variables on HCEs as introduced and estimated by Gerdtham et al. [9,14,15]. Many of the key research questions here are similar to thhose that can be found in Gerdtham et al. [9]. The difference here is that the ratio of HCE to GDP is the dependent variable not HCE in itself and the estimation method is nonlinear due to partial adjustment of expenditures.

As a sketch and short preliminary motivation for our analysis one can use Figure 1, according to which it seems that the level of health care spending is lower in publicly financed systems. The countries are grouped so that five year intervals from 1975 to 2005 are used and aggregation into country groups are formed based on OECD's recent working paper on system characteristics [9,16]. In Figure 2, the relationship between public funding and health care GDP share is plotted by five year intervals in a scatter diagram. This is an illustrative and descriptive sketch of the situation in which countries are strongly divided by financing source, financing form and service delivery into more public or more private systems. The correlation coefficient in the chart is quite high (r = -0,6, r-squared = 0.36).

As a general rule, health care systems can be divided into three broad categories by system type [9,14,15]:

- category 1 consists of public systems (both financing and services);
- category 2 consists of mixed systems (either financing or services private);
- category 3: market based systems (privately funded and private service providers).

When we talk of public finance we mean state, local authority or social insurance funding of services that are financed by taxes or compulsory health or social insurance. Private funding is by out-of-pocket payments, private insurance policies and other of such arrangements. A more detailed description of OECD countries health system institutional characteristics is given in Gerdtham and Paris [9,16], and we use this system to classify the countries into the three categories listed above and further into country groups for the regression analysis.

Public production of services can be organized and produced by the state or local authority (or third sector) level with the requirement that it is non-profit and strictly regulated by legislation on service production. Private services on the other hand are for-profit and less regulated. However the boundaries are not always easy to find and there are public-private mix in-between service forms [17]. Specific criteria on system dummy variables

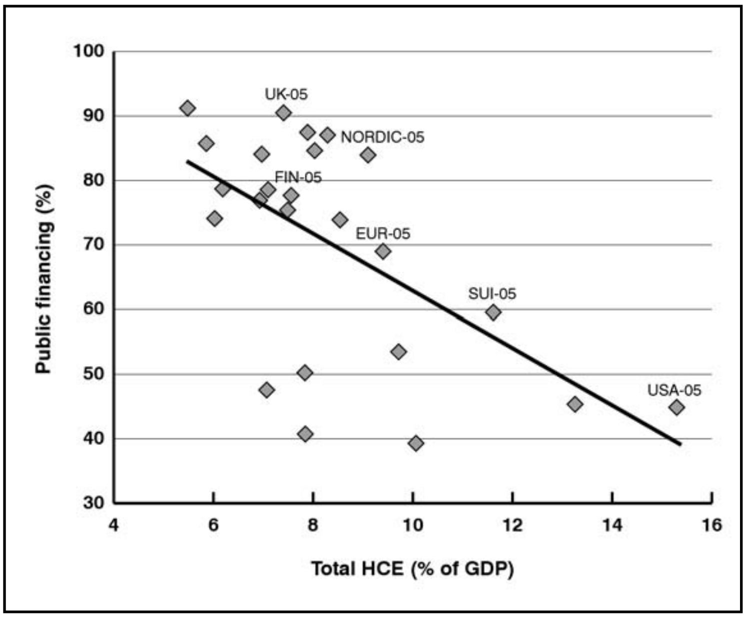

Figure 1. *Percent of health care expenditure by public financing and total health care expenditure (HCE) in selected OECD countries 1975-2005 (% of GDP).Source: OECD Health Data 2007, OECD. Western Europe (EUR): the Netherlands, France and Spain. Nordic countries (NORDIC): Norway, Sweden, Denmark (country group averages) [17]*

applied to data can be found in Gerdtham [9,14,16].

The health care sector in Europe is mostly publicly funded and financed, in contrast to other countries across the Atlantic and Pacific. For example in Finland the public sector accounts for 77 percent of health care funding and in other Nordic countries the share is roughly 85 percent. In contrast the corresponding public shares are 62 percent in the Netherlands, 59 percent in Switzerland and 45 percent in the USA in 2005. These figures have changed since then so that the three countries (NL, SUI, USA) have come closer or even above the 50-50 ratio public and private mix with public share increasing in 2010 [18]. The movement has been rapid from private to public financing schemes. In the Netherlands the development towards public financing has been most rapid [16,18]. An example of this is The Affordable Care Act enacted in 2011-2012 that will get about 30 million people to compulsory insurance in the USA (http://www.healthcare.gov/law/index.html).

Financial incentives and institutions play a key role in determining health care expenditures [7,15,19]. The financing is through taxes and service provision by public hospitals and health centers in the Nordic countries. The Nordic countries health care, together with the UK, are called public integrated systems [9]. In contrast the corresponding public shares are close to or below 50 percent with finance through reimbursement and insurance policies in the Netherlands, in Switzerland, and especially in the USA. In all these latter three countries the systems are still in many respects private insurance based and services are provided by private hospitals and clinics. However the Medicaid and Medicare programs for the lower socio-economic persons and older people in the US are publicly financed (mixed reimbursement).

According to Paris et al. and Gerdtham et al. [9,16] we can classify health systems based on their public-private mix, financing source, financial incentives and service delivery. This defines Nordic versus Netherlands, Switzerland and USA as two study groups with the third consisting of UK, Spain and France. Using the three categories based on OECD classification we roughly divide the countries into the following groups [16]:

1. Finland, Denmark, Sweden, France the UK and Spain;
2. The Netherlands;
3. The United States and Switzerland.

Figure 2 depicts the rapid growth of health care cost as a share of GDP in selected OECD-countries and country groups from 1975 to 2005. It is essential to note the rising trend that is presented in each of the groups (Finland is the author's home country and for domestic point of view reasons separated from the other Nordic countries). This means that an increasing fraction of the national economy's resources have been devoted to health and health care over the past three decades [17]. For example, the level of health spending was roughly 10 percent in OECD countries, 9 percent in the Nordic countries and 8 percent in Finland in 2007. These figures have been rather stable for the past five

