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Abstract

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According to Baumol (1993) health care epitomises Baumol's cost disease. Sectors that suffer from Baumol's cost disease are characterised by slow productivity growth due to a high labour coefficient. As a result, unit costs of these sectors rise inexorably if the respective wages increase with productivity growth of the progressive industries such as manufacturing. Thus, according to Baumol (1993) the secular rise in health-care expenditure has been unavoidable. This present paper demonstrates that health care is contracted by Baumol's cost disease, but only to a minor extent. Consequently, policy-makers have more leeway to curb ever-increasing health-care expenditure than is suggested by Baumol (1993) and other authors. In addition, we test the implications of Baumol's cost disease for health care by avoiding the well-known flaws in constructing medical price indices. Therefore, the adjusted Baumol variable derived in this paper is also extremely appropriate to test the validity of Baumol's cost diseases of other service industries such as education or the live performing arts. Additionally, our analysis suggests that health care is rather a necessity than a luxury at the national level, which conflicts with macroeconomic evidence provided in the relevant literature.

Keywords: Health-care expenditure, Baumol's cost disease, the macroeconomics of health care, the adjusted Baumol variable.

JEL codes: C23, H51, I10.

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1. Introduction

Over decades OECD countries have seen soaring health-care expenditure. The average of total current health-care expenditure of nine OECD countries has increased from 3.9% of GDP to 9.8% in the period from 1960 to 2007.[1] As the average share of public expenditure in current health-care expenditure amounts to about 75% across 20 OECD countries in 2006, public budgets are put under enormous strain by ever-increasing health-care outlays.[2] Therefore, policy-makers seek measures for dampening the cost dynamics in health-care. But according to Baumol (1967, 1993) the efforts to curb expenditure growth in health care are futile because health-care epitomises Baumol's cost disease. This present paper aims to demonstrate that health-care is only partly contracted by Baumol's cost disease. Consequently, policy-makers have more leeway to curb ever-increasing health-care expenditure than is suggested by Baumol (1993).

Sectors that suffer from Baumol's cost disease are characterised by slow productivity growth and a high labour coefficient. If, in addition, the demand for these services is rather price inelastic or the government subsidises these services, costs of these sectors increase in an over-proportional manner to the costs of sectors with continuous productivity growth such as the manufacturing sector. Baumol (1993) gives evidence in favour of his theory by showing that growth rates in health-care prices outstrip general inflation in a majority of OECD countries. However, Triplett and Bosworth (2003) demonstrate for several US service industries, but not for the health-care sector, that the average annual labour productivity growth in these service industries has not fallen behind the economy-wide growth rate from 1995. Triplett and Bosworth (2003) emphasise that in the past the measurement of price deflators in some service industries was severely flawed. This leads to underestimating of productivity growth in some service industries. In contrast, Nordhaus (2008) provide evidence that the US economy is contracted by the cost disease because low-productivity industries, in particularly services, have been gaining weight. However, Nordhaus (2008) emphasises that for some services such as health care or education it is still extremely difficult to come up with accurate measures of prices and output. Consequently, the conclusion by Baumol (1993) that health care is a prime ex-

[1] These countries include Australia, Austria, Canada, Finland, France, Spain, Switzerland, United Kingdom and the United States. Data of other OECD countries are not available as of 1960.

[2] These countries include Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States (see also Appendix).

ample of the cost disease might be based on inaccurately measured price deflators.

Some health economists conclude that health-care-price indices overstate true medical-care inflation. In a seminal paper Cutler et al. (1998), who use data of a major teaching hospital in the United States and of Medicare, estimate that growth of prices indices on treatments of heart attacks fall by 2.5 to 3.0 percentage point annually compared to the official price statistic if changes in care are more accurately tracked. Cutler et al. (1998) show that adjusting for quality changes would even bring about a lower inflation in prices on treatments of heart attacks than general price inflation. Therefore, Cutler et al. (1998) conclude that the driving force behind expenditure growth is increasing quantities and not soaring prices. Contrary to this view, Hartwig (2008, 2009) who conducts a panel-data analysis across 19 OECD countries provide empirical evidence in favour of Baumol's cost disease in health care. In particular, Hartwig (2008) avoids the shortcomings of the medical-price indices by introducing a so-called "Baumol-variable" to estimate the impact of price increase on healthcare expenditure. As a result, Hartwig's (2008) study does not suffer from the drawbacks emphasised by Cutler et al. (1998) and others. Thus, though there might be difficulties in deriving accurate medical price indices the empirical evidence in favour of Baumol's cost disease would appear to be quite strong. Nonetheless, further evidence provided for France based on microeconomic simulation shows that technological progress is the most important driver of health care expenditure (Dormont et al., 2006). This suggests that at least part of the price changes might be due to quality changes. Recently, a view would appear to be emerging that part of the health-care sector, long-term care, suffers from Baumol's cost disease whereas health-care expenditure excluding long-term care is virtually not influenced by Baumol's cost disease (e.g. Oliveira Martins, 2006; AWG, 2009). But the evidence provided by Hartwig (2009, 2008) challenges the emerging consensus regarding the role of Baumol's cost disease in health-care.

