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ORIGINAL PAPER

The sustainability of European health care systems: beyond income and aging

Fabio Pammolli · Massimo Riccaboni · Laura Magazzini

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Abstract During the last 30 years, health care expenditure (HCE) has been growing much more rapidly than GDP in OECD countries. In this paper, we review the determinants of HCE dynamics in Europe, taking into account the role of income, aging population, technological progress, female labor participation and public budgetary variables. We show that HCE is a multifaceted phenomenon where demographic, social, economic, technological and institutional factors all play an important role. The comparison of total, public and private HCE reveals an imbalance of European welfare toward the care of the elderly. European Governments should increasingly rely on pluralistic systems to balance sustainability and access and equilibrate the distribution of resources across the functions of the public welfare system.

Keywords Health care expenditure · Sustainability · Aging population · Unbalanced growth · Income elasticity · Welfare

F. Pammolli (✉)
IMT Lucca Institute for Advanced Studies,
Piazza San Ponziano, 6, 55100 Lucca, Italy
e-mail: pammolli@gmail.com

F. Pammolli
Fondazione CERM, via Poli 29, 00187 Rome, Italy

M. Riccaboni
DISA, University of Trento, Via Inama, 5, 38122 Trento, Italy
e-mail: massimo.riccaboni@unitn.it

L. Magazzini
Department of Economics, University of Verona,
viale dell'Università 3, 37129 Verona, Italy
e-mail: laura.magazzini@univr.it

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Introduction

During the last 30 years health care expenditure (HCE) has been growing much more rapidly than GDP in all OECD countries. All major international experts, including the OECD and the Working Group on Ageing Population of the European Commission, pose serious concerns about long-term sustainability of current trends, urging reforms of the health care system [29].

Since the seminal works of Baumol [5] and Newhouse [34, 35], the availability of international data on HCE has encouraged the development of several studies to explain the trend and determinants of HCE levels and growth. A wide array of factors has been taken into consideration, including demography, income, institutions and technological change [18, 31].

Not surprisingly, income is the prominent factor behind cross-country differentials in HCE. The magnitude of income elasticity is crucial to ascertain whether health is a luxury good (income elasticity above one) or a necessity (income elasticity below one). Unfortunately, this issue is largely unresolved, and empirical investigations which rely on different data, time frames and methodologies have come to conflicting results. Furthermore, it has been noticed that income elasticity of health spending increases with the level of aggregation, where the income elasticity of HCE at the individual level is typically near zero or negative (for insured people), while at the national level this is typically greater than one [13, 19]. Even more importantly, there is still a lack of theoretical models of the relationship between HCE and GDP growth, one

remarkable exception being the Baumol's model of "unbalanced growth" [5, 23].

Demography, institutions and technological change have been identified as important drivers of the rising HCE too. In particular, the relationship between population age and HCE has been largely explored by the empirical literature. Nonetheless, previous studies relying on the composition of the population in terms of age cohorts to measure the effect of an aging population are not consensual (see [10] for a review).[1] The aging population is caused by the increase in life expectancy and decrease in fertility rates. Both effects are made possible by improved living conditions and technological progress [44]. Besides that, fertility rates are related to socio-cultural factors, resources allocated to social services for the younger population as well as female labor participation [28].

In light of the HCE pressure, a number of reforms and HCE control policies have been recently passed to guarantee the financial sustainability of health systems. However, the impact of such measures is still largely debated [12, 14, 43].

In this paper, we take a broader perspective with respect to existing literature to jointly investigate the effect of income and productivity growth, aging, technological progress, women labor participation, as well as institutional factors as determinants of HCE dynamics. The focus is on the European countries, and we aim at assessing the elasticity of HCE to income controlling for a wide set of possible explanations. We perform separate econometric analysis of the level of total, public and private HCE. Our study casts new light on the effect of aging population and technological change in national specific institutional settings, as well as on the impact of female labor participation upon European HCE.

The paper is organized as follows. The next section introduces the data and the main research hypotheses underlying the explanatory variables included in the analysis. Section III describes the methodology and reports the results of our analysis. Section IV concludes, discussing some tentative policy implications of our work.

The determinants of HCE

The paper aims at identifying and possibly disentangling the key factors driving HCE dynamics in Europe to pinpoint the main areas of policy intervention to guarantee its long-term sustainability. Different equations have been estimated in a panel of EU-15 countries for total, public and private HCE in the period 1980–2007.[2]

We combine data from different sources (see Table 1). Data on HCE come from the OECD health data.[3] Per capita expenditure is considered, parity purchase parity (PPP). To deflate HCE at constant 1995 prices, we applied the "Health and social work" (ISIC rev. 3 class 85) industry-specific value added deflator from the EU KLEMS database.[4] The GDP deflator comes from the same data source; the figure for "All industries" is considered.

