ONLINE APPENDIX of the SSQ-Article "Drivers of Healthcare Expenditure: What Role Does Baumol's Cost Disease Play?" by Carsten Colombier

Appendix A

Table A.1: Descriptive statistics

Variable	Min.	Median	Mean	Max.	Stand. dev.	Observations
HCE per capita	-0.16	0.03	0.04	0.29	0.04	678
adj. Baumol variable (total services)	-0.17	0.000	0.002	0.20	0.04	691
adj. Baumol variable (community, social & personal services)	-0.51	-0.001	0.006	0.55	0.10	691
GDP per capita	-0.19	0.02	0.02	0.12	0.03	806
Share of the over-64-year-olds	-0.03	0.01	0.01	0.10	0.01	820
No. of acute bed-days per capita	-0.24	0.00	-0.02	0.17	0.05	533
Density of physicians	-0.09	0.03	0.03	0.19	0.03	585
Infant mortality	-0.37	-0.04	-0.04	0.23	0.06	783
Life expectancy	-0.01	0.00	0.00	0.03	0.00	770
Productiviy manufacturing	-0.14	0.03	0.03	0.21	0.04	670
Trade-union density	2.02	3.52	3.48	4.43	0.59	795
False adj. Baumol variable (total services)	-0.97	0.06	0.07	1.49	0.18	574

Notes: All macroeconomic variables are provided at 2005 GDP price levels. Except for the adjusted Baumol variable, all variables are given in logarithms and first differences. The adjusted Baumol variable corresponds to the difference of the economy-wide productivity- and wage growth rate adjusted by the inverse of the employment share of the respective Baumol sector.

Table A.2: Panel unit root tests of further explanatory variables

Variable	Unit root test	Test statistic		Time span	No. of countries
		Levels	First differences		
Share of the over-64-years-old	PCADF	0.38	-0.73	1970-2010	20
	PANICC	-2.57	-4.43***		
	PMSB	2.40	-1.43***		
No. of acute bed-days per capita	PCADF	2.29	-9.10***	1985-2009	13
	PANICC	-2.48	-4.85***		
	PMSB	-1.62***	-2.00***		
Density of physicians	PCADF	0.24	-4.48***	1981-2006	14
	PANICC	-2.75*	-4.09***		
	PMSB	2.16	-1.59***		
Infant mortality	PCADF	1.91	-9.89***	1970-2010	20
	PANICC	-0.97	-4.58***		
	PMSB	0.60	-2.41***		
Life expectancy	PCADF	4.41	-6.16***	1970-2010	20
	PANICC	-1.94	-5.36***		
	PMSB	2.30	-2.48***		
Death rate	PCADF	4.33	-9.09***	1970-2003	20
	PANICC	-2.66*	-6.88***		
	PMSB	-0.50***	-3.05***		
Productivity manufacturing	PCADF	3.85	-6.50***	1997-2007	18
	PANICC	-2.15	-5.01***		
	PMSB	0.99	-2.97***		
Trade-union density	PCADF	1.70	-9.12***	1976-2010	20
	PANICC	-0.81	-3.55***		
	PMSB	1.48	-2.90***		
'False' adj. Baumol variable (total services)	PCADF	-6.11***	-22.5***	1980-2006	15
	PANICC	-4.89***	-6.29***		
	PMSB	-2.41***	-2.57***		

Notes: see footnotes of Table 1. The tests for unit roots require continuous time series. Due to the availability of data we had to shorten either the country time series or reduce the number of countries or both for the following explanatory variables: the number of acute bed-days per capita, the density of physicians, the death rate, the labour productivity of the manufacturing industry, the trade-union density and the 'false' adjusted Baumol variable.

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

Table A.3: Lee-Stazicich-unit root test for individual time series of per capita current healthcare expenditure at 2005 GDP price levels

Countries	Test statistic levels	first differences	second differences	years of possible structural breaks
AUS	-4.59	-8.65***	-12.44***	1978, 1997
AUT	-5.68*	-6.71***	-6.42***	1977, 2005
CAN	-5.27	-5.50*	-6.28**	1991, 1998
DEN	-5.28	-9.91***	-5.27	1981, 1997
FIN	-4.29	-6.66***	-7.28***	1988, 1996
FRA	-4.16	-7.75***	-6.37***	1975, 1987
GER	-4.41	-7.70***	-5.32	1976, 1990
GRE	-5.58*	-7.63***	-7.67***	1988, 2003
IRE	-6.04**	-5.20	-5.67*	1998, 2003
ITA	-4.60	-6.91***	-6.75***	1989, 1998
JAP	-6.85***	-6.90***	-7.71***	1992, 1998
KOR	-4.91	-6.07**	-7.39***	1986, 1994
NED	-4.00	-6.54***	-5.17	1989, 1996
NOR	-3.89	-7.58***	-6.13**	1979, 1997
POR	-5.83**	-7.71***	-6.55***	1978, 2003
SPA	-4.47	-7.36***	-4.90	1974, 1985
SWE	-3.73	-6.74***	-4.25	1983, 1999
SWI	-7.34***	-7.09***	-8.38***	1989, 1992
UKD	-7.51***	-8.10***	-6.10**	1985, 1988
USA	-4.78	-6.22***	-4.48	1989, 2000

Notes: The unit root test according to Lee and Stazicich (2003) allows for two structural breaks in a time series. H0: unit root.