This paper contributes to this debate by showing that the recent empirical evidence concerning Baumol's cost disease in health care can be reconciled with the emerging consensus view. In particular, the paper shows though Baumol's cost disease is relevant in health-care the impact on expenditure growth is limited. By doing this, this paper also contributes to meeting a call by Gerdtham and Jönsson (2000, 48) in the Handbook of Health Economics to put the macroeconomics of health care on firmer ground. This paper is organised as follows - in the following section to avoid using, in all likelihood, flawed medical price indices, a term - the adjusted Baumol variable -, which is used to test the validity of

Baumol's cost disease in health care is derived from Baumol's (1967) model of unbalanced growth. Then, the empirical method used for this analysis and the data are described. In section four the findings of the panel-data regressions of health-care expenditure are presented. Section five concludes.

2. Derivation of the adjusted Baumol variable

Baumol's cost disease is based on the assertion that economic sectors can be grouped into sectors that are characterised by technologically progressive activities such as innovation, capital accumulation and economies of scale, which lead to continual increases in labour productivity, and sectors that are characterised only by occasional productivity growth (see Baumol, 1967, 415-16). The latter encompasses sectors in which the quality of labour is paramount to the quality of products. The elasticity of substitution between labour and capital is low. Health care and education, and on more general terms the personal services such as automotive repair and the performing arts are cited as prime examples for these nonprogressive or stagnant industries (see Baumol, 1993, 17- 18). If the demand for services of the non-progressive industries is rather price-inelastic or the government subsidises stagnant industries then the wages of these sector should increase with the labour productivity growth in the progressive sectors such as manufacturing. As a consequence, unit costs increase inevitably, which is known as Baumol's cost disease (e.g. Baumol, 1993). Baumol (1967) demonstrates the mechanisms at work by introducing a model, which he calls the model of unbalanced growth. In the following we derive based on Baumol's model a so-called adjusted Baumol variable that can be used to test empirically the validity of Baumol's assertion. This procedure has the advantage to avoid the difficulties in measuring medical price indices. Corresponding to Baumol's (1967, 417-18) model of unbalanced growth the economy is divided into two sectors, a progressive one, A, and a non-progressive one, B.[3] For simplicity only labour is explicitly taken into account as a factor of production. The respective real outputs at time t, $Y(t)_A$ and $Y(t)_B$, can be written as follows:

$$Y(t)_A = aL(t)_A\, e^{rt} \quad \text{with } r > 0 \tag{1}$$

$$Y(t)_B = bL(t)_B\, e^{st} \quad \text{with } s > 0 \text{ and } s \ll r \tag{2}$$

[3] In the original paper by Baumol (1967, 417) the progressive sector is called "2" and the non-progressive sector is called "1".

where $L(t)_A$ and $L(t)_B$ correspond to the respective amounts of labour engaged in sector A and B at time t. Both, r and s, represent the long-run labour productivity growth of the progressive and non-progressive sector respectively. Labour productive growth in sector A, r, is assumed to outstrip labour productivity growth in the Baumol sector B, s, by far. In deviation to Baumol's original paper (1967) the model presented in this present paper is generalised by assuming that productivity growth in the Baumol sector, s, can also be positive. The variables a and b are constants. For instance, these variables can represent the state of technological knowledge in the respective sector.

A division of Y_A by Y_B results in $bL_B/aL_A e^{(r-s)t}$. Assuming an equilibrium this ratio is identical to the ratio of real demand. The ratio of real demand diminishes over time if demand for both goods are price elastic. Thus, under the latter condition the Baumol sector has a tendency to vanish. However the ratio between the two sectors can be kept constant if the demand for good B is price inelastic or the government subsidises sector B. This lemma can be written down as follows:

$$Y(t)_B a/Y(t)_A b = L(t)_B\,/L(t)_A\,e^{(r-s)t} = \gamma \quad \text{with } \gamma := \text{constant} \tag{3}$$

Furthermore Baumol (1967, 418) assumes that wages per unit of labour, w, increases in both sectors with the rate of productivity growth of the progressive sector A, r.[4] This is confirmed by a study, which provides empirical evidence in favour of a co-integration between wages in the manufacturing, the progressive sector, and those of the tertiary sector, allegedly the non-progressive sector (Hartwig, 2005).To make the analysis simple, it is assumed that the wage rate in both sectors should coincide. Thus, unit labour costs of both sectors can be written as follows:

$$C_A = w(t)L(t)_A\,/Y(t)_A = \;we^{rt}L(t)_A/aL(t)_A e^{rt} = \;w/a \tag{4}$$

$$C_B = w(t)L(t)_B\,/Y(t)_B = \;we^{rt}L(t)_B/bL(t)_B e^{st} = \;we^{(r-s)t}/b \tag{5}$$

