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On the relationship between GDP and health care expenditure: A new look[☆]

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ABSTRACT

In this paper we analyze the relationship between income and health expenditure in 31 Organization for Economic Cooperation and Development (OECD) countries. We focus on the differences between short and long term elasticities and we also check the adjustment process of health care expenditure to changes in per capita Gross Domestic Product (GDP) and its cyclical and trend components. In both cases, we test if results differ in countries with a higher share of private expenditure on total health expenditure. Econometric results show that the long-run income elasticity is close to unity, that health expenditure is more sensitive to per capita income cyclical movements than to trend movements, and that the adjustment to income changes in those countries with a higher share of private health expenditure over total expenditure is faster.

1. Introduction

Most of the literature on the determinants of aggregated healthcare expenditure focuses on the effect of income, usually proxied by per capita Gross Domestic Product (GDP). As shown in Section 2, differences rely on data sets (regions or countries, time-series or panel data), econometric techniques, or control variables. Attention is mainly paid to the contemporaneous elasticity of health expenditure on per capita GDP. The main question raised by authors is the luxury or necessary nature of healthcare expenditure. However, there are a number of dimensions of this link very relevant from both, academic and policy-maker standpoints, which are most often neglected by researchers. The aim of this paper is to deal with two of them.

First, we analyze its dynamic aspects. Our hypothesis is that choices on healthcare expenditure do not adapt to changes in per capita GDP automatically. Lagged expenditure is relevant to explain current expenditure and then both, short-run and long-run income elasticities differ and should be estimated. Moreover, for both rises and cuts in expenditure, public choices are subject to more rigidities and delays than private choices, insofar as the former involve political processes at one or more fiscal tiers, when the power on public healthcare is decentralized. If this is true, we would expect different patterns in the relationship between income and expenditure depending on the relative relevance of both public and private choices on healthcare expenditure in each country.

Second, the observed changes in per capita GDP are decomposed to check if the income elasticity of healthcare expenditure is similar for changes in per capita GDP trend, positive gaps, and negative gaps. Gaps are defined as the difference between observed values and the trend component computed using the Hodrick–Prescott filter. Our hypothesis here is that variations in per capita income could involve different effects on healthcare expenditure when they are perceived as permanent or cyclical by individuals and governments. Again, we discuss if results are significantly different in countries where the share of private expenditure on total expenditure is higher.

To meet our aims, an unbalanced panel for 31 Organization for Economic Cooperation and Development (OECD) countries over the period 1970–2009 is used and four different specifications are estimated. The plan of the paper is as follows. Section 2 reviews the literature up to date. Section 3 describes the data, while Section 4 discusses methodological issues. Section 5 details the main results. Section 6 concludes.

2. Previous empirical evidence

As stated above, most of the literature on the determinants of health expenditure is focused on the relationship between health care expenditure and income. In general, it argues that there is not

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only a strong positive correlation between per capita healthcare expenditure and per capita income in developed countries, but also that per capita income explains a high percentage of the variation in expenditure.

Over the last few years, the debate on this link has moved on whether the income elasticity of health expenditure is greater or less than 1 (Bac and Le Pen, 2002). An income elasticity less than 1 classified health expenditure and income inelastic, therefore, as a “necessary” good. On the other hand, if the elasticity is higher than 1, health will be classified as a “luxury” good. In summary, the empirical literature on the determinants of national health expenditure shows that aggregate income is one of the most important factors in explaining health expenditure. But income elasticity changes depend on the study, as shown in Table 1.

The empirical literature on the determinants of health care expenditure started with the seminal paper by Newhouse (1977). He examined the relationship between medical care expenditures and income across 13 developed countries, regressing per capita medical care expenditures on per capita GDP. Newhouse reached the conclusion that the income elasticity of medical care expenditures across countries exceeds the unit. We should note that the most important studies in the 80s, Leu (1986) or Parkin et al. (1987) had used a methodology of cross-section data and they also had classified health care as a “luxury” good.