Different regression settings have been designed to identify and compare key drivers of HCE. Five broad explanatory factors have been taken into account: (a) national income (GDP) and the Baumol's "unbalanced growth" hypothesis; (b) aging of the population; (c) technological progress; (d) women labor participation; (e) composition of the welfare system and other public budgetary variables.[5]

Income and unbalanced growth

Since Baumol [5], most studies have documented a positive relation between GDP and HCE. However, as stressed by Hartwig [23], the evidence of a correlation between HCE and GDP does not tell much about any clear causal relationship. It can be argued that the higher HCE, the healthier the population. On the other hand, a healthier population is likely to be more productive and GDP per capita could grow as an effect of an increase in HCE. If this effect is not taken into account, econometric techniques can lead to biased and inconsistent results.

Income elasticity of health care demand and expenditure lies at the heart of a lively debate, focusing on whether health care is a "luxury good" in developed countries. The answer has important policy implications in terms of HCE growth and public finances sustainability. Some recent contributions point to the fact that health spending might well be a superior good, since it allows individuals to live

[1] As a tentative explanation, micro-level studies have shown that it is not age per se that is relevant in explaining HCE, rather remaining lifetime.

[2] Even though OECD data on health care expenditures cover a longer time span, information on the dependent variable is available for a limited set of countries before 1980, and the deflators provided by EU KLEMS database is available up to the year 2007. The list of EU-15 Countries follows: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.

[3] OECD Health Data available at http://www.ecosante.org/oecd.htm (edition 2010).

[4] Data are available at http://www.euklems.net (November 2009 edition). Data are available over the period 1970–2007. See O'Mahony and Timmer [38] for information about the methodology and construction of the database. See also [24]

[5] In principle, life habits should also be considered. However, due to lack of internationally comparable data and strong correlation with countries' GDP we did not find any significant effect on HCE.

Table 1 Descriptive statistics, EU-15 countries, 1980–2007

	Obs.	Mean	S.E.	Min.	Max.	Source
Dependent variables						
THE: total per capita HCE, PPP, deflated[a]	320	1623.3	521.3	887.3	3645.7	OECD
PHE: total per capita HCE, PPP, deflated[a]	314	1244.9	459.3	543.1	2813.1	OECD
PrHE: total per capita HCE, PPP, deflated[a]	309	392.1	154.9	115.1	947.3	OECD
Independent variables						
(a) Income						
GDP: total per capita HCE, PPP, deflated[a]	363	21644.0	6677.2	11534.3	79073.0	OECD
BAUMOL: ratio of labor productivity and wage as in Hartwig [23]	351	504.7	143.8	42.9	812.4	OECD
(b) Aging						
POP65: % share of population over 65	364	14.8	2.03	10.7	20.0	OECD
(c) Technological progress						
SC.PUB: number of biomedical publications per 1,000 inhabitants	364	0.495	0.758	0.001	7.603	PubMed; OECD
(d) Female labor participation						
FLPR: female labor participation rate	364	47.2	9.2	27.5	63.2	World Bank
(e) Institutional and regulatory variables						
CONC: concentration of social expenditure (HHI[b])	356	0.295	0.089	0.164	0.538	OECD
DEBT: General government consolidated gross debt (% GDP)	245	61.64	22.64	14.05	121.8	AMECO[c]

Belgium and Luxemburg excluded from computations. Log of all variables are included in the regressions (estimated coefficients can thus be interpreted in terms of elasticities). Wider data coverage corresponds to the period 1980–2007

[a] Deflators by EU KLEMS (2009)

[b] HHI: Herfindahl–Hirschman Index

[c] AMECO is the annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs (DG ECFIN)

longer and "purchase" additional periods of life and utility [21]. Within this framework, in any time period, people do not become saturated with health consumption, as it happens with non-health consumption. As income grows and people get richer, the most rewarding channel for spending is to purchase additional years of life (and consumption). As a result, the optimal composition of total spending shifts toward health, and health expenditure share grows along with income. Empirically, health care spending might not represent optimal consumption, due to exogenous Government regulation that limits the choices of patients and aggregate HCE mainly for equity and budget control purposes. For this reason, caution needs to be taken when inferring the "luxury good" versus "normal good" nature of health care from our estimates of income elasticity of public health expenditure.

In his seminal contribution, Baumol [5] developed a neoclassical model that provides a simple explanation for the dynamic relationship between HCE and GDP [23]. Since demand for health care services is inelastic, if productivity gains are lower for services like medical care (*nonprogressive* sectors) than in the rest of the economy (*progressive* sectors); then relative prices for health care services would rise over time, as well as HCE [5, 6].

The Baumol's unbalanced growth mechanism seems to be at work in Europe (see Table 2). In the period 1980–2007, the share of HCE over GDP has surged about 29 percentage points (col. 2 of Table 2). The growth of HCE is almost entirely due to the higher growth rate of the prices of health care services as compared to the general inflation rate (col. 3). As predicted by Baumol, the productivity gap between the health care sector and the rest of the economy has been of the same order of magnitude (28 percentage points; col. 4) while the growth rate of the compensation per hour worked has been roughly the same across progressive and nonprogressive sectors (col. 5). Thus, at a first glance, the Baumol's hypothesis should be hold as correct, at least as a long-run cross-country effect. On the one side, the relationship between the key macroeconomic variables is in line with the Baumol's prediction in all countries but Luxemburg. On the other, European countries are substantially different. In some countries (Ireland, Portugal, Italy, Finland and Greece), the increase of health care prices has been considerably larger than the