While unit costs of the progressive sector, C_A, remain constant over time, unit costs of the Baumol sector, C_B, inevitably rise with the difference of the rate of productivity growth in the two sectors. The latter is dubbed Baumol's cost dis-

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[4] Baumol (1967, 418) seems to assume that nominal wages are equal to productivity growth. But we assume that real wages go up in line with productivity growth. The latter is a common assumption in macroeconomics.

ease or the Baumol effect. The greater the difference between r and the productivity growth of the stagnant sector s, the more severe is this sector contracted by Baumol's cost disease. If s equalled r, but which is excluded by assumption, Baumol's cost disease would be 'cured'. Baumol's model predicts that unit costs in the Baumol sector increase with the difference in productivity growth of the two sectors. According to a recent study by Hartwig (2008, 609) this is tantamount to say that unit costs of the Baumol sector increases in a directly proportional manner to the excess of wage increases over productivity growth of the whole economy - the so-called Baumol variable. But the latter deals with a special case as is shown below. In the following we derive an adjusted Baumol variable based on the model presented above.

Given that equation (3) holds and that the total labour input of the economy at time t, L(t), corresponds to the sum of labour inputs in sectors A and B, the succeeding equations can be derived by solving equations (1), (2) and (3) for $L(t)_A$ and $L(t)_B$:

$$L(t)_A = \frac{L(t)}{1+\gamma e^{(r-s)t}} \qquad \text{with } L(t) = L(t)_A + L(t)_B \tag{6}$$

$$L(t)_B = \frac{L\gamma e^{(r-s)t}}{1+\gamma e^{(r-s)t}} \tag{7}$$

Substituting the right-hand side of equations (6) and (7) for $L(t)_A$ and $L(t)_B$ in equations (1) and (2) leads to the following expression of the total output:

$$Y = Y(t)_A + Y(t)_B = \frac{Le^{rt}(a+b\gamma)}{1+\gamma e^{(r-s)t}} \tag{8}$$

A division of equation (8) by L yields the labour productivity of the overall economy.

$$\frac{Y}{L} = y = \frac{e^{rt}(a+b\gamma)}{1+\gamma e^{(r-s)t}} \tag{9}$$

Thus, productivity growth of the economy, ŷ, is equal to:

$$\hat{y} = \frac{r+s\gamma e^{(r-s)t}}{1+\gamma e^{(r-s)t}} \tag{10}$$

Taking both, the assumption that the growth rate of wages is assumed to be equal to r and equation (7) into account, we can derive the excess of increases in wages, ŵ, above labour productivity growth, ŷ.

$$\widehat{w} - \widehat{y} = r - \frac{r + s\gamma e^{(r-s)t}}{1+\gamma e^{(r-s)t}} = (r-s)\ \frac{\gamma e^{(r-s)t}}{1+\gamma e^{(r-s)t}} = (r-s)l(t)_B \tag{11}$$

with $l_B = L_B/L$

From equation (11) we can infer that the excess of wage growth above productivity growth cannot be equalled with the growth in unit costs of the Baumol sector, (r-s), unless the share of the Baumol sector in total labour force, $l(t)_B$, does approach 1. Thus, the Baumol variable, (ŵ- ŷ), applied in Hartwig (2008, 418) implies that virtually all labour is employed in the Baumol sector. In fact, the adjusted Baumol variable approaches the growth in unit costs of the Baumol sector asymptotically (see equation (12)).

$$\lim_{t\to\infty}(\widehat{w} - \widehat{y}) = (r-s)\ \frac{\gamma e^{(r-s)t}}{1+\gamma e^{(r-s)t}} = (r-s) \tag{12}$$

At the same time, the productivity growth of the economy approaches asymptotically the productivity growth of the Baumol sector, s. However, the transition period until this terminal equilibrium of the Baumol model can be reached is certainly long-lasting. Empirical evidence shows that though the proportion of labour employed in the progressive sectors of developed economies have been shrinking, the assumption that almost all labour is employed in the non-progressive sectors of the economy cannot be underpinned. For example the goods producing industries, which certainly can be viewed as progressive, had an average share in total hours worked across the member states of the European Union of roughly one third from 2000 to 2005 (see Appendix EU KLEMS data base). Consequently, to test Baumol's cost disease empirically one should take the share of the Baumol sector in total labour force into account. Therefore, the Baumol variable has to be adjusted by the inverse of the share of the Baumol sector in the total labour force (see equations (11) and (13)).

$$r - s = (\widehat{w} - \widehat{y})\ \frac{1}{l(t)_B} \tag{13}$$

To consistently estimate the possible impact of Baumol's cost disease on healthcare expenditure one can resort to the right-hand side of equation (13). In addition, the left-hand side of equation (13) corresponds to the growth rate of unit costs in the Baumol sector:

$$\Delta\, log\ (C_B(t)) = r - s = \frac{1}{l(t)_B}(\widehat{w} - \hat{y}) \qquad (14)$$

This assumption is necessary to exclude other price effects than Baumol's cost disease from our model. But for the service industries, researchers ascertain an incline of the ratio of real output of services to real GDP in recent decades (e.g. Machin and Kalwij, 2007). In particular, this increase is explained by the marketization- and the luxury-good hypothesis (Fuchs, 1968; Freeman and Schettkat, 2005).[5] Thus, one can draw the conclusion that medical prices are also affected by other drivers than Baumol's cost disease. Therefore, we control for these drivers in the empirical analysis.