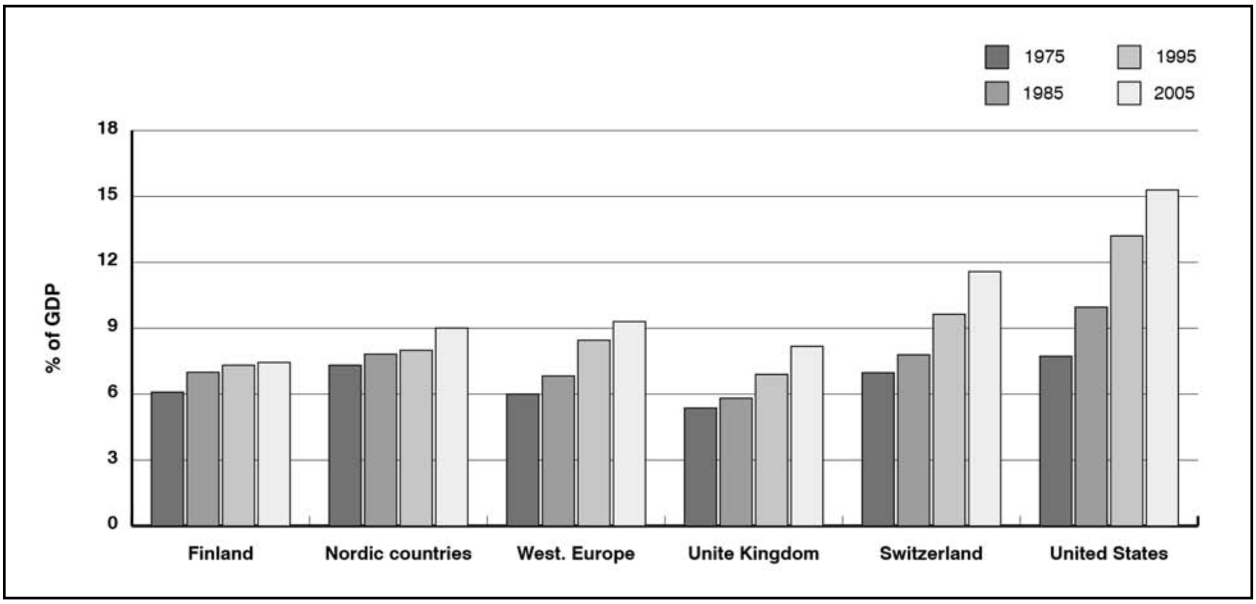

Figure 2. *Total health care expenditure (HCE) in selected OECD countries 1975-2005 and country groups (% of GDP). Source: OECD Health Data 2007, OECD. Western Europe (EUR): the Netherlands, France and Spain. Nordic countries (NORDIC): Norway, Sweden, Denmark (country group averages) [17]*

years up until 2010 when Finland totaled 8.9 percent and the OECD average was 9.5. Public HCEs have increased both nominally and in deflated terms during this period according to OECD health policies and information by the data division latest bulletin outpacing private demand increases [18,20].
Due to ageing population and advances in medicine and medical sciences, the costs of health care are expected to rise markedly and rapidly in OECD countries in the coming years in western and developed OECD countries [21]. Health spending per capita averaged 3268 US$ PPP per capita and increased on average across OECD countries by 3.5% in 2010 data. Public spending on health grew even faster, at an average 4.1% in 2009. In comparison private spending also continued to increase in most countries, but at a slower pace. The total HCE spending extremes in our data are the USA with 8233 US$ PPP per capita and Spain with 3076 US$ PPP per capita in 2010 [18].
In economic discussion related to health care policies the focus is usually on cost and cost-effectiveness analysis. The benefits of improved public health through health promotion and health care services is relatively much harder to measure accurately. Indicators such as life expectancy, infant mortality and measures of morbidity such as disability pensions and use of medicine are most commonly used.
The effects of health care and health promotion on functional and working capabilities of the adult population are evident only in the long run in the form of lower morbidity, sickness and disability. Growing attention is paid to the reduction in socio-economic health differences. The National Institute for Health and Welfare (THL) estimated in 2007 that morbidity, sickness and disability are the cause of half a million potential working years lost and related to 5 to 6 billion Euros or about a third of national health care costs (in 1995 prices) [22]. The impact of the habit related diseases (smoking, alcohol abuse, lack of exercise) on health care costs is estimated to be one billion Euros annually. Some key health indicators and their changes are shown for the Nordic countries in Figure 3.
The key to understanding Figure 3 is looking at the differently shaded areas within countries not the totals of country "basement-roof" graphs as a whole. Those areas under the 0-line are possible reduction in morbidity and mortality (not necessarily negative developments in general health status). For example in Finland cerebrovascular diseases have decreased by roughly 20 percent, alcohol consumption has increased by 20 percent and overweight population by roughly 10 percent (adding up these doesn't make sense). No adding up style cross-country comparisons should be drawn from this figure although the development of chosen health has been quite similar in all Nordic countries.

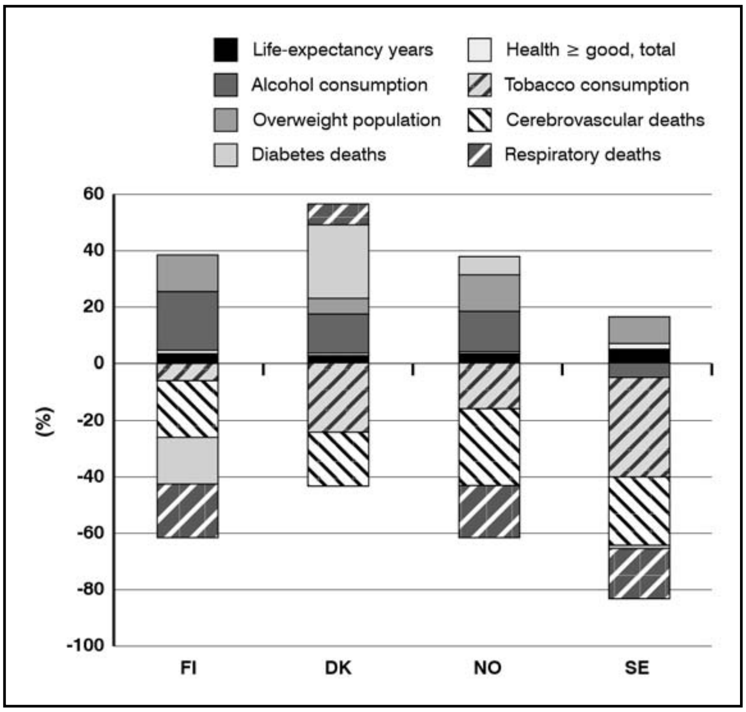

Figure 3. *Change in selected health indicators, annual %-change, Nordic countries, 1970-2005. Source: OECD*

RESEARCH AGENDA

The model variables (both endogenous and exogenous) used in this article are based on the previous work and articles by Gerdtham et al. [9,14,15] on health care expenditure in OECD-countries. Our focus is on reporting the effects of system characteristic variables on HCEs. The estimation plan is to estimate a static model by backward selection to find the variables of statistical significance related to the analysis of HCE as a share of GDP in the first stage. In the second stage these variables are then used as explanatory variables in the dynamic equation on the variable to be explained that is the HCE per GDP-share.
For institutional arrangements it has been found in previous literature that capitation budgeting of GPs and gatekeeping arrangements are cost saving in country comparison studies for out-patient level care [14]. The same has been found for global budgeting of specialized care [15]. More developed DRGs in specialized care and/or global hospital budgeting may be needed to ensure high quality care with cost-control measures in in-patient care [14,15].