Table 2 The Baumol's "unbalanced growth" hypothesis, EU-15 countries, 1980–2007

	(1) ΔPROD.T	(2) ΔVA.HT	(3) ΔP.HT	(4) ΔPROD.HT	(5) ΔW.HT	(6 = 3 + 4) $DIFF_1$	(7 = 6–5) $DIFF_2$
Luxemburg	0.986	0.343	−0.343	0.008	−0.241	−0.335	−0.094
Austria	0.675	0.197	0.178	−0.405	−0.266	−0.227	0.039
Sweden	0.694	−0.024	0.279	−0.400	−0.090	−0.121	−0.031
Germany	0.814	0.439	0.126	−0.232	−0.148	−0.106	0.042
Spain	0.370	0.192	0.244	−0.324	−0.047	−0.080	−0.033
Belgium	0.599	0.382	0.366	−0.430	−0.207	−0.064	0.143
France	0.607	0.463	0.251	−0.265	−0.058	−0.014	0.044
United Kingdom	0.881	0.343	0.316	−0.311	−0.003	0.005	0.008
Denmark	0.426	0.084	0.191	−0.127	−0.005	0.064	0.068
Netherlands	0.469	0.139	0.416	−0.316	−0.038	0.099	0.138
Greece	0.238	0.875	0.420	−0.264	0.091	0.156	0.066
Finland	0.901	0.382	0.861	−0.576	−0.024	0.285	0.309
Italy	0.321	0.499	0.432	−0.118	0.191	0.314	0.123
Portugal	0.906	1.396	0.792	−0.328	−0.017	0.464	0.481
Ireland	1.072	0.897	1.129	−0.242	0.397	0.886	0.490
EU-15	1.632	0.293	0.286	−0.278	−0.029	0.008	0.037

(1) $\Delta PROD.T = (VA_{2007}/L_{2007})/(VA_{1980}/L_{1980}) - 1$; the growth of total labor productivity (value added per worked hour), 1980–2007. (2) $\Delta VA.HT = (VA_{H,2007}/VA_{T,2007})/(VA_{H,1980}/VA_{T,1980}) - 1$; the growth of the share of health care (health and social work) value added in total value added, 1980–2007; (3) $\Delta P.HT = (P_{H,2007}/P_{H,1980})/(P_{T,2007}/P_{T,1980}) - 1$; the excess growth of the health care deflator (health and social work) as compared to the economy-wide deflator, 1980–2007; (4) $\Delta PROD.HT = (VAL_{H,2007}/VAL_{H,1980})/(VAL_{T,2007}/VAL_{T,1980}) - 1$; the growth of health care labor productivity as compared to total labor productivity, 1980–2007. (5) $\Delta W.HT = (W_{H,2007}/W_{H,1980})/(W_{T,2007}/W_{T,1980}) - 1$; the growth of health care labor compensation per hour worked as compared to total labor compensation per hour worked, 1980–2007

productivity gap between the progressive sectors of the economy and health care (col. 6). For some of them (Ireland, Greece and Italy), this is partially due to the higher growth rate of wages in heath care as compared to the rest of the economy. However, other factors such as the share of the elderly population, female labor participation, technological progress and the role of the public sector can be at work. Thus, in the following analysis, first we test the Baumol's hypothesis on nominal GDP as in Hartwig [23] and next, we analyze the impact of other factors on real HCE dynamics.

Aging population

Over the last decades, developed countries have experienced a sharp transformation in the age composition of the population. The share of elderly people has increased, as a consequence of lower fertility rates and of higher life expectancy, largely due to improved living condition and medical progress. This trend is deemed to continue over the next decades. The impact of population aging on the social structure and on the long-term sustainability of public finances is one of the main challenges for Europe in the upcoming years.

Aging is placing an increasing burden on the health care systems. The health care of the elderly is usually financed by those in work, and demographic change brings about a smaller proportion of the population in working age. The difficulties will be more pronounced in tax-based, pay-as-you-go systems, but all health care systems are facing this issue.

In addition, aging will push health spending up, since the elderly make a higher use of health care services, and individual health care costs tend to rise with age. This effect might be mitigated or offset by the fact that over time longevity gains correspond to more years in good health. This "healthy aging" component tends to lower the average cost per individual at any older age, and in this scenario aggregate HCE will not necessarily increase with an aging population.

In a static framework a positive relationship between age, aging and health expenditures has been detected; while a dynamic assessment, using time series or panel data, provides mixed evidence about the sign and significance of this relationship, reflecting the interplay of the different determinants (see [10] for a review).

In order to take into account the effect of an aging population, in our analysis we rely on the composition of

the population in terms of age classes. We measure the impact of demographic changes and aging by considering the share of the population over 65 (POP65).