Before we proceed further one should check if Baumol's model of unbalanced growth has some empirical merits. Some empirical results would appear to lend support to Baumol's model of unbalanced growth. For example, the average share of persons engaged in health care as of total employment of nine OECD countries has increased by around 40% from 8% in 1992 to 11% in 2007, which does not reject the hypothesis of Baumol's model of unbalanced growth. Moreover, Nordhaus (2008) concludes that an ever-greater part of the economy of the United States is contracted by Baumol's cost disease. In addition, provided that the labour market is sufficiently competitive and labour is homogenous the values of the marginal products of labour equalise across the progressive and the Baumol sector in a long-term equilibrium. Otherwise, even if demand for the services of the Baumol sector is price-inelastic the Baumol sector would vanish due to labour shortages.

3. Methods and data

The sample, which is used for the estimations, consists of 20 OECD countries within the time period from 1965 to 2007 (see Appendix). As data has not been available across all countries for the entire time period the panel is unbalanced. To avoid the seemingly not resolvable issue of determining the degree of integra-

[5] Whereas the luxurry-good hypothesis is well-known, i.e. the demand for health-care increases over-proportionally with rising income, Freeman and Schettkat (2005) provide a further exponation for a continual increase of the ratio of the real output of service sectors to real GDP the so-called marketization hypothesis. According to the latter services of private households such as cooking ironing are outsourced because the share of women in the active labour has been steadily rising. In health-care this social trend applies to long-term care. Long-term care of the elderly in their families, which has been usually provided by women, has been shifting towards institutional care.

tion of current health-care expenditure (HCE) we use growth rates instead of levels for the regressions as has been proposed by Gerdtham and Jönsson (2000). In addition, Hartwig (2008, 609) provides empirical evidence that the growth rates of per-capita HCE, gross domestic product, labour productivity and the wage rate are stationary. Therefore, to assume that the growth rates of the key variables used in this study are stationary seem to be well-grounded. Furthermore, current and not total health-care expenditure are applied because firstly, Baumol (1967) does not refer to investment expenditure in health care and secondly, the investment expenditure takes only a minor share in total health-care expenditure, which amounts to about 0.5% across 20 countries from 1970 to 2007. To avoid the difficulties in measuring medical-price indices the difference between productivity growth in the progressive and the Baumol sector, r-s, is substituted with the adjusted Baumol variable (see right-hand side of equation (13), Cutler et al., 1998, 991). Also, other drivers of HCE are taken into account so that the stochastic equation of the growth rate of per-capita HCE can be written as follows:

$$\Delta\, log\, (HCE_i(t)) = \alpha \underbrace{\frac{1}{l(t)_{B,i}} (\widehat{w}_i(t) - \hat{y}_i(t))}_{\text{adjusted Baumol varibale}} + \beta_j Z_{i,j} + u_i(t) \qquad (15)$$

with $u_i(t) = \mu_i + \lambda(t) + e_i(t)$

where i stands for country i and i:= 1,...,20, t represents time and t:= 1965,...,2007, α is the regression coefficient of the adjusted Baumol variable, $\beta_{j=0}$ is the intercept, $\beta_{j>0}$ represent the regression coefficients of health-care drivers other than the adjusted Baumol variable, $Z_{i,j}$ is a matrix of regressors of HCE drivers including the intercept, but excluding the adjusted Baumol variable, and $u_i(t)$ is the error term. If α is equal to one health care is contracted by Baumol's cost disease to full extent.[6] In the case of $\alpha = 0$ health care does not suffer from Baumol's cost disease at all. Equation (15) represents an error-component model so that the error term can be decomposed into unobserved country effects, denoted by μ_i and unobserved time effects, denoted by $\lambda(t)$and a remainder error term $e_i(t)$.

[6] Note that the coefficient α does not provide information on the severity of Baumol's cost disease (see section 2). This coefficient expresses to what extent the difference between the productivity growth of the progressive sectors and the stagnant sector impact on unit costs of the stagnant sector.