Over the following decade, other authors like Hitiris and Posnett (1992), Hansen and King (1996) and Hitiris (1997) had deepened in the debate about the income elasticity of health care. In this way, Hitiris and Posnett (1992) estimated a panel data model for 20 OECD countries during the period 1960 to 1987 and found a strong positive relationship between per capita health expenditure and income. After that, Hansen and King (1996) with a model based on Hitiris and Posnett (1992) and data from 20 OECD countries over the period 1960–1987, showed that the variables of a “standard” model of health expenditure were non stationary in levels. Later, Hitiris (1997) with data for 10 OECD countries over the period 1960–1991, showed that income elasticity of health expenditure ranges from 1.14 to 1.17. As a summary of the 90s, we should note that most of the studies had used a methodology of time-series and they continued classifying health care as a “luxury” good. However, some papers that considered health care as a “necessary” good started to appear.

In the first decade of the present century, the following studies were published: Okunade and Murthy (2002), Jewell et al. (2003), Sen (2005), Dregerd and Reimers (2005), Carrion-i-Silvestre (2005), Hagist and Kotlikoff (2009), or Chakroun (2009). Thereby, Okunade and Murthy (2002), with a methodology of time series confirm a significant and stable long-run relationship among per capita real health care expenditure. One year later, Jewell et al. (2003) using a panel data model of 20 OECD countries during the period 1960–1997, analyzed the stationary of national health care expenditures and GDP. They concluded that both are stationary around one or two breaks. Information from 1990 to 1998 for 15 OECD countries was used in Sen (2005) to assess the relationship between per capita income and health expenditure. These data allow the author to control the effects of various non institutional demand and supply covariance introducing new variables of cost or supply. The results were income elasticities of health expenditure between 0.21 and 0.51. Dregerd and Reimers (2005) using panel co integration techniques and data from 21 OECD countries, determined that health care expenditure is not a luxury good. In Carrion-i-Silvestre (2005), the stationarity of real per capita health expenditure and income for 20 OECD developed countries was examined allowing the presence of structural shocks that can affect both the level and slope time series. While, Hagist and Kotlikoff (2009), using data for 10 OECD countries, studied how government healthcare expenditures have been growing much more rapidly than GDP and concluded that growth in benefit levels explains 89 of overall healthcare spending growth. Chakroun (2009), derived country-specific and time-specific income elasticities for 17 OECD countries over the period 1975–2003 using a panel threshold regression model. The results showed that health care is a necessity rather than a luxury. So that, as a summary of the last decade, we should note that the methodology of panel data models had become the most important and health care has come to be regarded as a “necessary” good.

Concerning the most recent studies we can refer to the ones made by Baltagi and Moscone (2010), Mehrara et al. (2010), and Liu et al. (2011). Then, using data for 20 OECD countries, Baltagi and Moscone (2010), studied the non-stationarity and co integration properties between health care expenditure and income; their findings suggest that health care is a necessity rather than a luxury. Similarly, Mehrara et al. (2010) using data for 1993–2007 concluded that income elasticity for all OECD members is about 2.59. They also estimated that income elasticity of health expenditure over time and across the countries has been rather unvarying. Liu et al. (2011) have tested for structural breaks with panel varying coefficient models doing an application to OECD health expenditure. They found a full-sample income elasticity of 1.603. Then, in recent years panel co integration techniques should have been considered the most popular but they did not solve the still open debate in health economics.

In short, most of the studies summarized find a positive income elasticity for national health care expenditure, but they do not reach a consensus on whether health care is a “necessary” or a “luxury” good. While we are also interested on the value of this elasticity, we try to bring to the discussion the relevance of distinguishing between short-run and long-run dynamics, the nature of changes in per capita GDP growth rates (structural or cyclical), and the different logics of private and public choices on healthcare expenditure.

Table 1
A summary of previous studies. Dependent variable: national health care expenditure.
Source: Authors' elaboration.