Technological innovation

Technological innovation in medicine includes new physical capital and equipment, new surgical procedures, drugs and treatments, as well as new procedures based on original combinations of the above. As for the aging population, economic theory does not predict a clear-cut effect of technological innovation on health care costs and expenditure. On the one side, new technologies can reduce unitary costs as more efficient and cost-effective technologies replace old and less efficient ones. On the other side, there are factors that can offset the savings and induce an increase in aggregate health expenditure, such as the increasing number of applications and indications, the higher number of treatable conditions, the increase in the rate of use for the same condition, and the broadening of the definition of "disease" [17]. As a result of these contrasting effects, medical innovations which are cost-reducing at the micro level can lead to an increase in overall aggregate expenditure due to higher demand for health care services. Indeed, available empirical evidence consistently shows that new medical technologies are a major determinant of the rise of health care expenditure [37].[6]

Empirical evaluation of the impact of technological innovation is restrained by the complexity of measuring technological change, as well as its direct and indirect effects. Studies at the macro level generally deduce the effect of technological change as the "residual" increase in expenditure not explained by the interplay of demographic change and GDP growth assuming unitary income elasticity. On a different ground, applied work has proxied the extent of medical technology adoption in a given country by the stock of available high-tech medical devices, such as magnetic resonance equipment, or medical practices based on high-tech equipments, e.g., patients undergoing dialysis [10]. Under the assumption that technological progress deploys its effect linearly over time, other studies represent technological change as a linear time trend [7, 44]. Alternatively, measures of innovation input (such as research and development expenditure, or employees) or output (i.e., patent counts, patent citations, scientific publications) can be employed (see [22, 25]). Ford et al. [15] show that improvements in medical treatments accounted for approximately 47% of the decrease in mortality rate due to coronary diseases. The wider the adoption of high-tech devices, the lower the mortality rate. This effect has been rigorously documented by a series of highly influential recent contributions [30, 32] also for other lethal diseases such as cancer. Unfortunately, available cross-country time series of data on medical technology equipment stock and usage are severely incomplete, and thus unsuitable for this study. Moreover, it should be considered that technological progress spills over institutional and national boundaries and diffuses across institutions and countries leveling off productivity and innovation differentials. Accordingly, we prefer to rely on indicators of innovation output and, given the characteristic of the health industry, we use the number of scientific publications in biomedical and health care journals as a proxy for the quality of health care services in different countries. The count of scientific publications has been preferred to patent statistics because the innovation process in health is mostly related to the exploitation, diffusion and expert use of existing technologies, institutional and organizational changes as well as medical innovation [17]. This likely does not lead to a patentable claim, but it has been increasingly documented in scientific publication [27, 39]. The number of biomedical publications comes from the PubMed database.[7]

Female labor participation

On a different ground, it is important to control for the impact of female labor participation on HCE. Indeed, the participation of women to the labor force implies a substitution between informal and formal health care and presumably an increase in aggregate HCE. On the one hand, a positive coefficient should pose additional concern on the sustainability of current HCE trends. On the other hand, it should be noticed that a higher female participation in the service economy and formal assistance is key to GDP growth in Europe and to the development of a complementary private health care sector [16, 41, 42]. The relationship between female labor participation, aging population (through fertility rates) and public budget variables (through public child care services) are also important [11, 28]. Typically, improvements in schooling levels and wage rates of women lead to higher female labor supply and decreasing fertility rates. However, in some institutional settings, low labor market participation rates of married women are observed together with low birth rates. This negative effect has been explained based on rigidities and imperfections in the labor market and the

[6] See also [39] for a review.

[7] PubMed is a service maintained by the US National Library of Medicine, covering over 17 million citations from MEDLINE and other life science journals for biomedical articles back to the 1950s. We queried PubMed for publications in the countries and time periods considered in the analysis to proxy the extent of informed adoption of medical technologies (accessed on March 2011).

characteristics of the publicly funded child care system. The lack of social services in some European countries implies a growing trend of private HCE to take care of non self-sufficient young and old family members [20].

Public budget variables

In our analysis, we include a set of variables aimed at capturing public budget constraints and composition that are expected to affect Governments' attempts and policies to curb expenditure, in order to pursue long-term sustainability of public finances. It has been argued that budget variables are likely to exert strong constraints on public expenditure, therefore affecting public spending on HCE [18]. Implementing a durable budgetary reform requires the reduction of the budget deficit and of the debt to GDP ratio. Indeed, empirical accounts based on US data have provided evidence of a stable long-run economic relationship between HCE and government deficit [33]. In the period of time under investigation, we do not find strong evidence of the impact of public HCE policies. We failed to find an impact of European health care reforms due to data incompleteness and the lack of a common classification of policy measures in Europe.[8] General budget constraints and cost containment measures can thus be uninformative or ineffective; especially if we consider that that demand for health care services is rigid. The effect of total debt to GDP ratio can create downward pressures on fiscal budgets with variable time lags and cause public/private cost shifting. We also control for the structure of the welfare system by considering the Herfindahl–Hirschman index (HHI) of concentration of the resources allocated to main social policy areas.[9] EU-15 countries are largely diversified in terms of the structure of social expenditure, as shown in Fig. 1, which reports the share of expenditure in the main social policy areas over GDP in 2007. The larger share of resources is devoted to old age benefits, followed by social expenditure for health.