The following questions and hypothesis are to be tested in this article:

1. How do the budgeting and remuneration models, i.e. global budgeting (GLO) in specialized care and fee-for-service (FFS) in primary care, affect health care spending (HCE)? Are these factors sensitive to model selection procedures?
2. How does the public share of health care spending affect total spending? And has its the impact changed?
3. How do other factors, such as exogenous technological change, relative prices of health care and the growth of the health care profession affect HCE spending?

In this article a dynamic regression model is specified to model variation in within and between panel data variation of HCE expenditure. Nonlinear econometric model of HCE expenditure with country and time specific adjustment is provided. The model has been previously applied to labor demand studies in Sweden, Finland and Estonia. However the model is applicable to a wide variety of estimation problems where adjustment costs are nonlinear and lags of the dependent variable are of importance. For further details on methods see [23-25] and Appendix.

In the econometric model the health care financing and services structure is captured by five indicator (dummy) variables. The FFS-dummy is a fee-for-service indicator that captures the effect of the insurance and co-payment system by classifying the countries in two categories based on fee-for-service policies in outpatient care. The GLO-dummy is a global budgeting indicator that captures the effect of specialist care hospital budget constraint and few channel funding. The CAP-dummy captures the out-patient capitation effect as opposed to salaries or fee-for-service. The GATE-dummy does the same for gatekeeping in primary care. The PUBINT-dummy accounts for a closed shop arrangement where the services are provided and financed by public authority as opposed to contracting or reimbursement arrangements. Thus the indicators capture the structure of remuneration and financing of health care, i.e. the link between health care systems and their financing: economic evaluations of global budgeting and fee-for-service payment systems. To summarize as in Gerdtham [15] fee-for-service and non-global budgeting system are more open-ended ones. And those with capitation accompanied by gatekeeping and global budgeting or public integration are more closed ones.

As to the data for a reasonable comparison of these three groups long time series have been obtained for at least one country representing each of these groups. This is not an easy task and therefore countries with large disparities or shortcomings in the OECD data period have been omitted. Thus we have the 10 selected countries for years 1970 to 2005. Note that no developing economies, transitional economic countries are present in our analysis. The other thing to note is that we have included in our data European countries (western, mostly EU) and the USA. Therefore the homogeneity of the study data measured by GDP is reinforced. If one looks at the details in Paris et al. [16], it is quite obvious that pooling of developing and developed countries and imposing same econometric model structures could and probably would be a big mistake.

Our interest in this paper is the point of view taken in the research papers by Culyer [19], Leu [7] and especially Gerdtham [14,15]. They have come to the conclusion that HCE costs are not so much dependent on the financing sector aspect (state vs. private) but on the type as characterized by open ended or closed system (public integration, fee-for-service, global budgeting) or in between these two and other key institutional arrangements (capitation, gate-keeping). **We estimate two dynamic regression models that test for the statistical significance of system parameters in panel data**. The trend growth in expenditures is taken into account by including a full set of country group dummies and time trend.

The idea in this paper is to test and see whether the incentives to develop and guide the services as well as exercise cost-controls are best managed in a system where the financiers and service providers operate in the same contextual framework and structures (municipality, county, state, third sector or other organization). **In this article it is investigated whether the points made by Culyer [19] and Leu [7], that closed systems may be better for cost-control than open ended systems, are valid**. As an example of closed system one can mention Finland and Sweden where outpatient and inpatient care are publicly financed and delivered with a minor (although growing) role for co-payments and insurance schemes. On the other hand countries such as the Netherlands, Switzerland and the USA represent open ended health care systems with multiple source (mostly private) financing schemes and multiple sources service delivery.

According to Leu [7], total HCE increases with public share of funding of finances because the relative price faced by the consumer is heavily subsidized and the budget constraint of the individual service user based on co-payments, hospital fees and private medical costs on pharmaceuticals are highly cost-shared by the state. Therefore we investigate a fee-for-service dummy in primary (basic) care and global budgeting in specialized care system dummy as in Gerdtham [14]. Culyer [19] on the other hand points out that the financing sector is too passive in fee-for-service systems and has to rely on asymmetric information when making decisions. This poses moral hazard problems for the service provider. Thus the service provider has less incentives for over-care of patients or for example grouping higher diagnosis related group or DRG-classes than needed (DRG-drifting). The pay-for-performance schemes like diagnosis related groups (DRGs) are comparable for example to the Prometheus-model for hospital remuneration in the US [26,27].

The interest is on investigating the effect of institutional arrangements or in this case financial variables on supply of health care services as in Gerdtham [14,15]. The interest in this paper is on time period, country and regional variations[1]. We investigate a gatekeeping dummy in the paper among other system variables. This awards special attention for it is found to be a major contributor to HCE spending in Gerdtham et al.'s paper [14]. Turning to the effects of gatekeeping in the Swiss articles by Dreger and Reimers [13] and Lehner [28], the characteristics of outpatient gatekeeping practices are thoroughly estimated by random trial study designs. Especially in the article by Lehner [28], the characteristics of gatekeeping and fee for service beneficiaries were largely similar. Unadjusted total costs per person were 8 percent lower in the gatekeeping group. After multivariate adjustment, the estimated cost savings achieved by replacing fee for service based health insurance with gatekeeping in the study population amounted to savings of 15-19 percent per person in local currency. Some selection effects were detected but did not substantially influence the result.

In the article by Lehner, Preiswerk et al. [28] the characteristics of gatekeeping and fee for service beneficiaries were largely similar. Unadjusted total costs per person were Sw fr231 (8%) lower in the gatekeeping group. After multivariate adjustment, the estimated cost savings achieved by replacing fee for service based health insurance with gatekeeping in the source population amounted to Swfr403-517 (15-19%) per person. Some selection effects were detected but did not substantially influence this result. Also in Etter's article [29] introduction of gatekeeping and budget management by physicians caused a favorable self selection process for the university plan. In addition, the managed care plan achieved a substantial decrease in overall health care expenditures in its first year of operation, chiefly by reducing outlays for technical procedures (laboratory tests, physical therapy, drugs) decreased most in the university plan. No impact on hospital admissions was detected.

For an example of HCE growth, the US based Medicare and Medicaid insurance policies have grown in customer fees and insurance premiums considerably in recent years (insurance premiums and fees-for-services have increased). This might have had a increasing effect on HCE. This has been explained in the literature by considerable market power of providers and the lack of incentives to promote cost-controls in health care services (OECD 2006[2] and Altman [26]). The same picture is shaping up in the Netherlands where insurance companies face oligopolistic markets and find contracting of services difficult with respect to quality and incentives for cost-efficient care. If public providers are complained of trying to maximize budget shares then it is evident that private providers that are quoted in the stock-market have probably even more incentives for maximizing profits and shareholder value. Health care reform is an active issue on the political agenda in many countries. In the USA the Obama health reform plan and its related legislation changes have passed Congress by 2010. There are also newly enacted major legislative changes in the Netherlands. In the Finnish government's proposal the Health care act is to be given to parliament in 2010.