Authors	Sample	Model description	Elasticity of income
Newhouse (1977)	13 developed countries	Cross section	>1
Leu (1986)	19 OECD countries	Cross section	>1
Parkin et al. (1987)	18 OECD countries	Cross section	>1
Hitiris and Posnett (1992)	20 OECD countries	Panel data	Income elasticity close to unity.
Hansen and King (1996)	20 OECD countries	Time series	No long-term relationship.
Hitiris (1997)	10 OECD countries	Time series	>1
Sen (2005)	15 OECD countries	Panel data	<1
Dregerd and Reimers (2005)	21 OECD countries	Panel cointegration techniques	<1
Chakroun (2009)	17 OECD countries	Multivariate regression model	<1
Baltagi and Moscone (2010)	20 OECD countries	Panel data	<1
Mehrara et al. (2010)	16 OECD countries	Panel data	>1
Liu et al. (2011)	22 OECD countries	Semiparametric panel varying coefficient model	>1

Table 2
Variables and data sources.
Source: Authors' elaboration.

	Definition	Data source
EXP	Per capita total health care expenditure. Expressed in current prices and logarithms.	OECD Health Data (2012)
GDP	Per capita Gross Domestic Product. Expressed in current prices and logarithms.	OECD Health Data (2012)
DPRIV	Dummy variable coded 1 for observations corresponding to the US, Switzerland, Chile, Mexico, Korea, and Greece and 0 otherwise.	Authors' elaboration.
GDPTREND	The smoothed series of *GDP* computed using the Hodrick–Prescott (HP) filter.	Authors' elaboration.
POSGAP	It is defined as *GDP-GDPTREND* when *GDP*> *GDPTREND* and 0 otherwise.	Authors' elaboration.
NEGGAP	It is defined as GDP-*GDPTREND* when *GDP*≤*GDPTREND* and 0 otherwise.	Authors' elaboration.
OLD	Percentage of population over 64 years old.	OECD Health Data (2012)

3. Data description

The econometric analysis relies on annual data for 31 OECD countries from 1970 to 2009 gathered from the OECD Health Data (2012), as the largest available source of statistics to compare OECD health care systems.[1] So, this database allows doing benchmarking and international comparisons of different health systems.

Definitions and data sources of variables are depicted in Table 2. Variables *EXP* and *GDP* contain information on per capita total health care expenditure and per capita GDP respectively; both variables are expressed in current prices and logarithms. Variable *DPRIV is* a dummy coded one for those countries with a higher percentage of private health care expenditures over the total, and zero in other cases. Additionally, following the proposal by Hodrick and Prescott (1997) for annual data, the smoothing parameter used to estimate the trend component of *GDP* is $\lambda = 100$.[2] Once *GDPTREND* is estimated, *POSGAP* and *NEGGAP* are computed as indicated in Table 2. We also use *OLD*, the percentage of population aged over 64, identified by the literature as having a role in determining health care expenditure.[3]

Table 3 summarizes country information on the share of private expenditure on total health care expenditure, so let us made the *DPRIV* variable. The definition of *DPRIV* variable is based on data: the share of private expenditure over the total is systematically over 40% in the six countries where *DPRIV*=1. A cluster analysis on means and medians in Table 3 formally supported this criteria and groups of countries.

We applied one of the more commonly used partition clustering methods, called kmeans cluster analysis. In kmeans clustering, the user specifies the number of clusters, k, to create using an iterative process. Each observation is assigned to the group whose mean is closest, and then based on that categorization, new group means are determined. These steps continue until no observations change groups. After some graphical and preliminary analysis, we set k = 3. The similarity or dissimilarity measure used is the Euclidean distance. For each country, three variables were taken into account: mean, median and minimum of the share of private expenditure on total expenditure shown in Table 3. Computations were made using the statistical package STATA 12. Average means, medians, and minimums are, respectively, 0.14, 0.14, and 0.07 for group 1 (Czech Republic, Denmark, Iceland, Luxembourg, New Zealand, Norway, Slovak Republic, Sweden, and UK),

[1] It is a public database, but the access to the full data is via subscription.

[2] We checked that econometric results below do not significantly change if $\lambda = 6.25$, following to Ravn and Uhlig (2002).

[3] We tried to include additional regressors. The problem was the sharp cut in sample sizes. For instance, when hospital beds were included sample size dropped to 519; and to 453 when the number of physician was used.

Table 3
The share of private expenditure on total health expenditure.
Source: Authors' elaboration based on OECD Health Data (2012).