Two effects can be captured by the index. On the one side, under budget constraints, lower resources devoted to one area makes larger resources available for other policy items (substitution effect). On the other side, a wider coverage of the social expenditure and improved social and market labor conditions are able to promote endogenous economic growth and to open the possibility for higher HCE without compromising financial sustainability and health outcomes (complementary effect). A well-articulated welfare system (promoting education, labor participation and effective employment, and targeted to contrast poverty/needs) can help to enhance the conditions of the population, and preventing the worsening of the health status and the incidence of illnesses and pathologies.

Methodology and results

In line with previous work in this field (e.g. [10, 13]), we perform a set of exploratory econometric tests aimed at identifying the factors affecting the level of per capita HCE.[10] In particular, we aim at ascertaining the impact of five categories of variables on per capita HCE: income, aging, technology, female labor participation, institutional framework and budget constraints. Table 1 summarizes the main descriptive statistics of the variables included in our regressions.[11]

We run different sets of regressions for public, total and private HCE (Table 3, 4 5).[12]

A set of tests for stationarity of the variables has been conducted country by country.[13] For most series, the hypothesis of trend stationarity is not rejected in our data,

[8] We defined a dummy variable for health care reforms as listed by the European Observatory on Health Systems and Policies (http://www.euro.who.int/en/home/projects/observatory). The reform dummy variable has been dropped in our regressions since it was not statistically significant.

[9] The index is computed as the sum of shares (squared) of expenditures in all areas reported in OECD data (excluding health): pensions and services for the elderly; pensions and services for survivors; incapacity-related benefits; family support; active labor market policies; unemployment; housing allowances and rent subsidies; and a residual category (other social policy areas). The index ranges from 1/8 (if all social policy areas have the same allocated resources) to 1 (when only one area exhibits a positive allocation, whereas all the other areas have an allocation equal to zero).

[10] Due to the high incidence of missing data, Belgium and Luxemburg are excluded from the analysis.

[11] Expenditure and GDP values have been converted into current US dollars using the deflators provided by EU KLEMS database (2009). The "Health and social work" (ISIC rev. 3, class 85) deflator is considered for health expenditure, whereas the figure for "all industries" is applied in the case of GDP data. Log-values (natural) have been used for all regressed variables.

[12] Results are broadly consistent when a restricted time period is considered. Particularly we run the regressions using the last available ten years (1998–2007). Due to missing data, UK is also excluded in the analysis of private and public HCE. The following changes are detected in estimated coefficients: (regression on total HCE) the coefficient of DEBT becomes positive and statistically significant; (regression on public HCE) the coefficient of CONC becomes negative and statistically significant; (regression on private HCE) the coefficient of SC.PUB becomes negative and statistically significant.

[13] We considered both the KPSS stationarity test and the (augmented) Dickey-Fuller unit root test.

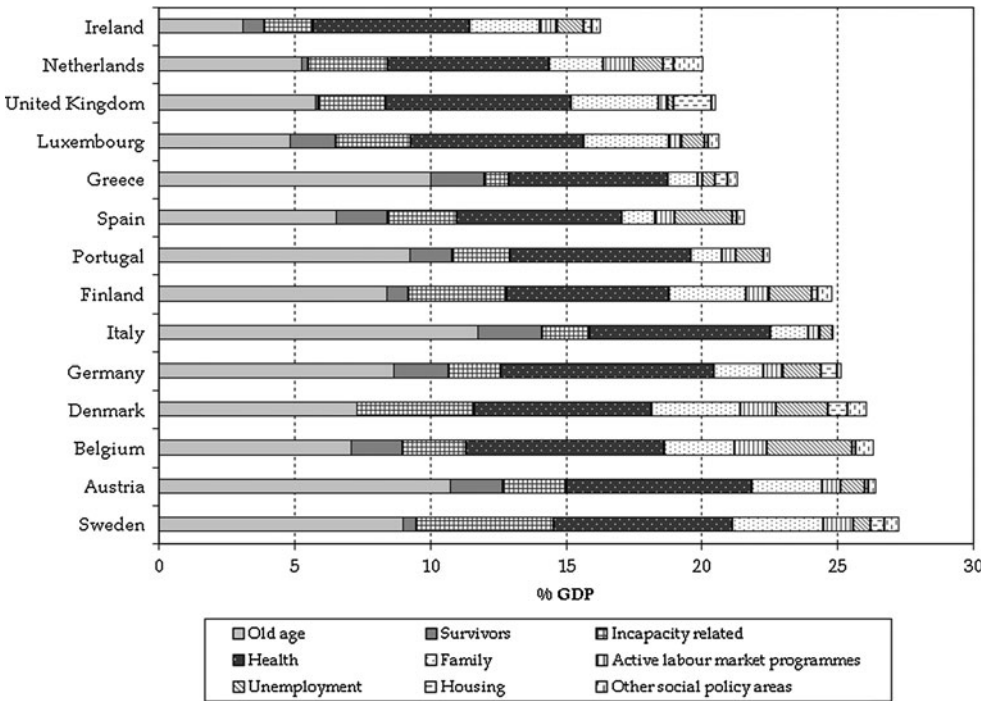

Fig. 1 Main social policy areas of public intervention, % GDP, European countries, 2007