Based on the research literature on country comparisons (especially on remuneration and financing systems of out-patient care and hospital care). As in Gerdtham [14,15], we estimate nonlinear regression models to test for system characteristics effects. What is new to previous studies is the flexible functional form and adjustment cost considerations that

[1] In this article the relationships between variables is investigated by means of regression, correlation and descriptive analysis that may (but not necessarily) reflect causal relationships. For a causal effects analysis refer to following articles on Swiss health care reform: [28,29].

[2] Health care reform is an active issue on the political agenda in many countries. In the Finnish government's proposal the Health care act is to be given to parliament in 2010. The reforms will be in place by 2014. The financing models in Finland include the capitation, total billing and income share models. For specialized care the NordDRG-system and billing for GP services to be developed further. This is comparable to the Prometheus-model for hospital remuneration in the US (Prometheus-models include far more than hospital payments).

allow for partial adjustment and lagged dependent variables.

METHODS AND DATA

The health care expenditure per Gross domestic product unit (HCE per GDP, PPP, percent of GDP) is modeled as a linear combination of previous N_{it-1} and current expenditure N_{it}* which implies convex adjustment costs on average and on the margin. This process is often referred to as the adaptive expectations model with smooth adjustment. The explanatory variables are factors thought to impact the variation in the response variable [15]. Thus the model equation to be estimated in the first stage estimates for iteration is

(1)

$$N_{it}^{*} = F(X_{it}, Z_{it}, t; \beta)$$

where N_{it}* is the expected health expenditure for country i at time t as a proportion of GDP, X_{it} is the vector of explanatory variables, Z_{it} is the indicator variable set, t is the variable capturing exogenous technological change over time (i.e. time trend variable) and β is the vector of parameters to be estimated.

The explanatory variables (see also Table I and Table II) in the first stage are the relative price index of HCE-expenditure (P), public finance share of total expenditure (PF), the doctors per population ratio (DOC), the share of over 65 year olds of the total population (OLD), the urbanization rate (URB), female participation rate in the labor market (FEM) and a standard time trend (t) to capture otherwise immeasurable exogenous technological change (advances in medicine, etc. time-variant factors). The model for N_{it}* (HCE/GDP) is the specification either as in (2) "full model" (Table III) or by OLS-backward selection procedure ("reduced form model", Table IV).

The full model can be written as follows

(2)

$$\begin{aligned} \ln(N_{it}^{*}) &= \alpha + \beta_1 \ln(PF_{it}) + \beta_2 \ln(IP_{it}) \\ &+ \beta_3 \ln(DOC_{it}) + \beta_4 \ln(URB_{it}) + \beta_5 \ln t \ln(PF_{it}) \\ &+ \beta_6 \ln t + \beta_7 (\ln t)^2 + \beta_8 \ln(P_{it}) + \beta_9 \ln(OLD_{it}) \\ &+ \beta_{10} \ln(FEM_{it}) + \sum_{i=1}^{6} countrygroup_i \\ &+ \sum systemdummy \end{aligned}$$

In model (2) all the estimated β parameters are in elasticity form as a result of the log-form of the equation [9,15,25,30]. The model for N_{it}* is estimated by OLS or a backward induction selection of variables then substituted as starting values for the nonlinear estimation process described by equations (5,6,7,8). The derivatives for public funding and technological change are as follows

(3)

$$E_{PF} = \frac{\partial \ln N_{it}^{*}}{\partial \ln(PF)_{it}} = \beta_1 + \beta_5 \ln(t)$$

(4)

$$TC = \frac{\partial \ln N_{it}^{*}}{\partial \ln T} = \beta_6 + \beta_5 \ln(PF_{it}) + \beta_7 \ln(t_{it})$$

The nonlinear optimization adjusts both equation (2) and (5) in a simultaneous manner taking as "starting values" for optimization the OLS-estimates of equation (2). The estimation procedure is quite complex and presented in SAS language in the Appendix. Model for HCE-expenditure is:

(5)

$$\frac{N_{it}}{N_{it-1}} = \left(\frac{N_{it}^{*}}{N_{it-1}}\right)^{\delta_{it}} \Rightarrow \ln\left(\frac{N_{it}}{N_{it-1}}\right) = \ln\left(\frac{N_{it}^{*}}{N_{it-1}}\right)^{\delta_{it}}$$

$$\Leftrightarrow \ln(N_{it}) = (1-\delta_{it})\ln(N_{it-1}) + \delta_{it}\ln(N_{it}^{*})$$

$$\Rightarrow \ln(N_{it}) = (1-\delta_{it})\ln(N_{it-1}) + \delta_{it}\ln(N_{it}^{*}) + u_{it}.$$

where $0 \le \delta_{it} \le 1$ is the parameter for the rate (or speed) of adjustment, which in this article is modeled by distance or deviation from current forecasted expenditures. This parameter is the percentage by which the target variable adjust per year to the change in explanatory variables. In the extreme case of $\delta_{it} = 1$ adjustment is instant and occurs within a single time period (in this case year). On the other hand if $\delta_{it} = 0$, there is no adjustment and expenditures follow a stochastic random walk process. Because of model structure we expect the adjustment parameter to be in the interval $0 \le \delta_{it} \le 1$ but we do not force it to be a priori or in estimating results between or equal to 0 and 1. Not only in our view, but also also according to Kumbhakar [23], Piekkola [24] and Heshmati [30], this gives flexibility to the specification.

In comparison to many other studies using a dynamic model specification the parameter δ_{it} is a variable to be modeled in the nonlinear estimation (in many studies it is assumed that the adjustment parameter δ_{it} μ = constant for all i and t). This brings flexibility as country specific adjustment is taken into account explicitly (note that in our model here the adjustment parameter is both flexible in t and i dimensions, so for example it can be calculated for Finland for the year, say year 1977, or Sweden for the year 2005, and separately for all other country & year pairs also) and allows for heterogeneity between different health care financing strategies and schemes. The cyclical fluctuation can also be a potential factor in adjustment which is allowed by variation in t. Thus a following model is specified for adjustment:

(6)

$$\delta_{it} = \delta_0 + \delta_1 DIST_{it} + \delta_2 GLO_{it} + \delta_3 FFS_{it} + \sum_i \delta_i Countrygroup_i$$

or

(7)

$$\delta_{it} = \delta_0 + \delta_1 DIST_{it} + \delta_2 PUBINT_{it} + \delta_3 FFS_{it} + \delta_4 GATE + \delta_5 CAP_{it}$$

The coefficients estimating SAS coding is available in the Appendix. The distance from optimum defined as the non-negative difference between current periods optimum and previous periods observed for all i and t values.