Code	Country	Mean	Median	Maximum	Minimum	Observations[a]
1	Australia	0.34	0.34	0.41	0.26	37
2	Austria	0.27	0.25	0.37	0.23	39
3	Belgium	0.25	0.25	0.27	0.24	8
4	Canada	0.27	0.26	0.3	0.23	40
5	Chile	0.47	0.46	0.53	0.41	14
6	Czech Republic	0.09	0.1	0.17	0.03	19
7	Denmark	0.16	0.16	0.18	0.12	37
8	Finland	0.24	0.25	0.29	0.19	39
9	France	0.22	0.21	0.24	0.2	23
10	Germany	0.22	0.22	0.27	0.18	38
11	Greece	0.44	0.45	0.57	0.38	23
12	Hungary	0.23	0.27	0.31	0.11	18
13	Iceland	0.16	0.16	0.34	0.1	39
14	Ireland	0.24	0.24	0.29	0.17	39
15	Italy	0.25	0.24	0.3	0.21	22
16	Japan	0.24	0.24	0.34	0.17	38
17	Korea	0.62	0.64	0.8	0.45	29
18	Luxembourg	0.09	0.1	0.12	0.07	12
19	Mexico	0.55	0.55	0.59	0.52	20
20	Netherlands	0.32	0.32	0.4	0.26	31
21	New Zealand	0.2	0.22	0.26	0.05	39
22	Norway	0.13	0.15	0.19	0.02	39
23	Poland	0.27	0.28	0.35	0.08	19
24	Portugal	0.37	0.37	0.49	0.27	37
25	Slovak Republic	0.18	0.11	0.33	0.08	12
26	Spain	0.25	0.24	0.35	0.15	39
27	Sweden	0.13	0.13	0.18	0.07	39
28	Switzerland	0.45	0.45	0.5	0.4	25
29	Turkey	0.4	0.33	0.78	0.28	26
30	UK	0.15	0.16	0.21	0.09	39
31	US	0.58	0.59	0.64	0.53	39

[a] The available data in OECD Health Data 2012 sample in countries like Belgium, Czech Republic, Luxembourg and the Slovak Republic is smaller than for the rest of the OECD countries studied. This may be because in these four countries the available data on health expenditure and health financing on which the OECD is based to develop the database is more recent.

0.27, 0.27, and 0.20 for group 2 (Australia, Austria, Belgium, Canada, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Netherlands, Portugal, Poland, Spain, and Turkey), and 0.52, 0.53, and 0.45 for group 3 (Chile, Greece, Korea, Mexico, Switzerland, and the US).

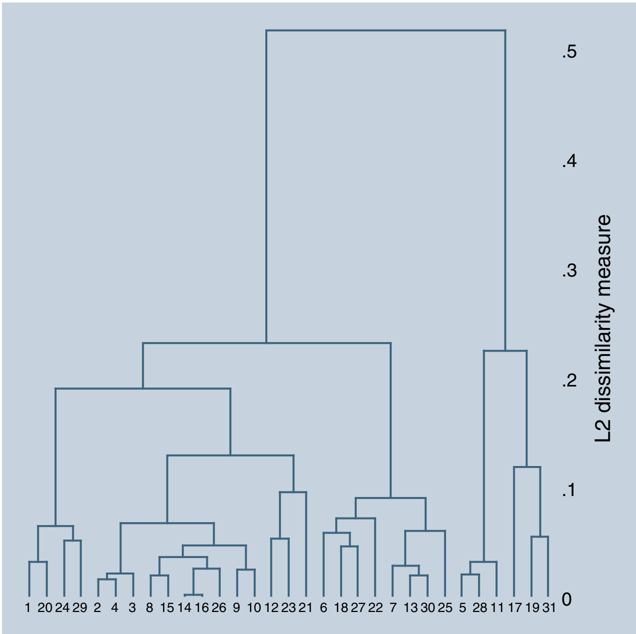
Without imposing the value of k, we also estimate a hierarchical agglomerative linkage clustering for the 31 countries. The corresponding dendrogram is represented in Fig. 1, using the same variables and distance criteria than before. The closest two groups are determined by the average (dis)similarity between the observations of the two groups. Results are the same. The group composed by Chile (5), Greece (11), and Switzerland (28) and the group composed by Korea (17), Mexico (19) and the US (31) are merged into one group. The rest of countries are merged into the two groups pointed out above before collapsing into one.