Table 3 The determinants of total per capita HCE, 1980–2007

	(1) FD-OLS	(2) MG	(3) FD-IV	(4) PMG	(5) PMG	(6) PMG	(7) MG
BAUMOL	0.949***						
	(0.073)						
GDP		1.099***	1.003***	0.668***	0.905***	0.898***	0.028
		(0.145)	(0.134)	(0.054)	(0.073)	(0.114)	(0.848)
POP65				0.756***			
				(0.211)			
SC.PUB					0.081***		
					(0.009)		
FLPR						0.784***	
						(0.090)	
CONC							−0.183
							(0.459)
DEBT							−0.417
							(0.591)
Hausman test[a]		7.65**		0.49	5.54*	3.33*[c]	37.01***
t: GDP = 1		0.68	0.02	−6.14***	−1.30	−0.89	−1.15
No. of countries[b]	13	13	13	13	13	13	13
T (max)	28	28	28	28	28	28	28

Statistically significant at: *** 1% level; ** 5% level; * 10% level (unilateral alternative for the test "t: GDP = 1"). Standard errors in parenthesis

[a] MG estimates reported when Hausman test statistically significant at the 5%

[b] EU-15 (Belgium, Luxemburg excluded due to lack of data)

[c] The coefficient of GDP is left unrestricted. The Hausman test is only related to FLPR. Joint Hausman test = 21.54 (p-value = 0.00)

Table 4 The determinants of public per capita HCE, 1980–2007

	(1) FD-OLS	(2) PMG	(3) FD-IV	(4) PMG	(5) PMG	(6) PMG	(7) PMG
BAUMOL	0.915***						
	(0.088)						
GDP		0.971***	1.249***	1.120***	0.966***	1.046***	0.880***
		(0.082)	(0.199)	(0.085)	(0.071)	(0.091)	(0.056)
POP65				0.583***			
				(0.210)			
SC.PUB					0.061***		
					(0.011)		
FLPR						0.878***	
						(0.223)	
CONC							0.165
							(0.144)
DEBT							−0.130***
							(0.029)
Hausman test[a]		0.03		1.29	0.69	2.64	3.28
t: GDP = 1		−0.35	1.25	1.41	−0.48	0.51	−2.14**
No. of countries[b]	13	13	13	13	13	13	13
T (max)	28	28	28	28	28	28	28

Statistically significant at: *** 1% level; ** 5% level (unilateral alternative for the test "t: GDP = 1"). Standard errors in parenthesis

[a] MG estimates reported when Hausman test statistically significant at the 5%

[b] EU-15 (Belgium, Luxemburg excluded due to lack of data)

the only exception being the GDP series.[14] In order to tackle this issue and avoid spurious results, we apply different methodologies.

We exploit the "panel" characteristic of our data and apply the pooled mean group (PMG) estimator proposed by Pesaran et al. [40]. The advantage is twofold. On the one side, it is possible to control for unobserved heterogeneity at the country level. On the other side, dynamic relationship can be specified and estimated. As the inclusion of lagged dependent variable causes the fixed effect estimator to be biased [36], GMM estimation is usually employed in this setting [1–3, 8]. However, the properties of GMM estimators depend crucially on the assumption of common parameters. Furthermore, consistency of the estimators requires N (the number of units) growing large, whereas in our case $N = 13$. As T is quite large, the mean group (MG) estimator is an option, where separate regressions are estimated for each country and then average of country-specific coefficients is considered. This estimator is likely to be inefficient particularly in small country samples. The PMG estimator is an intermediate option, where it constraints the long-run coefficient to be identical, while allowing for differences among short-run coefficients and error variances of different countries (see [4]). The assumption of common long-run coefficients can be tested using the Hausman test.[15] Both PMG and MG require the number of observations available for each country to be large enough to estimate the regression for each country separately. Therefore, by MG and PMG we are not allowed to estimate the effect of all variables *jointly*, rather the variables are added separately to the regressions in order to investigate the effect of the inclusion on the magnitude and significance of the GDP coefficient. In our baseline

[14] Carrion-i-Silvestre [9] provides evidence that HCE and GDP series can be characterized as stationary processes evolving around a broken trend. Similar results are reported in Jewell et al. [26]. A throughout investigation of the pattern of series stationarity is carried trough only as a preliminary step to the regression analysis. The empirical size and power of the unit root tests largely depend on the available data. Therefore, we prefer to employ an estimation strategy that is "robust" to stationarity patterns.

[15] Under the null hypothesis (equal long-run coefficients), the difference between PMG and MG should be insignificant and the PMG is efficient. On the contrary, under the alternative (different long-run coefficients), the PMG estimator is inconsistent and the MG estimator should be considered. In the Tables, when the Hausman test is statistically significant at the 5% level, the MG estimator is reported.