(8)

$$DIST_{it} = \left| N^*_{it} - N_{it-1} \right| > 0, \forall i, t.$$

The variable dist is generated in the estimation process and reflects the model adjustment between past and present forecasted values. The larger the deviance the faster the "catch-up" effect is expected to be. For example if health care costs or expenditures have grown substantially faster than GDP without major changes in health financing structures, the age structure, medical technology or medicine costs it can be expected that this is a temporary or economic cyclical shock expected dampen out rather quickly. Thus it is expected that $\delta_1 > 0$. The other adjustment parameters have no a priori hypothetical value.

The estimation approach and method used is flexible and allows for adjustment over several time periods (lags). This takes account of the adjustment costs present when policy or exogenous variables change. These points of view give justification to the model selected in equation (5). The limitation is the possibility of co-integration between variables which is most often present between HCE and GDP series. Here the explanatory variable (y) is however the ratio between HCE and GDP (in percent). Possible omitted variables are subsumed into the fixed effects country and year specific constant terms.

The nonlinear equation to be estimated is presented in equation (5) and the initial values for the β parameters come from equation (2) by standard OLS estimation. The δ parameters of equation (5) with the β parameters (5) being the subjects of adjustment are then estimated by a nonlinear method. Using panel data these are estimated with a nonlinear SAS procedure Nlin (Appendix). The method used here for nonlinear estimation is the Gauss-Newton-iterative method with u_{it} the independently identically normal distributed error term. As a "round up" one can conclude that the new features of the model are the flexibility of adjustment with respect to cross-sectional as well as time units. The results are presented below.

Operationalizing explanatory variables, we have the following model variables: public financing (PF = the percentage share of public financing in health care, % of total HCE), inpatient share of expenditure (IP = the percentage share of specialized care in health care, percent of total HCE), practicing physicians per population (DOC, multiplied by 1000), the urbanization rate (URB, percent of population), exogenous technological change (t), (e.g., t is 1 for the first year used, 2 for the second year used, etc.), the share of over 65+ year olds (OLD, percent of population), the relative price index of health care (P, price index with respect to other goods as estimated by OECD) and female labor force participation rate (FEM, % of 15-64-old women) [15]. All these variables were used before beginning that the backwards stepwise procedure so the are the full x-set (results in Table III) as opposed to the procedure reduced set (Table IV).

The GLO- (global hospital budget) and FFS- (fee-for-service) variables as well as other system indicator variables are described in table 1. The expected signs (of elasticity) of the dynamic model system dummy coefficients are argued and given in Gerdtham [9,14,15]. The fee-for-service has proven more costly and global budgeting, gatekeeping and capitation remuneration less costly than the reference in previous studies with OECD data. The system dummies (cap, pubint, FFS and gate) are the indication of such arrangement in a particular country and if zero then some other arrangement. These are the key indicator variables to be estimated, tested and reported.

Total HCE expenditures are positively related to public finance if the arguments of Gerdtham [15], Leu [7], Culyer [19] are valid, so equation (3) is expected to be positive in sign, $E_{PF} > 0$. In more urbanized societies the transport costs and access to health care are lower, so $b_4 > 0$. If inpatient care is more expensive than outpatient care, then $b_2 > 0$. The GP-population ratio is expected to increase costs, thus $b_3 > 0$. The effect of exogenous technological change is expected to be positive (advances in medicine and medical science, etc. factors), thus TC > 0 and we expect parameters $b_{6,7} > 0$ (see [13]). Also the share of elderly population is expected to increase costs $b_9 > 0$. The effect of female participation in labor markets is also expected to be a positive factor as well, $b_{10} > 0$, with informal home care reductions as a result. However we do not have an a priori view of the sign of b_8 and higher prices may increase or decrease costs. By economic reasoning an increase in the relative price of health care should reduce demand (and lower HCE).

For further reference on variables and definitions see [14,15].

ESTIMATION RESULTS

Two dynamic models with estimation result are presented according to the model of the "Research agenda" section. with the difference of two different system dummy sets and exogenous variable sets (in Tables III and IV, respectively) and based on previous papers by Gerdtham [9,15]. A preliminary country and time dummy anova type analysis (without interaction terms) shows that without model structure or explanatory variables included the individual country specific dummies are statistically significant. The exceptions are Denmark, Switzerland and France that do not differ from the reference level of Sweden. The lowest level of expenditure in this "naïve" model can be found in Spain (-32%) and the UK (-30%). On the contrary the high level of US expenditure (+25%) is clearly evident from the preliminary analysis. These results point to the system variation of expenditure with the highest levels found in more open ended regimes [7,9,19].

The dynamic model is estimated as described in the "Research agenda" section. Firstly a full model with all explanatory variables is estimated using system and country group dummies. Due to collinearity the global budgeting dummy had to be omitted from Table III estimation. The results from this regression are presented in Table III. Second a backward OLS regression procedure on equation (2) is used to identify the target equation for HCE expenditure and a more parsimonious specification. The estimates from this equation are then used as starting values for the nonlinear Gauss-Newton iteration procedure for the dynamic equation with time lag. Now the global budgeting dummy is included and other dummies dropped. The results of this regression are presented in Table IV for model 2.

The reason behind running two models in Tables III and IV is that we want to check the

Response variable (Y)	Y =N = HCE/GDP = health care expenditure as share of Gross domestic product (percentage of GDP) HCE = health care expenditure (public + private) per capita corrected by Purchasing Power Parity (PPP), 1000 USD/capita GDP = gross domestic product corrected by PPP, 1000 USD/capita
Explanatory variables (X)	RP = relative price index of health care expenditures AGE = the relative share of 65 year olds of wrp. working age population, 15-64 year olds DOC = the ratio of general practitioners wrp. to population, multiplied by 1000 IP = inpatient care as share of total HCE funding (%) PF = public HCE as share of total HCE (%) URB = urbanization rate, (percent of urban population) PRICE = the relative price of health care, index variable OLD = population aged 65 or over as share of total population FEM = female participation rate, labor force wrp. to population, 15-64 year olds t = exogenous technological change (capturing the effects of advances in medicine, etc.)
Health system characteristics - Indicator variables (I)	GLO = the global budgeting-dummy is a global budgeting indicator that captures the effect of specialist care hospital budget constraint and few channel funding. 1 = global budgeting in specialized health care, else =0. FFS = The fee for service-dummy is a fee for service indicator that captures the effect of the insurance and co-payment system by classifying the countries in two categories based on fee-for-service policies in outpatient care. 1 = outpatient care funded by fee-for-services, else=0 GATE = The gatekeeper-dummy is an indicator variable for observable gatekeeper procedures in primary care i.e. need for a referral to specialized care PUBINT = The public integration-dummy is an indicator of publicly integrated systems (=1) as opposed to public contracting or public reimbursement systems (=0) CAP = The capitation-dummy is an indicator whether doctors are reimbursed according to capitation principle in outpatient care (=1) as opposed to salaries or fee-for-service (=0)
Country dummies	Countrygroup1 – Finland; Countrygroup2 – Sweden, Denmark, Norway, Countrygroup3 – Spain, France, Netherlands; Countrygroup4 – United States (US) Countrygroup5 – United Kingdom (UK); Countrygroup6 - Switzerland