4. Specifications and econometrics

4.1. Specifications

The first specification includes as regressors the lagged dependent variable, *GDP*, and *OLD*. Insofar as population brackets tend to be highly correlated, multicollinearity is troublesome when they are simultaneously included (Cantarero and Lago-Peñas, 2012). This is the reason why *OLD* is the only demographic variable added as control. Specification (1) also includes individual fixed effects. The short-run elasticity of income on health care expenditure is β and the long-run elasticity is computed as $\frac{\beta}{1-\rho}$:

$$EXP_{it} = \alpha_i + \rho \cdot EXP_{it-1} + \beta \cdot GDP_{it} + \delta \cdot OLD_{it} + \varepsilon_{it}. \tag{1}$$



Source: Authors' elaboration.

Notes: Country code numbers reported in Table 3. Euclidean distance is the similarity of dissimilarity measure.

Fig. 1. Dendrogram for clustering of countries. Notes: Country code numbers reported in Table 3. Euclidean distance is the similarity of dissimilarity measure.
Source: Authors' elaboration.

Specification (2) extends (1) to test if parameters for EXP_{-1} and GDP are different for countries with a lower ratio between public and total health care expenditure. For those countries $DPRIV = 1$ and then the effect of EXP_{-1} is $\rho_1 + \rho_2$ and the effect of GDP is $\beta_1 + \beta_2$:

$$EXP_{it} = \alpha_i + \rho_1 \cdot EXP_{it-1} + \rho_2 \cdot EXP_{it-1} \cdot DPRIV_i + \\ + \beta_1 \cdot GDP_{it} + \beta_2 \cdot GDP_{it} \cdot DPRIV_i + \delta \cdot OLD_{it} + \varepsilon_{it} \tag{2}$$

Specification (3) extends (1) disaggregating GDP into the trend, the positive gap, and the negative gap: $GDP_{it} = GDPTREND_{it} + POSGAP_{it} + NEGGAP_{it}$

$$EXP_{it} = \alpha_i + \rho \cdot EXP_{it-1} + \beta_3 \cdot GDPTREND_{it} + \\ + \beta_4 \cdot POSGAP_{it} + \beta_5 \cdot NEGGAP_{it} + \delta \cdot OLD_{it} + \varepsilon_{it}. \tag{3}$$

Finally, specification (4) combines specifications (2) and (3) to test the existence of asymmetries between groups of countries also in the effect of the filtered components of variable GDP.

$$EXP_{it} = \alpha_i + \rho \cdot EXP_{it-1} + \beta_3 \cdot GDPTREND_{it} + \beta_4 \cdot POSGAP_{it} + \\ + \beta_5 \cdot NEGGAP_{it} + \beta_6 \cdot GDPTREND_{it} \cdot DPRIV_i + \\ + \beta_7 \cdot POSGAP_{it} \cdot DPRIV_i + \beta_8 \cdot NEGGAP_{it} \cdot DPRIV_i + \delta \cdot OLD_{it} + \varepsilon_{it} \tag{4}$$

4.2. Econometrics

As usual when working with time series, the first step is to analyze the data generator process of variables in order to detect and avoid the problem of spurious regressions. In particular we are interested in the existence of unit roots in the level of series GDP and EXP and, if this is the case, if they are co integrated or not. With this aim, two unit root tests for panel data have been carried out: the LLC test and the IPS test.[4] A summary of results is reported in Table 4. The null hypothesis is clearly rejected in all cases. Both series may be treated as I(0) or stationary.

Table 4
Unit root tests. TSCS data.
Source: Authors' elaboration.

Variable	LLC	IPS	Observations
EXP	−15.3 (p-value<0.0001)	−4.43 (p-value<0.0001)	942
GDP	−23.5 (p-value<0.0001)	−11.81 (p-value<0.0001)	1086

Notes: Individual intercepts included in test equations.
Null hypothesis LLC: Unit root (assumes common unit root process).
Null hypothesis IPS: Unit root (assumes individual unit root process).