Table 5 The determinants of private per capita HCE, 1980–2007

	(1) FD-OLS	(2) PMG	(3) FD-IV	(4) PMG	(5) PMG	(6) PMG	(7) PMG
BAUMOL	1.046***						
	(0.138)						
GDP		0.813***	0.402	1.770***	0.604***	0.863***	0.786**
		(0.157)	(0.305)	(0.257)	(0.157)	(0.193)	(0.323)
POP65				−3.582***			
				(0.733)			
SC.PUB					0.056***		
					(0.014)		
FLPR						1.365***	
						(0.188)	
CONC							0.046
							(0.622)
DEBT							0.416
							(0.303)
Hausman test[a]		2.02		2.65	1.39	3.20	18.41***
t: GDP = 1		−1.19	−1.96**	3.00	−2.52***	−0.71	−0.66
No. of countries[b]	13	13	13	13	13	13	13
T (max)	28	28	28	28	28	28	28

Statistically significant at: *** 1% level; ** 5% level; * 10% level (unilateral alternative for the test "t: GDP = 1"). Standard errors in parenthesis

[a] MG estimates reported when Hausman test statistically significant at the 5%

[b] EU-15 (Belgium, Luxemburg excluded due to lack of data)

specification, the PMG estimator is complemented with an instrumental variable regression on first differenced variables.[16] Different methodologies complement each other allowing us to assess the impact of the different regressors on the level of expenditure. All in all, the two approaches allow us to deal explicitly with the endogeneity of GDP and non-stationarity of the series.

The Baumol effect is tested as in Hartwig [23] by means of an OLS regression on first differenced variables. In this case, nominal data are considered (column 1 in Tables 3, 4, 5).

The Baumol effect is confirmed by the analysis [5, 23]. The coefficient of the "Baumol" variable is always very close to 1 (never statistically different from 1 at custom level of significance). The growth rate of nominal HCE is driven by the imbalance between labor productivity and wage at the global level. A one percent increase in excess productivity with respect to wages corresponds to an equal increase in nominal HCE.

Next, we remove the price effect and consider real data, that is, we analyze the factors affecting the demand for health care (columns 2–8 in the Tables). We include in our regressions the variables aimed at capturing aging population, technological change, female labor participation and budget constraints. The PMG estimator is applied to per capita variables; and our baseline specification also employs first difference estimation coupled with a two-stage approach (FD-IV).

In line with previous findings in the literature, we identify a positive relationship between HCE and GDP.[17] Given the log–log specification of the equations, estimated coefficients can be interpreted as the elasticity of HCE with respect to income. As for the magnitude of this coefficient, both total and public expenditures exhibit an elasticity that is not different from one in most specifications. On the contrary, the estimated elasticity of private expenditure, obtained as the difference between total and public HCE, is below unity. In most of the European countries, private

[16] Country fixed effects are considered in order to allow for different trends across countries. A two-stage approach is considered where GDP is treated as an endogenous regressor. The instruments considered for estimation are energy use (kg of oil equivalent per capita) and an index of openness to trade, computed as the sum of imports and exports of goods and services (as a share of GDP). Data are provided by the World Bank database (World Development Indicators). The validity of the selected variables is assessed with the Hansen test.

[17] In our baseline specification, FD-IV estimation confirms the results of PMG. The latter estimator is then preferred because better suited to estimation on our data.

HCE has a residual role since it represents, on average, less than one forth of total expenditure.

The results add insights to the current debate on the nature of health care. Available evidence shows that health care behaves as an inferior good at the micro level, while becoming a luxury good when data are aggregate at regional, national or even global scale [19]. Coherently with these findings, the estimated elasticity of total HCE provides empirical support to the luxury good hypothesis, where the impact of economic growth on HCE passes mainly through the public component. Even though, as previously stressed, the empirical evidence provided needs to be treated with caution given the presence of exogenously imposed regulation limiting the choices of patients and aggregate HCE (which therefore might not represent optimal consumption), this result points directly to the core of the sustainability problem. Income growth cannot be invoked to stabilize the incidence of HCE on GDP and to expand the level of the demand for care.

When total and public real HCE are analyzed, a higher share of the elderly population (over-65) implies higher HCE. The results confirm the fact that aging population leads to an increase in the demand for health care services, especially as far as public HCE is concerned. The public component is more exposed to the aging driver (which has a negative effect on private HCE), as well to the economic growth driver since private health care plays a residual role in most EU countries.

The number of scientific publications exerts a positive effect on HCE, pointing to a positive effect of technological change on HCE. Our results support the view that in the long-run technical change expands aggregate expenditure.[18] Even though the empirical literature provides examples of new technologies that exert both positive and negative effects on health costs, increases in aggregate expenditure are expected [39]. The health care sector is one of the leading examples of a nonprogressive sector, thus we predict a higher share of health care innovations to be quality-enhancing rather than cost-reducing. We argue that the number of scientific publications per capita is a proxy for the quality of the health care services. The result shows that the demand of health care services is higher in countries with better health care systems. The "Baumol effect" is amplified through the increase of hedonic prices of health care services too.[19]

A higher rate of female participation to the labor force corresponds to higher levels of HCE. We argue that this is driven by wider reliance on the formal assistance provided by the health care system as opposed to informal family assistance. Given increasing female labor participation, the result deserves policy attention in European countries to ensure sustainability of the current trends.

The results regarding the institutional and budgetary variables included in the analysis are of limited quality.[20] Results show that countries with higher debt exhibit lower level of public expenditure, but the relationship with private HCE is positive, even if not significant, revealing that a public/private cost shifting might be present.