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

Table A.4: Panel unit root tests of per capita current healthcare expenditure, per capita GDP at current price levels for 20 OECD countries from 1970 to 2010[a]

Variable	Unit root test	Test statistic Levels	First differences	Second Differences
HCE per capita	PCADF	-0.03	-8.18***	-1.19***
	PANICC	-2.00	-3.00**	-3.33***
	PMSB	-0.83***	-2.54***	-1.93***
GDP per capita	PCADF	2.02	-2.52***	-0.60
	PANICC	-2.48	-3.73***	-3.74***
	PMSB	-0.63***	-2.80***	-0.73***

Notes: see footnotes of Table 1.

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

[a] Since labour productivity and the wage rate are deflated by the same deflator - the GDP deflator – the real and nominal adjusted Baumol variable coincide.

Table A.5: Testing the difference of the productivity growth between the service industries and the manufacturing industry from 1970 to 2010 for 20 OECD countries

Industry 1	Sample average	Industry 2	Sample average	Hartung's combinig t statistic (p-value)
Manufacturing	2.13	Total services	1.50	2.46*** (0.007)
Manufacturing	2.13	Community, social and personal services	1.44	2.66*** (0.004)
Total services	1.50	Community, social and personal services	1.44	0.25 (0.40)

Notes: Panel Wilcoxon rank sum test, H0: no significant difference between sample averages; labour productivity is measured as value-added per employee and is deflated by the GDP deflator. The panel Wilcoxon rank sum test is constructed by using a well-established method by Hartung (1999). Based on Hartung's proposal we combine country-wise estimated Wilcoxon rank sum test statistics and estimate a common test statistic. A benefit of Hartung's combining t test is that it allows for stochastically dependent individual test statistics.

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

Table A.6: Estimations including the trade union density as an explanatory variable

Dependent Variable	Log difference of HCE per capita at 2005 GDP price levels	
Instrumented regression	no	yes
adj. Baumol variable	-	0.37*** (0.09)
GDP per capita	0.40*** (0.07)	0.54*** (0.07)
Share of the over-64-year-olds	0.24 (0.17)	0.46** (0.19)
No. of acute bed-days per capita	0.07** (0.03)	0.05** (0.03)
Trade union density	0.01 (0.04)	-0.05 (0.03)
adj. R^2 (as%)	28	30
No. of obs.	467	365
Sargan's test		0
Stock & Watson's rule of thumb (F test)		21.2
Hausman–Wu test		8.16***
Breusch–Godfrey test	20.9**	7.34
GHM test (2-ways vs. pooling)	935***	1339***
F test (time vs. pooling)	1.18	1.67**
F test (country vs. pooling)	2.50***	1.36
Normality test	0.92***	0.89***

Notes: see footnotes of Tables 2 and 5. Note that we instrument the adjusted Baumol variable with the contemporaneous time date and the first lag of the productivity growth of manufacturing.
***:= 1% significance level; **:= 5% significance level; *:= 10% significance level.

Table A.7: A "Falsification" test

Dependent Variable	Log difference of HCE per capita at 2005 GDP price levels		
Model	I	II	III
False adj. Baumol variable	-0.02 (0.013)	-0.02 (0.013)	-0.02 (0.016)
GDP per capita	0.43*** (0.07)	0.41*** (0.07)	0.38*** (0.08)
Share of the over-64-year-olds	0.44** (0.18)	0.44** (0.18)	0.34* (0.19)
No. of acute bed-days per capita	0.06** (0.03)	0.06** (0.03)	
Infant mortality	-0.05* (0.03)		
adj. R^2 (as%)	25	25	28
No. of obs.	332	332	475
Breusch–Godfrey test	7.03	7.15	18.5*
GHM test (2-ways vs. pooling)	1503***	1500***	535***
F test (time vs. pooling)	1.91***	1.86***	2.62***
F test (country vs. pooling)	1.23	1.26	1.55*
Hausman test (FE vs RE)	2.35	1.67	499***
Normality test	0.93***	0.92***	0.95***

Notes: see footnotes of Table 2. We carry out a so-called "Falsification" test with the false adjusted Baumol variable. The false adjusted Baumol variable corresponds to the difference of the productivity growth between the industries 'electrical and optical equipment' and 'basic metals and fabricated metals' that replaces the adjusted Baumol variable adjusted by the employment share of total services. A statistically positively significant coefficient of the ‘false’ Baumol variable would suggest reversed causality and not the fact that the health care sector suffers from the cost disease.
***:= 1% significance level; **:= 5% significance level; *:= 10% significance level.