Results from preliminary estimates of Eq. (1), not reported in the paper, have revealed a number of problems to deal with:

1. Both the lagged endogenous and the individual fixed effects were highly significant.
2. Residuals suffered from first-order autocorrelation.
3. Residuals revealed group-wise heteroskedasticity and cross-sectional dependence.

As is well known, the Least Square Dummy Variable (LSDV) estimator is biased when the lagged endogenous is included as a regressor (Nickel, 1981). Insofar as the bias is of O(1/T) it is troublesome when T is small. However, we are working with TSCS with T up to 40, involving that biases tend to fade.[5]

LSDV errors were serially correlated (p-value<0.01) based on the results from the Breusch–Godfrey serial correlation LM test. Because the lagged endogenous is also included as a regressor, OLS or non-iterated versions of more sophisticated estimators (Cochrane–Orcutt, Prais–Winsten, Hatanaka…) are not consistent. Nevertheless, Nonlinear Least Squares (NLLS) estimates are asymptotically equivalent to maximum likelihood estimates and are asymptotically efficient. The coefficients on the exogenous variables and the lagged dependent variables are then estimated simultaneously by applying a Marquardt NLLS algorithm following an iterative procedure.

Following Greene (1997), we calculated a modified Wald statistic for groupwise heteroskedasticity in the residuals. According to the results, the null hypothesis of homoskedasticity can be rejected (p-value<0.0001). Moreover, we have computed the Breusch–Pagan statistic for cross-sectional independence in the residuals of a fixed effect regression model (Greene, 1997, p. 601). The null hypothesis can be rejected (p-value<0.0001). Hence, OLS standard errors are replaced by Panel Corrected Standard Errors (PSCE) proposed by Beck and Katz (1995) robust to both cross-sectional heteroskedasticity and contemporaneous correlation in residuals.

5. Results

The estimation of the four specifications described yielded the results reported in Table 5. The goodness of fit is very high in all cases.

[4] The test developed by Levin et al. (2002) or LLC, assumes that each individual unit in the panel shares the same AR(1) coefficient. On the contrary, the test by Im et al. (2003) or IPS allow for different AR(1) coefficients in each series. Both tests assume that all series are non-stationary under the null hypothesis. All computations in Section 4 have been made using EViews 7.2.

[5] In fact, according to the Monte Carlo results presented by Beck and Katz (2009), with T = 20 or more, LSDV performs relatively well and is flexible enough to allow us to deal with other estimation problems , as in our case. By contrast, the Kiviet correction (Kiviet, 1995), extended to unbalanced dataset by Bruno (2005), works better in terms of bias and the root mean square error (RMSE), but does not report analytical standard errors. Only bootstrap standard errors are reported.

Table 5
Econometric estimates of Specifications (1) to (4).
Source: Authors' elaboration.

Variables	Specification				
	(1)	(2)	(2b)	(3)	(4)
EXP_{-1}	0.74***	0.75***	0.72***	0.81***	0.82***
	(17.84)	(17.34)	(14.42)	(22.78)	(21.56)
GDP	0.28***	0.27***	0.24***		
	(5.53)	(5.14)	(4.56)		
$EXP_{-1}*DPRIV$		−0.11*	−0.13**		−0.12
		(1.92)	(2.26)		(2.00)**
$GDP*DPRIV$		0.19**	0.22***		
		(2.41)	(2.76)		
$GDPTREND$				0.19***	0.19***
				(4.32)	(4.04)
$POSGAP$				0.34**	0.43**
				(2.14)	(2.42)
$NEGGAP$				0.63***	0.53***
				(3.72)	(2.77)
$GDPTREND*DPRIV$					0.20**
					(2.33)
$POSGAP*DPRIV$					−0.63**
					(2.27)
$NEGGAP*DPRIV$					0.59*
					(1.81)
OLD	0.0046**	0.0043**	0.0022	0.0036**	0.0035**
	(2.25)	(2.13)	(1.19)	(2.02)	(2.01)
AR(1)	0.36***	0.35***	0.37***	0.27***	0.26***
	(4.77)	(4.66)	(4.55)	(3.85)	(3.72)
Time trend			0.0038**		
			(2.28)		
Wald test: $GDPPOSGAP = GDPNEGGAP$				p-value = 0.28	p-value = 0.72
Wald test: $GDPPOSGAP + GDPPODGAP*DPRIV = 0$					p-value = 0.40
Wald test: $GDPNEGGAP + GDPNEGGAP*DPRIV = 1$					p-value = 0.64
Adjusted-R^2	0.9975	0.9975	0.9975	0.9975	0.9975
S.E. of regression	0.0447	0.0444	0.0441	0.0443	0.0440
Number of observations (unbalanced panel)	916	916	916	916	916