It is of interest to compare the effect of each variable on the dynamics of public and private HCE. Our results show that the share of elderly (POP65) has an opposite effect on the two components of HCE, being positively correlated with public HCE and negatively correlated with private HCE. Also, the effect of female labor participation ratio (FLPR) is larger on the private component than on the public one. In a well-balanced system, we would expect the main driver of HCE to have the same effect on the public and the private components. On the contrary, this is not the case, and the result is striking when the share of elderly (aged 65 or older) is taken into account. According to our estimates, private expenditure is lower in countries with a higher share of elderly, with a more than proportionate effect of FLPR. Coupled with the descriptive evidence on the composition of the social expenditure in Europe, which is largely devoted to the care of the elderly with limited support to other items of the social expenditure (see Fig. 1), the results suggest an unbalanced welfare system, where care of the elderly is accumulated on the public component, with drawbacks for the other branches of the social expenditure. We urge a rebalancing of the welfare agenda, where unsupported care services to working women can affect their fertility choices [28], further increasing the aging of the population in the long run, and establishing a vicious cycle of increasing expenditure. European governments should increasingly rely on pluralistic systems to balance sustainability and access and equilibrate the distribution of resources across the functions of the public welfare system.

[18] Either the new technology is used in addition to the old ones, or it replaces the old ones with an expansion in the treatable conditions. We thank one referee for raising the issue. Unfortunately, our data do not allow to discriminate between the two effects.

[19] No account is made in our analysis of the benefits associated with medical technology improvements; therefore no conclusions can be drawn on the issue of the net value accrued to patients from innovation.

[20] Unreported regressions include a dummy variable identifying the years when health care reforms came into force. The variable has been built on the basis of the information provided by the European Observatory on Health Systems and Policies (http://www.euro.who.int/en/home/projects/observatory). The reform dummy variable was not statistically significant in all our regressions.

Conclusions

The analysis presented in this paper contributes to our understanding of the key driving forces of HCE in Europe. We consider multiple factors and incentives, taking into account technological change, consumer preferences, aging of the population, women labor participation, as well as budgetary and institutional variables.

The first set of regressions confirm previous empirical evidence showing that the "Baumol disease" affect health care expenditure [5, 23]. We next remove the price effect and show that income is one of the key drivers of real HCE, where the estimated elasticity provides evidence of public (and total) health being a "luxury good", whereas estimated elasticity for the private component of the expenditure is below unity. This is a key point, since HCE projections are highly sensitive to assumptions on the elasticity value, and elasticity to income is key for health care budget sustainability in the long run and along the business cycle. Confirmation of the "luxury good" hypothesis would imply that policy actions to sustain health care budget cannot rely on an increase in GDP (leading to a more than proportionate increase in HCE), and would provide further support to the statement that economic growth cannot be advocated as a way to smooth or reduce budgetary controls in the health sector. Even though the result needs to be interpreted with caution as observed HCE might not reflect optimal consumption (due to the presence of exogenously imposed government budget constraints), it points directly to the core of the sustainability problem.

Besides GDP, aging population and female labor participation contribute positively to HCE. Results also stress the importance of technological change and the quality of services in determining differences in the level of HCE across countries.[21]

As far as institutional and budgetary variables are concerned, no single recipe exists for keeping health care budgets under control, and different countries have implemented different models. Public debt seems to play a role in limiting public expenditure in health even if public/private cost shifting may be at work.

All in all, the structural features of health care systems make it difficult to sustain the current trend in the long run. On the one side, the effect of technological change in the health care sector with respect to the other sectors inexorably lead to an increasing share of public finances allocated to health. Hartwig [23] provides an empirical account of the Baumol model of unbalanced growth that is confirmed by our analysis. The health care sector is indeed labor intensive, characterized by negative productivity differentials with respect to other goods and services in the economy. The equalization of wages across sectors, then, produces the inexorable rise of relative prices in nonprogressive sectors such as health care. Moreover, quality-enhancing technological progress and socio-demographic changes—an aging population and increasing female labor participation (linked to fertility choices)—are likely to exacerbate funding problems in the future.

Our findings in this paper on the different effects of aging and women labor participation on the public and private components of the HCE should drive European policy maker's attention to promote a political debate aimed at devising those structural reforms that are required to rebalance the distribution of resources across the functions of the public welfare system.

We suggest that system reforms should be framed within a wider perspective to include the multiple functions of the welfare system and the multifaceted nature of health care. Health care reforms should be accompanied by regulation on supply and demand side; the reform of the welfare system structure and of the labor market; the development of fully founded financing schemes based on funds, both for health care and for pensions. Results on the uneven distribution of social expenditure in Europe support the rationale at the basis of the so called "Lisbon agenda", aiming at reinforcing welfare instruments capable of promoting participation to labor market, effective employability, especially for the young, women and the elderly, and productivity gains especially in nonprogressive sectors such as education and health care.

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[21] Needless to say, the benefits associated with longer healthy life are not easily accounted for in this type of regressions, nonetheless being an important implication of technological progress.

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