Table I. *The model variables of HCE expenditures. Data source: OECD health data 2007 [17].*

Year	HCE	GDP	N	PF	IP	DOC	URB
1975	430	6,329	75.3	310	57.5	1766	70.6
1980	745	10,041	75.4	542	53.7	1959	72.0
1985	1,088	14,154	74.6	773	51.2	2259	73.4
1990	1,544	18,673	73.4	1072	46.7	2477	74.7
1995	1,958	22,014	73.3	1367	43.1	2660	76.3
2000	2,532	28,475	71.8	1745	38.5	2910	77.6
2005	3,475	34,884	72.9	2433	33.3	3260	79.0

Table II. *Averages of key variables used in the model 1975-2005. Source: OECD Health Data 2007 [17]*

Estimation summary		
Method	Gauss-Newton	
Iterations	122	
Subiterations	166	
Average Subiterations	1.360656	
R	7.958E-6	
PPC(c0)	0.000606	
RPC(c0)	0.001708	
Object	8.18E-11	
Objective	0.299991	
Observations Read	340	
Observations Used	340	
Observations Missing	0	
Parameter	**Estimate**	**SE**
Mean	-5.4934*	0.8212
Public finance share (%)	0.7473*	0.0381
Female partic. rate (%)	0.2044*	0.0601
Urbanization (%)	-0.3116	0.1838
GP-rate/pop.	-0.1134*	0.0320
Inpatient share (%)	0.0340	0.0261
Elderly share, 65+ (%)	0.1704*	0.0692
Relative price index	-0.1614*	0.0463
Exog. tech. change	-0.0961*	0.0419
Tech. change **2	-0.1816*	0.0265
FIN indicator	0.0918	0.0856
W-EUR indicator	0.4727*	0.0452
USA indicator	0.7743*	0.0485
UK indicator	0.0165	0.0378
SUI indicator	0.5104*	0.0404
System indicators		
FFS-dummy	0.4912*	0.1436
GATE-dummy	0.2681	0.1432
PUBINT-dummy	0.1849*	0.0860
CAP-dummy	0.0470	0.1232
Adjustment parameter		
Mean	0.0005	0.0044
Optimum distance	1.3031*	0.3867
FFS-dummy	-0.7277*	0.0719
GATE-dummy	-0.5084*	0.1393
CAP-dummy	0.1184	0.1403
PUBINT-dummy	0.1073	0.0630

Table III. *Model 1. HCE expenditure model with country and system indicators. (OECD,1972-2005) with SAS proc nlin-method, Gauss-Newton. NOTES: the table shows the country specific effects -b and their standard errors (SE).*
p1 = the p-value of a test of joint significance of the coefficients; significance levels –p: * $p < 0.05$; country dummies = p-value of significance test of the country type dummies; country group 2 reference: Sweden, Denmark, Norway.

sensitivity of the selected model. Therefore we include all X-variables in Table III results. However the best fit is obtained for the model in Table IV that uses backward model selection in the first stage linear regression equation (2). This gives the optimization starting values for the nonlinear regression parameter estimation in equation (5).
In the first stage in model 1. all regressors (except global budget dummy) are included. In the second phase a backward OLS regression procedure is used to identify the target equation for HCE expenditure and the model estimated is model 2. The estimates are in both equations from the nonlinear Gauss-Newton iteration procedure for the dynamic equation with one time lag. The adjustment parameter is also shown both by system indicators and country groups. This gives validity and robustness to the results.[3]

INTERPRETATION AND ANALYSIS OF RESULTS

The following questions and hypothesis were investigated in this article:

1. How do the budgeting and remuneration models, i.e. global budgeting (GLO) in specialized care and fee-for-service (FFS) in primary care, affect health care spending (HCE)? Are these factors sensitive to model selection procedures?
2. How does the public share of health care spending affect total spending? And has its the impact changed?
3. How do other factors, such as exogenous technological change, relative prices of health care and the growth of the health care profession affect HCE spending?

We answer these question primarily based on the econometric models estimated in this paper. The baseline model is the model in Table IV. Regarding question 1. from the descriptive and correlation analysis the main findings point to advantages of the one- or few channel financing system (taxes and public insurance schemes) with global budgeting practices as opposed to the multi-channel funding and financing schemes (e.g., private insurance schemes with clients co-payments and fees-for-service).
From Table III, model 1, we get a hawk's eye view of the overall model although there are many statistically insignificant coefficients. The fee-for-service and public integration system dummies are positive and significant. Regarding the elasticities for example the impact of a 10 percent increase of the elderly

[3] The calculations are available from the author upon request.

share of population has an 1.7% effect on health care expenditure with respect to GDP and increase of relative prices of health care an 1.6% decrease effect.

Turning to the more parsimonious and backward induction selected nonlinear Table IV, model 2, we make conclusions about the two key system variables under review (FFS and GLO). The share of public financing, the urbanization rate, the share of elderly population and the growth of the doctor profession has had a growth impact on health care expenditures per GDP. These impacts are anticipated and in line with previous research. The only two unexpected signs in model 2. were that of the in-patient share which is cost saving and the female labor force participation rate which had on the contrary had a negative impact on the model.

From Table IV the indicator variable for a fee-for-service system is 22 percent higher in costs and the global budgeting indicator is 34 percent lower in costs as compared to the base line reference. By a variation of model variables and system dummies the results for fee-for-service stay the same, i.e. it is a cost increasing remuneration practice. This can be seen by looking at Tables III and IV.

As to question 2, the development of expenditures, adjustment parameter and public financing share are given in Figure 4. One can see that the contribution of national economic resources devoted to HCE expenditures has been on a steady rise since 1975 with the exception of the late 1990s based on the more parsimonious model 2 results. This result holds by taking account of the country specific variation in the OECD data.

On the other hand the adjustment parameter has weakened in strength so the explanatory variables of the target models have lost ground to sluggish adjustment making it possibly more difficult to guide health care system's expenditures in the short run. The major obstacles encountered by the US health care reform and other countries reforms are a showcase for this development. For example due to employer arrangements and lack of reform in the primary care sector the private sector has gained significant foothold in occupational health care services in Finland.