Notes: All specifications are estimated by NLLS. Estimates include individual fixed effects. t-statistics computed using PCSE in parenthesis. Wald tests are computed using PCSE. All the estimates were performed using EViews 7.2.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

Coefficients are highly significant with expected signs in most cases. In particular, per capita GDP has a positive effect on health expenditure and the coefficient on the lagged endogenous is over 0.7. Sluggishness in adjustments of healthcare expenditure to income changes involves that this relationship is stronger when the observed time span increases. Both individuals and governments need time to adjust their expenditure and demand on healthcare to changes in households' income and tax revenues.

But they do. According to econometric estimates for specification (1), while the estimated short-run elasticity $\left(\hat{\beta}\right)$ is around 0.3, the long-run elasticity $\left(\frac{\hat{\beta}}{1-\rho}\right)$ is 1.1. All in all, the unitary long-run is inside the confidence ellipse at 99% (Fig. 2).[6] That means that the hypothesis $\frac{\beta}{1-\rho} = 1$ can be rejected at 95% but not at 99% level of confidence.

According to the results for specification (2), health care systems with a higher share of private expenditure over total health care expenditure adjust faster to per capita GDP changes. It confirms one of our hypotheses exposed in the introduction. All in all, income elasticity is not significantly higher in the long term: a positive value for β_2 is compensated by a negative value for ρ_2.

There is a high level of consensus among researchers and decision makers operating in the health sector about the importance of evaluating the impact of time (technological progress in health care and its impact on quality of the services provided), but there is no such consensus concerning how to implement it. In this sense, in the third column of Table 5 a time trend is added to specification (2) in order to check the sensitivity of results to specification problems; in particular, biases due to the omission of relevant variables. The modified specification (2) is denoted

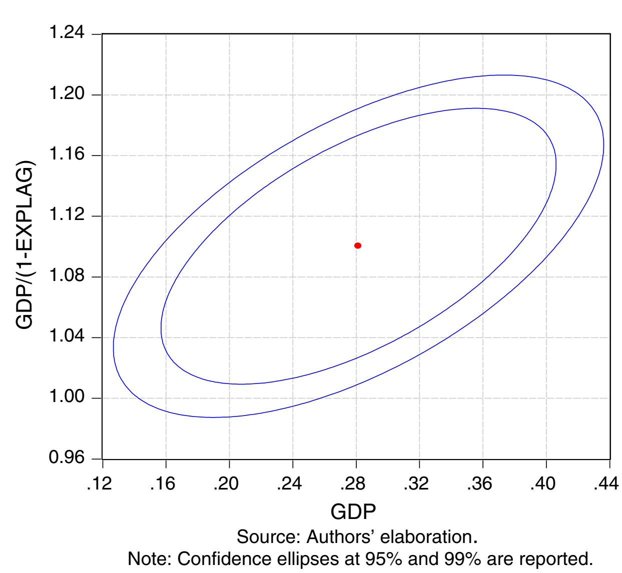


Fig. 2. Estimated confidence ellipses for coefficients β and $\frac{\beta}{1-\rho}$ in specification (1) estimated in column (1) of Table 5. Note: Confidence ellipses at 95% and 99% are reported. Source: Authors' elaboration.