Table A.8: Estimations with the data set of 50 U.S. states by Bates and Santerre (2013) (BS, 2013) – a comparison with the approach by BS (2013)

Dependent Variable	Log difference of HCE per capita at current price levels			
Adjustment of dependent variable[a]	yes (BS, 2013)	no	yes (BS, 2013)	no
Instrumented regression	no	no	yes	yes
Baumol variable	0.008*** (0.003)		0.07*** (0.01)	
adj. Baumol variable		0.003 (0.003)		0.08*** (0.02)
95%-confidence interval of the (adj.) Baumol variable	[0.002,0.012]	[-0.001,0.008]	[0.04, 0.09]	[0.03,0.12]
GDP per capita	0.009*** (0.002)	0.12*** (0.04)	0.05*** (0.002)	0.97*** (0.05)
Share of the over-64-year-olds	0.002*** (0.005)	0.17*** (0.05)	0.04*** (0.005)	0.91*** (0.11)
Unemployment rate	0.00009 (0.0003)	-0.002 (0.005)	0.003*** (0.004)	0.05*** (0.007)
Trade union density	-0.00006 (0.003)	-0.003 (0.005)	0.0002 (0.0002)	0.005 (0.008)
Poverty rate	0.000004 (0.0002)	-0.001 (0.003)	0.0002 (0.0002)	0.002 (0.005)
adj. R^2 (as%)	64	69	52	42
No. of obs.	1450	1450	1352	1352
Sargan‘s test	-	-	n.a.	n.a.
Stock & Watson’s rule of thumb (F test)	-	-	2.66	0.80
Hausman–Wu test	-	-	8.74***	10.5***
Breusch–Godfrey test	536***	87.7***	82.2***	74.4***
GHM test (2-ways vs. pooling)	3347***	3158***	5242***	3125***
F test (time vs. pooling)	16.6***	2.12***	4.91***	0.37
F test (country vs. pooling)	14.4***	43.8***	46.5***	8.31***
Normality test	1.00***	1.00***	0.98***	0.85

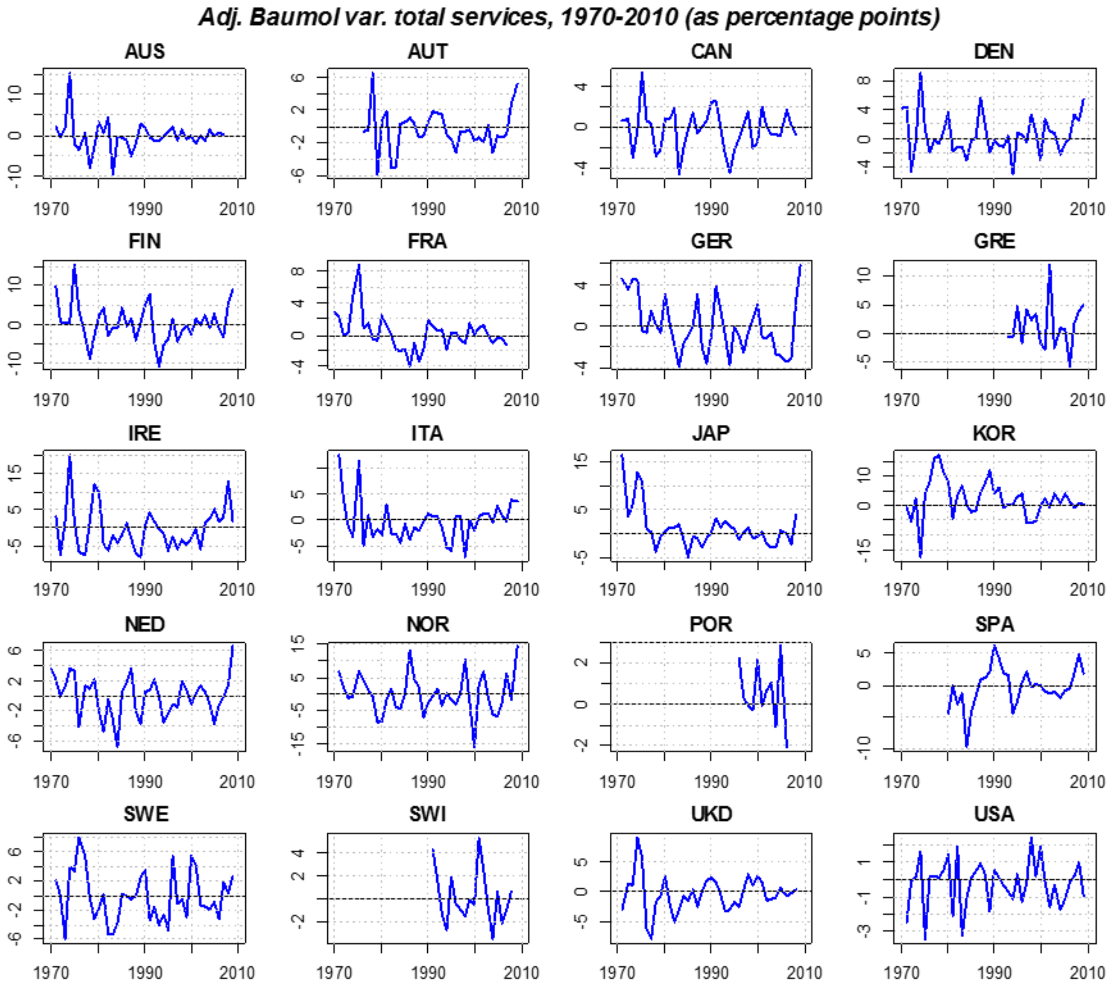
Notes: see footnotes Table 5. Note that our approach differs from BS (2013) in the following way: while we adjust the Baumol variable, BS (2013: 389) adjust the dependent variable, i.e. per capita HCE by the share of the stagnant sector in total employment. Note that BS (2013) assume that the stagnant sector comprises only healthcare. Consequently, the coefficient of the Baumol variable is lower than in our estimations (see Table 3 and Appendix B). Adjusted Baumol variable (per employee):= (wage-rate growth – labour-productivity growth) * 1/(share of Baumol sector in total employment). Baumol sector:= healthcare services.