To test the robustness of results with regard to the adjusted Baumol variable we include proxies of other possible crucial drivers of HCE, which have been identified by healh economists, such as national income, the health status of the population, population ageing and medical progress in our regressions (see e.g. Oliveira Martins et al., 2006, 10 - 15). Apart from the adjusted Baumol variable all variables are expressed as first differences of logarithms. Since the cost disease represents a relative price effect the majority of estimations is carried out in real terms, i.e. at 2000 GDP price levels. However, since Baumol (1967) would appear to have constructed the model of unbalanced growth in nominal terms, we also apply nominal data. Note that we follow a recommendation by the OECD and do not convert data into purchasing power parities (PPP) because the baskets of national price indices are broader than that of PPP (see Ahmad et al., 2003, 19).

In order to construct an adjusted Baumol variable one has to determine the share of the Baumol sector in total employment. Thus, we have to make an assumption which industries epitomise Baumol's cost disease a priori. Baumol (1993, 17) cites as prime examples personal services such as the live performing arts, automotive repair, health care, social care, education, postal services and automotive repair. Also restaurant and hotel services can plausibly belong to the Baumol sector. However, for other services such as financial intermediation the validity of Baumol's cost disease might be contested. Moreover, the severity to which an industry suffers from Baumol's cost disease can vary (see section 2). As a result, long-term productivity growth in different service industries can differ substantially. For example, data of the EU KLEMS project, which provides measures on productivity growth, shows that average labour productivity growth of the tertiary sector of 15 member states of the European Union lies indeed below average productivity growth of all industries for the time period from 1970 to 2005.[7] [8] But productivity growth varies greatly across the 20 service industries included in the project, from almost 4 percentage points below the total industry average to 1 percentage points above this average. In particular, market services have grown annually by an average of 2.1% in contrast to only 1.3% of non-market services. Moreover the deviation from the average growth rate

[7] Mahony and Timmer (2009) give an overview of the EU KLEMS project.

[8] Note that the measurement of productivity growth in many service industries, in particular public services, derived from national account data such as in the EU KLEMS project suffer from major drawbacks such as measuring output and price indices (e.g. Cutler et al, 1998; Nordhaus, 2002). Nonetheless, the productivity measures of the EU KLEMS project should provide some indication of productivity growth in the service industries.

amounts to only 0.7 percentage points within the non-market sector. Given the latter, the fact that health care services are part of the non-market services and limited data availability, we concentrate only on non-market services. Thus, we define $1/l(t)_B$ as the share of non-market services, which due to data availability include services of private households, in total persons engaged in an economy in our study. Consequently due to the reasons mentioned above, we do not take into account all service industries that are possibly caught by Baumol's cost disease in the labour share variable $1/l(t)_B$.

Our estimation strategy is as follows. First, only regressions including the adjusted Baumol variable are carried out. Then, to check for the robustness of results further allegedly key drivers of health care, national income, the morbidity of the population and the ageing of the population respectively, and medical progress are succeedingly taken into account. For lack of suitable proxies different measures of medical progress are applied.

Estimations of equation (15) are performed by applying panel-data methods. Therefore, we can take country- and time-specific effects into account. To test for country- and time-specific effects we use two different tests, the Gourieroux-Holly-Monfort test and the ANOVA F test (see Baltagi, 2008, 66-68). We proceed by testing whether panel data can be consistently estimated by applying a fixed-effects or random-effects model. As usual this is carried out by applying the well-known Hausman specification test (see e.g.Baltagi, 2008, 72-74). Furthermore, we use Arellano's version of White's covariance estimator, which is robust against serial correlation and heteroscedasticity, for the fixed-effects model (see Baltagi, 2008, 16). To check for serial correlation the Breusch-Godfrey test is applied.

4. The impact of Baumol´s cost disease on HCE

Before we comment on the results concerning the relevance of Baumol's cost disease in health care some general remarks are given. The various tests show that a two-ways-fixed-effects model would appear to be best-suited for the underlying data set. This result coincides with the fact that the sample is chosen systematically. Only well-developed OECD countries are taken into account. In seven out of nine regressions the hypothesis that the random-effects model is consistent is rejected. Furthermore, the fit of the estimations improves if additional regressors are added to the estimations. The adjusted R^2 improves by 2 to 8 percentage points. The value of the adjusted R^2, which averages 36% across the estimations with real data, seems to be reasonable for a panel-data analysis. Nonetheless, if the data are converted to nominal terms the adjusted R^2 jumps to even above 60%. The latter suggest that, at least for the regressions in nominal terms, the key drivers of health care are taken into account. In addition, in order to illustrate the way the inclusion of further regressors affects the unobserved components of the estimations, the results of an arbitrarily chosen country and time effect are reported in the tables below.[9]

4.1. Macroeconomic effects

The macroeconomic effects on health-care encompass the Baumol effect, which is predicted by Baumol's model of unbalanced growth and the impact of aggregate demand on health care, which is the most undisputed driver of HCE. However, it remains controversial if health care is a necessity or a luxury good (see Getzen, 2000, 259-60). In our study we use per capita gross domestic product (GDP) as a proxy for per capita national income. Both the estimations with and without per capita GDP show that the adjusted Baumol variable exerts a positive influence on the growth rate of per capita HCE (see Table 1).