The share of public financing (PF), the urbanization rate (URB) and the relative growth of the doctor (general practitioners, specialist) profession (DOC) has had a growth impact on health care expenditures per GDP. These impacts are anticipated and in line with previous research. However relative prices or ageing (the share of over 65 year olds) did not show statistical significance in the "reduced" form model (Table IV). The female labor force participation rate has had on the contrary had a negative impact on expenditure which was not expected a priori.

Variable	Estimate Coefficient (SE) - HCE-target: N_{it}*	SE
Mean	-9.871***	0.566
Public finance share (%)	0.667***	0.104
Pf-share.* t	-0.087	0.052
Female partic. rate (%)	-0.163**	0.052
Urbanization (%)	0.839***	0.084
GP-rate/pop.	0.188***	0.043
Inpatient share (%)	-0.062*	0.029
Exog. tech. change	0.530*	0.220
System indicators		
Fee-for-service (FFS)	0.221***	0.028
Global budget (GLO)	-0.343***	0.051
Adjustment parameter δ_{it}		
Mean	-0.448***	0.096
Optimum distance	1.256***	0.138
FIN indicator	-0.215***	0.055
W-EUR indicator	0.185*	0.083
USA indicator	-0.324	0.168
UK indicator	0.096	0.071
SUI indicator	0.096	0.173
Fee-for-service (FFS)	0.417***	0.088
Global budget (GLO)	0.185*	0.077

Table IV. *Model 2. HCE expenditure model with country and 2 key system indicators. (OECD,1972-2005) with SAS proc nlin-method, Gauss-Newton, (OLS backward selection of variables, 1.stage) Iterations 32, R 9.819E-6, PPC(ccg6) 0.000099, RPC(ccg6) 0.000152, Object 3.79E-10, Objective0.624276; Observations Read 340; Observations 339. NOTES: the table shows the country specific effects -b and their standard errors (SE)*

p1 = the p-value of a test of joint significance of the coefficients; significance levels –p: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; country dummies = p-value of significance test of the country type dummies; time dummies = p-value of a joint significance test of the time fixed effects (not shown, all significant at $p<0.01$-level); country group 2 reference: Sweden, Denmark, Norway.

The effect of public financing share (PF) on total HCE has declined over time from 5% to 3.5% according to Figure 4. This may point to the increased share of private funding but also to more cost-effective public use of finances. According to the data used in this research the private share of health care financing has indeed grown over time. In Finland this is particularly pronounced in occupational health care where private services financed by employers have come to dominate the scene.

Thus finally regarding question 3 the impact of a 10 percent increase in public financing has an 0.5 to 1 percentage point effect on health care expenditure with respect to GDP. This effect has decreased with time which may point to better cost control or private sector provision of certain services.

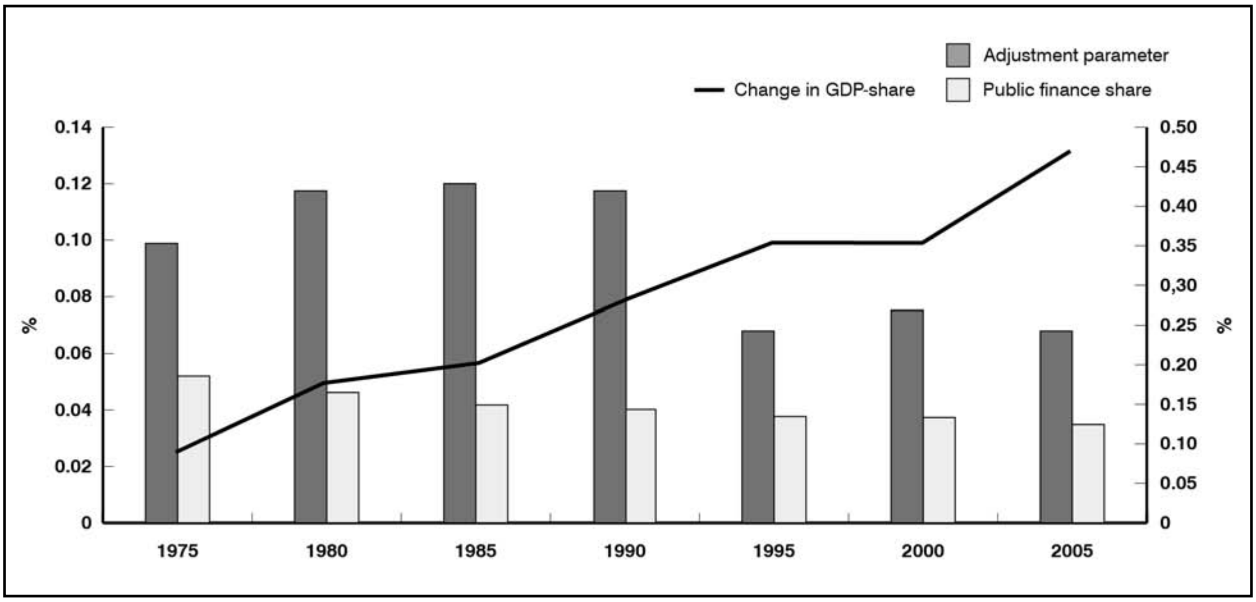

Figure 4. *Health care expenditure in sample by 1.GDP-share (right, pp.), 2. adjustment, 3. public finance share /left, %)*

According to Leu [7] view total HCE increases with public share of funding (PF) of finances because the relative price faced by the consumer is heavily subsidized and the budget constraint of the individual service user based on co-payments, hospital fees and private medical costs on pharmaceuticals are cost-shared. Culyer [19] on the other hand points out that the financing sector is too passive in fee-for-service systems (FFS) and has to rely on asymmetric information when making decisions. Therefore fee-for-service is relatively more expensive than other systems. These previous research going in the same direction as our findings may partly explain our results.

DISCUSSION

We discuss here the results of Tables III and IV. The results of these tables can be compared and analyzed side by side. The model 1 in Table III is the full or unrestricted model that has the long run optimum equation based on variables suggested by Gerdtham [9,14,15]. The more parsimonious model of Table IV was selected based on backward induction of the originally proposed long-run model (used in Table III) [9]. It was found during estimating different dynamic model specifications that the time trend (exogenous technology) made the estimates somewhat sensitive to model specification. The best models with smooth adjustment were selected into Tables III and IV based on speed of convergence to optimum in maximum likelihood (ML) values and stability of estimates to slight specification changes.

The system dummy effects are similar to Gerdtham [14,15] and the exogenous variables effects to Roberts' findings [10]. Increases in public financing share and advances in technology seem to drive up costs (Tables III and IV). This is also the case for the urbanization rate in the parsimonious model of Table IV.