As the data by BS (2013) are only available at current prices, we carry out the estimations in nominal terms. We use the instrument proposed by BS (2013), i.e. the housing prices of the U.S. states lagged by two years. Note that BS (2013) use a clustered covariance, which is robust to heteroscedasticty but not to serial correlation. In contrast, we use Arellano’s HAC estimator, which also deals with serial correlation (see footnotes of Table 2). Moreover, our method for the instrumented regressions differs from the one taken by BS (2013) (see footnotes of Table 5).

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

[a] Since BS (2013) adjust the dependent variable per capita HCE by the employment share of the Baumol sector, except for the Baumol variable, the coefficient of each explanatory variable has to be corrected in order to estimate the true correlation with per capita HCE. In contrast, BS (2013, 389) argue that the coefficient of the Baumol variable should be adjusted. However, this coefficient represents already the true relationship between the Baumol variable and per capita HCE adjusted by the employment share of the Baumol sector. Thus, under the setting of BS (2013) the coefficient of the Baumol variable is equal to the one of the adjusted Baumol variable in our approach.

Figure A.1: Adjusted Baumol variable (total services) across 20 OECD countries



Source: OECD, own calculations.

Appendix B: Multiple Baumol industries

The total labour supply of the economy can be written as follows:

$$L = L_A + \sum_{j=1}^{m} L_{B_j} \quad \text{with } L_{B_1} = \frac{L\gamma_1 e^{(r-s_1)t}}{1+\sum_{j=1}^{m} y} \tag{B.1}$$

whereby: s_j:= productivity growth of the j^{th} Baumol industry

γ_j:= real value-added of the j^{th} Baumol industry divided by real GDP

If one assumes that the production technology of the j^{th} Baumol industry corresponds to equation (2), the labour productivity of the overall economy can be written as follows:

$$y = \frac{e^{rt}(a + \sum_j b_j * \gamma_j)}{(1+\sum_j \gamma_j e^{(r-s_j)t})} \tag{B.2}$$

First differencing of equation (B.2) leads to the following growth rate of labour productivity:

$$\hat{y} = r - \sum_j \frac{L_{B_j}}{L}(r - s_j) = r - \sum_j l_{B_j}(r - s_j) \tag{B.3}$$

The difference between the growth rate of real wages and the productivity growth is as follows:

$$\hat{w} - \hat{y} = \sum_j l_{B_j}(r - s_j) \tag{B.4}$$

If one presupposes that the productivity growth of the Baumol industries is small or close to zero, one can plausibly assume that $s_j \approx s_i$ for $j \neq i$. Consequently, one can write an approximated adjusted Baumol variable, which is equivalent to the one for a single Baumol industry (see equation (13)):

$$\frac{(\hat{w} - \hat{y})}{\sum_j l_{B_j}} = r - s \tag{B.5}$$

Equation (B.5) reveals why it is important to know the size of the whole Baumol sector to estimate the impact of Baumol's cost disease.