Independently from the fact that the growth rate of per capita GDP enters the estimated equation the coefficient of the Baumol variable is highly statistically significant and remains fairly stable at 0.15. This suggests that the health-care sector is partly contracted by Baumol's cost disease. As is expected, per capita GDP is highly statistically significant. What is surprising is that the coefficient of per-capita GDP, which can be defined as income elasticity remains well-below one. Usually, an income elasticity above one is estimated at the aggregated national level (see Oliviera-Martins et al., 2006, Annex 2b). This seems to be due to the inclusion of the adjusted Baumol variable. This comes as no surprise as the Baumol effect can be defined as a relative price effect. Our findings do not change substantially if the variables are estimated in nominal terms (see Table 1).

4.2. Sensitivity analysis – adding further explanatory variables

To test the sensitivity of the findings concerning the adjusted Baumol variable further possibly crucial cost drivers of HCE such as population ageing are added

[9] The findings of the remainder country- and time effects are available upon request from the author.

to the regressions. Empirical evidence provided by several studies suggests that the impact of population ageing, which is frequently cited as a factor, on HCE is grossly overstated because the corresponding studies do not take a person's time remaining to death into account (see Zweifel et al., 1999, 485 - 87). The latter is viewed as paramount by the proponents of the so-called 'red-herring' hypothesis (e.g. Werblow et al. 2007, 1125).[10] As this present paper does not focus on this controversy we adopt the position put forward by Dormont et al. (2006, 950). They claim that time to death is a rough indicator for the morbidity of the population and that the morbidity level is increasing with age. Thus, population ageing can be viewed as a proxy for a changing morbidity level of the population. In other words population ageing represents the health status of the population. Furthermore, to find suitable measures of medical progress is challenging (see Dormont et al., 2006, 948). Therefore, we adopt a three-tier approach with respect to medical progress. Firstly, it seems to be reasonable to think that global medical progress should be reflected in the time-specific effects of the regression if no explanatory variable for medical progress is included in the regression equation. This is due to the fact that medical innovations in one OECD country probably spill-over to other OECD countries. Moreover, if medical innovations remain within the boundaries of a single country their impact should be reflected in the country-specific effects. However, these effects can also encompass the impact of other cost drivers such as policy reforms in health-care or price shocks of the commodities markets. Secondly, we apply proxies, though incomplete, for medical progress. These are life expectancy, infant mortality and the death rate of the population. These variables have been used before as proxies for medical progress (see Dreger and Reimers, 2005, 6). Medical advances should prolong life expectancy and reduce infant mortality and death rates of the population. However, they are incomplete insofar as they are also influenced by other factors such as the nutrition behaviour of the people. Moreover, they also represent indicators for the health status of the population. Thirdly, we apply expenditure of the pharmaceutical industry on research and development to our study. Total expenditure on research and development in health care could not be included in the analysis due to limited data availability.

The regressions with additional drivers of per capita HCE confirm the above result that Baumol's cost disease does not impact HCE to full extent (see Table 2). The coefficient of the adjusted Baumol variable is statistically significant at a 1% significance level and varies between 0.16 and 0.20. Thus, a one-percentage-point excess of the growth rate of real wages over productivity growth adjusted

[10] These authors claim that the impact of population ageing on HCE was a 'red herring'.

by the inverse of the share of non-market services in total employment causes around 0.2 percentage-points increase in the growth rate of per-capita HCE. Furthermore, the coefficient of per-capita GDP is highly statistically significant across the estimations shown in table 2. As in the regressions above, the income elasticity remains well-below one (see Table 2).

The coefficient of population ageing, which can serve as a proxy for the health status of the population, is significant at a 1% level across all estimations in Table 2 but one. This result coincides with previous findings (see e.g. Oliviera Martins et al, 2006, 76). A one-percent increase in the share of the 65 year old and above leads on average to a rise in per capita HCE by about 0.3%. Only two out of four proxies for medical progress, infant mortality and per capita pharmaceutical R&D expenditure show a significant coefficient, albeit only at a 10% level. Both, infant mortality and pharmaceutical R&D expenditure have the expected sign. The time specific effect of 2007, which is shown in Table 2, is considerably lower in the estimations including a statistically significant proxy for medical progress. The latter indicates that the impact of medical progress is captured by time specific effects if no variable for medical progress is included in the regression. Country-specific effects do not seem to reflect medical progress, which is plausible. Moreover, this finding suggests that medical progress is globalised, which seems to be in view of globalised markets, for instance, in the pharmaceutical industry reasonable (see Table 3).