As for the main health care organizational results (the dummy z-variables controlling for continues x-variables) are that the indicator variable for a fee-for-service system is 22 percent higher in costs and the global budgeting indicator is 34 percent lower in costs as compared to the base line reference. This is reflected in good cost-control performance of the global budgeting schemes in health care. Cost-control in health care services may require GP's to be publicly employed or closely regulated gatekeepers to prevent leakages from primary to specialized care. There is solid evidence on this in the Swiss health care sector [28,29].

So, according to our findings globally budgeted systems with salaried (or capitation) physicians do well in comparison the more open-ended financing schemes. Examples of such are health care services that rely on fee-for-service based remuneration as opposed to capitation based or salaried GPs.

The results point to the fact that cost-controls in health care services may require GP's to be publicly employed or closely regulated private sector gatekeepers to prevent moral hazard and leakages from primary to specialized care [9]. There seem to be incentives to overproduce (moral hazard) when the remuneration system is volume compensation based (FFS). On the contrary framework (global) budgeting was found less expensive in international comparison. The public integrated

system was found to be more expensive than public reimbursement and other finance as in the previously mentioned literature. The results for gatekeeper-practice (referral of a GP needed to go to a specialist) and capitation remuneration (size of the population the GP is responsible of and gives medical services) were not statistically significant here (as was the significant case consistently in [9]).
A cautionary note on results is that the quality of data could be somewhat better. There are some problems with unified definitions of variables and accounting standards across countries in the OECD health data (also some replacement of missing values by data source). Whether these are bigger or smaller problems is a matter of research evaluation. Another matter for same kind of issues could be somewhat weak theoretical background of explanatory variables used in the optimum (long run) equation in (2) [9]. Of minor issues the sample size was adequate for our study and the rigidity of the coefficient structure was significantly relaxed in our research.
As a general discussion one can say based on latest OECD statistics on HCE-GDP ratios the Nordic countries that Great Britain and Spain (that have NHS type or public integrated systems) seem to do well in containing HCE costs. Global budgeting (and DRGs) are used in all these countries, fees-for-service are not primarily used in basic health care, and all these countries rely mostly on public financing of services (taxes, social insurance). However public integration in these countries may not be less costly than public reimbursement or public contracting arrangements (see [9,14]).
There are cost pressures evident in more private oriented systems that have led for example Switzerland to introduce tougher GP-gatekeeper measures and global budgeting in Swiss health insurance plans. They have been cost-control effective according to research. The NHS in the UK has introduced the NICE center for evaluating care and for counting the health economic effects and cost-effectiveness of various practices. In Finland the Centre for Health and Social Economics – CHESS (at National institute for health and welfare) has begun similar work in recent years. Health care reform, cost control, cost-efficiency are active and growing issues on the political agenda in many (especially western) OECD-countries with fast ageing populations.
Commissioning of services and purchaser-provider may be more cost-efficient than exclusive public delivery. In our study the results show that publicly integrated systems are more costly in the long run than public contracted, public reimbursed, or more private systems. This reinforces the point made by Gerdtham [9,14,15], Culyer [19], and Leu [7] that the financing source or provider sector (the shares of public-private mix) is not so important as are the economic incentive arrangements on the out-patient and in-patient levels in hospitals and primary care units.
Indeed there are reforms under way (for example in the UK, USA or Finland) that aim at increasing the “bottom to top” incentives and decisions instead of the usual “top to down” processes [31]. The Obama administration health reforms are also under way. The situation is quite similar in Finland where new health care legislation was enacted in May of 2011. Patient choice, quality of care and economic incentives are in many cases top of the agenda. The outcomes and costs of these reforms are thus far mostly unclear. More research on the questions of system characteristics and especially economic incentives of financiers and service providers is thus needed.

APPENDIX

SAS-program for estimating results in Tables III and IV health care expenditure model (copyright: Eero Siljander, THL, Finland):

```
proc nlin data=health12 method=gauss
outest=bols2 maxiter=1000;
/* note parms could also be from saved file of
OLS estimates that is used in table 4. model
2. */
/* parms set to zero for nonlinear optimazi-
tion in table 3. model 1. */
parms b0 0 blogpubshare 0 bpublictrend 0
blogfemale 0 blogurbanization 0
blogphysician 0 bloginpatient 0 bold 0
blogprice 0
bFFSdummy 0 bGLOdummy 0 bGATEdum-
my 0 bPUBdummy 0 bCAPdummy 0
btrend 0 btrend2 0 bcg1 0 bcg3 0 bcg4 0 bcg5
0 bcg6 0 btrend 0 bcg1 0
bcg3 0 bcg4 0 bcg5 0 bcg6 0
c0 0 cdist 0 ccg1 0 ccg3 0 ccg4 0 ccg5 0 ccg6
0 cFFSdummy 0 cGLOdummy 0
cGATEdummy 0 cCAPdummy 0 cPUB-
dummy 0 ctrend 0 ctrend2 0 cpublictrend 0
clogpubshare 0 ;
/* the optimum (long run) model ------*/
lstar = b0+bFFSdummy*FFSdummy
/*+bGLOdummy*GLOdummy*/ +bGATEd
ummy*gatekeep1+bPUBdummy*pubintegra
tion1+bCAPdummy*capitation1
+btrend*t+btrend2*trend2/*+bpublictrend*p
ut*/+blogpubshare*logpublic
+blogurbanization*logurbanization+blogph
ysician*logphysician+bloginpatient*loginpa
tient
```



```
+blogfemale*logfemale+blogprice*logprice
+bold*logpopratio
+bcg1*cg1+bcg3*cg3+bcg4*cg4+bcg5*cg5
+bcg6*cg6;
/* the unrestricted dist variable in adjustment
parameter equation */
dist = abs(lstar-lgl);
/* the dynamic partial adjustment model */
model l = (1-(c0+cdist*dist+cFFSdummy*F
FSdummy+/*bGLOdummy*GLOdummy*/
+cGATEdummy*gatekeep1+cPUBdummy*
pubintegration1+cCAPdummy*capitation1)
)*lgl
+(0+cdist*dist+cFFSdummy*FFSdummy+/*
bGLOdummy*GLOdummy*/+cGATEdumm
y*gatekeep1+cPUBdummy*pubintegration1
+cCAPdummy*capitation1)*(b0+bFFSdum
my*FFSdummy+/*bGLOdummy*GLOdum
my*/+bGATEdummy*gatekeep1+bPUBdum
my*pubintegration1+bCAPdummy*capitatio
n1+btrend*t+btrend2*trend2/*+bpublictrend
*put*/+blogpubshare*logpublic+blogurbaniz
ation*logurbanization+blogphysician*logph
ysician+bloginpatient*loginpatient+blogfem
ale*logfemale+blogprice*logprice+bold*log
popratio+bcg1*cg1+bcg3*cg3+bcg4*cg4+b
cg5*cg5+bcg6*cg6); run.
```

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