Furthermore, the findings of the Hausman specification test suggest that a random-effects model may be more suited in the case of the regressions with the death rate and R&D expenditure. Therefore, additional regressions using random-effects models are carried out (see Table 3).[11] Overall, the results do not change substantially. The notable exception is population ageing, which is not found to be as statistical significant as in the fixed-effects regressions. Though this means that population ageing is less robust to different specifications of the estimated equation as the macroeconomic variables, the adjusted Baumol variable and GDP, overall this present analysis suggest that population ageing is still a crucial driver of HCE.

[11] Note that we only apply a random time-effects model. The choice of the time period for every country can be viewed as random since the time length is given by the availability of data. In contrast, countries are not randomly selected as the selection is based on the maturity of their economies. For example, emergent economies are excluded from the sample of this analysis.

5. Conclusion

This analysis demonstrates that although the health-care sector is caught by Baumol's cost disease, this effect does not come fully into effect. This result is extremely robust against different specifications of the estimated equation. According to our findings a one percentage-point increase in the excess of wage growth over productivity growth in health care should raise the growth rate of per capita HCE by almost 0.2 percentage-points. In particular, we avoid using, in all likelihood, biased medical price indices. Instead we have derived a term, which is dubbed the adjusted Baumol variable, from Baumol's (1967) model of unbalanced growth. The adjusted Baumol variable would appear to be an appropriate proxy to measure the impact of Baumol's cost disease on health care. At first sight the findings of this analysis seem to conflict with a recent empirical study by Hartwig (2008), which provides evidence in favour of a full Baumol effect. However, the latter study makes the implicit assumption that the nominal value-added of the Baumol industries make up close to 100% of nominal GDP. In view of the actual data this assumption would seem to be unreasonable.

Furthermore, our study provides evidence that health care is rather a necessity than a luxury at the national level. This is somewhat surprising because most of the studies find that the income elasticity is above one at the national level (e.g. Getzen, 2000). This can be due to the inclusion of the adjusted Baumol variable. In addition, this present study offers evidence for a cost-driving impact of medical progress.

Since Baumol's cost disease impacts HCE growth in a less than proportional manner the fact that inflation in health care outstrips nationwide inflation by far cannot be caused by Baumol's cost disease as has been suggested in the literature (Hartwig, 2008 and 2009). This lends support to the view that inflation in health care and in most service industries is overestimated due to difficulties in constructing reasonable price indices in some service industries such as health care (Cutler et al. 1998; Triplett and Bosworth, 2003). Rather HCE seems to be predominantly quantity-driven. Consequently, policy-makers have more room for manoeuvre to curb ever-increasing HCE. Since the application of the adjusted Baumol variable avoids the flaws of constructing price indices in the service industries it can be viewed as an extremely appropriate tool to test the validity of Baumol's cost hypothesis also in other service industries such as education.

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Appendix A

Health-care and demographic data stem from the OECD Health Data base of November 2009. Macroeconomic variables, i.e. gross domestic products, value added of different industries and compensation of wages, originate from the OECD Annual National Accounts of November 2009. Moreover, employment data has been extracted from the Total Economy Database of the Conference Board and Groningen Growth and Development center of June 2009. Finally, productivity data stem from the EU KLEMS data base (see www.euklems.net).

The sample include the following countries: Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Republic of Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK and the USA. Belgium and New Zealand have been excluded from the sample due to a lack of data. Luxembourg and Iceland have not been chosen due to their comparatively small populations (450 000 and 289 000 respectively). All estimations have been carried out with the packages plm and nlme of the open-source software R 2.10.1 (see http://stat.ethz.ch/CRAN/welcome.html).

Appendix B

Table 1: Drivers of per capita current health-care expenditure - the Baumol effect

Model	Static two-ways FE			
Unit	at 2000 GDP price levels		in nominal terms	
Dependent Variable	Log difference of HCE per capita			
adj. Baumol variable	0.153*** (0.020)	0.155*** (0.019)	0.109*** (0.022)	0.143*** (0.031)
GDP per capita		0.421*** (0.087)		0.522*** (0.079)
country effect Australia	0.040*** (0.006)	0.031*** (0.007)	0.073*** (0.007)	0.041*** (0.007)
time effect 2007	0.031*** (0.007)	0.021*** (0.007)	0.053*** (0.007)	0.025*** (0.007)
adj. R^2	0.32	0.36	0.62	0.68
No. of obs.	425	425	425	425
Breusch-Godfrey test	18.12*** (0.002)	19.3*** (0.002)	92.7*** (0.0)	18.76*** (0.002)
GHM test (2-ways vs. pooling)	1512*** (0.0)	586*** (0.0)	15081*** (0.0)	1157*** (0.0)
F test (time vs. pooling)	1.25 (0.16)	1.73*** (0.006)	7.06*** (0.0)	2.83*** (0.0)
F test (country vs. pooling)	4.17*** (0.0)	1.96*** (0.009)	8.88*** (0.0)	1.53* (0.07)
Hausman test (FE vs RE country)[a]	15.5*** (0.0)	15.7*** (0.0)	31.9*** (0.0)	n.a.
Hausman test (FE vs RE time)[a]	6.93*** (0.008)	12.3*** (0.002)	9.58*** (0.002)	n.a.

Note: Estimation technique: Within-estimator using Arellano's HAC-estimator to deal with autocorrelations and heteroscedasticity; all variables are in first differenced logarithms; adjusted Baumol variable:= (real wage rate - labour productivity) * 1/(share of Baumol sector in total employment).

***:= 1% significance level; **:= 5% significance level; *:= 10% significance level.

t-tests: figures in parentheses are SE; Breusch-Godfrey test on serial correlation, H0: no serial correlation, chi-sqare statistic; Gourieroux-Holly-Monfort (GHM) test on country and time effects, H0: no significant effects, chi-sqare test statistic; F-test on country effects and time effects respectively, H0: no significant effects; Hausman test on fixed-effects (FE) vs. random-effects (RE) model, H1: RE model is inconsistent, chi-sqare test statistic; Shapiro-Wilk normality test, H0: Gaussian distribution, W-test statistic; across all tests: figure in parentheses is p-value.

[a]:= Only one-way RE models are available in applied statistical software.

Table 2: Drivers of per capita current health-care expenditure - sensitivity analysis

Model	Static two-ways FE at 2000 GDP price levels				
Dependent Variable	Log difference of HCE per capita				
adj. Baumol variable	0.157*** (0.034)	0.187*** (0.034)	0.156*** (0.035)	0.174*** (0.034)	0.195*** (0.040)
GDP per capita	0.414*** (0.073)	0.512*** (0.090)	0.426*** (0.078)	0.441*** (0.069)	0.651*** (0.091)
65 years old and over to total population	0.384*** (0.123)	0.253*** (0.004)	0.359*** (0.122)	0.287*** (0.094)	0.178* (0.105)
Infant mortality		-0.031* (0.019)			
Life expectancy			0.253 (0.627)		
Death rate				-0.088 (0.082)	
R & D for pharmaceuticals					0.018* (0.010)
country effect Australia	0.027*** (0.007)	0.025*** (0.007)	0.026*** (0.007)	0.025*** (0.007)	0.024*** (0.007)
time effect 2007	0.017** (0.007)	0.012 (0.008)	0.021** (0.008)	0.025** (0.012)	-0.009 (0.020)
adj. R^2	0.34	0.36	0.37	0.38	0.40
No. of obs.	425	396	411	400	224
Breusch-Godfrey test	18.49*** (0.002)	7.87** (0.020)	17.4*** (0.004)	14.61** (0.012)	0.270 (0.61)
GHM test (2-ways vs. pooling)	675*** (0.0)	1469*** (0.0)	1377*** (0.0)	881*** (0.0)	1738*** (0.0)
F test (time vs. pooling)	1.77*** (0.0)	1.99*** (0.0)	1.91*** (0.002)	1.69*** (0.009)	1.85** (0.012)
F test (country vs. pooling)	2.06*** (0.005)	2.08*** (0.005)	1.93** (0.011)	2.04*** (0.006)	1.73** (0.039)
Hausman test (FE vs RE country)[a]	19.75*** (0.0)	25.5*** (0.0)	18.38*** (0.001)	8.58* (0.07)	3.860 (0.42)
Hausman test (FE vs RE time)[a]	19.7*** (0.0)	13.0** (0.011)	11.49** (0.022)	2.490 (0.47)	2.210 (0.53)

Note: Estimation technique: Within-estimator using Arellano's HAC-estimator to deal with autocorrelations and heteroscedasticity; all variables are in first differenced logarithms and at 2000 GDP price levels; adjusted Baumol variable:= (real wage rate - labour productivity) * 1/(share of Baumol sector in total employment).
***:= 1% significance level; **:= 5% significance level; *:= 10% significance level.
See Note Table 2.

Table 3: Drivers of per capita current health-care expenditure - random effects model

Model	Static one-way (time-effects) RE at 2000 GDP price levels	
Dependent Variable	Log difference of HCE per capita	
Random effects	Maximum-likelihood estimator	Swamy-Arora feasible GLS
adj. Baumol variable	0.186*** (0.0)	0.212*** (0.027)
GDP per capita	0.522*** (0.0)	0.631*** (0.099)
65 years old and over to total population	0.185* (0.065)	0.166 (0.131)
Death rate	-0.056 (0.067)	
R & D for pharmaceuticals		0.021* (0.013)
adj. R^2	0.38	0.32
No. of obs.	400	224
Breusch-Godfrey test	14.40** (0.01)	0.275 (0.60)

Note: Estimation technique: MLE:= maximumum likelihood estimator with error-correlation structure; GLS:= generalized least squares; all variables are in first differenced logarithms and at 2000 GDP price levels; adjusted Baumol variable:= (real wage rate - labour productivity) * 1/(share of Baumol sector in total employment).

***:= 1% significance level; **:= 5% significance level; *:= 10% significance level.

see Note Table 2.

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