[6] A confidence ellipse plots the joint confidence region of two functions of estimated parameters.

as (2b). As discussed in Cantarero and Lago-Peñas (2010), including a time trend is usual to proxy for technological progress in health care. All results hold except in the case of variable *OLD*. Due to its collinearity with the time trend, its statistical significance drops below usual levels.

Results for specification (3) show that healthcare expenditure tends to be more sensitive to per capita income cyclical movements than to trend movements. On the contrary, a Wald test confirms that the difference between the response in times of positive and negative gap component of per capita GDP is not statistically significant.

Things are different when attention is focused on countries with a stronger role of private expenditure in health care (last column of Table 5). On the one hand, a Wald test confirms that their healthcare systems are insensitive to changes in the cyclical component of per capita GDP when it is positive. On the other hand, another Wald test shows that they are much more sensitive than the rest of countries to the cyclical component when it is negative. In sum, the higher the relevance of private over total outlays, the higher the flexibility to adjust total healthcare expenditure in bad economic times.

6. Conclusions

The contribution of this paper to the literature on the relationship between healthcare expenditure and income is threefold. First, we analyze the dynamics of the relationship and in particular, the difference between short and long term elasticities. Second, we analyze whether the response of health expenditure is similar when there occur changes in per capita GDP trend or in the gap between the observed per capita GDP and the trend GDP. Finally, we test if results hold in the case of countries where the share of private expenditure over the total is more relevant.

According to econometric estimates, while the estimated short-run elasticity is around 0.3, the long-run elasticity is 1.1. All in all, the null hypothesis of unitary long-run elasticity can be rejected at 95% but not at 99% level of confidence. Second, health expenditure is more sensitive to per capita income cyclical movements than to trend movements. Third, countries with a higher private share in total health care expenditure adjust faster to changes in GDP, but income elasticity is not significantly higher in long term. A similar result is found for the US in Sood et al. (2007). Finally, expenditure in those countries is insensitive to changes in positive output gaps, but it is very sensitive to changes in negative output gaps. In sum, the higher the relevance of private choices over expenditure, the higher the flexibility to adjust it to changes in per capita income.

References

Bac, C., Le Pen, Y., 2002. An international comparison of health expenditure determinants. *10th* International Conferences on Panel Data, Berlin, July 5–6.
Baltagi, B.H., Moscone, F., 2010. Health care expenditure and income in the OECD reconsidered: evidence from panel data. IZA Discussion Paper Series, 4851.
Beck, N., Katz, J.N., 1995. What to do (and not to do) with time-series cross-section data. American Political Science Review 89, 634–647.
Beck, N., Katz, J.N., 2009. Modeling Dynamics in Time-series-Cross-section Political Economy Data. New York University, Department of Politics.
Bruno, G.S.F., 2005. Approximating the bias of the LSDV estimator for dynamic unbalanced panel data models. Economics Letters 87, 361–366.
Cantarero, D., Lago-Peñas, S., 2010. The determinants of health care expenditure: a reexamination. Applied Economics Letters 17 (7), 723–726.
Cantarero, D., Lago-Peñas, S., 2012. Decomposing the determinants of health expenditure: the case of Spain. The European Journal of Health Economics 13 (1), 19–27.
Carrion-i-Silvestre, J.L., 2005. Health care expenditure and GDP: are they broken stationary? Journal of Health Economics 24, 839–854.
Chakroun, M., 2009. Health care expenditure and GDP: an international panel smooth transition approach. Munich Personal RePEc Archive, 14322.
Dregerd, C., Reimers, H.E., 2005. Health care expenditures in OECD countries: a panel unit root and cointegration analysis. IZA Discussion Paper Series, 1469.
Greene, W.H., 1997. Econometric Analysis. Prentice Hall, New Jersey.
Hagist, C., Kotlikoff, L., 2009. Who's going broke? Comparing growth in public healthcare expenditure in ten OECD countries. Hacienda Pública Española 188, 55–71.
Hansen, P., King, A., 1996. The determinants of health care expenditure: a cointegration approach. Journal of Health Economics 15, 127–137.
Hitiris, T., 1997. Health care expenditure and integration in the countries of the European Union. Applied Economics 29, 1–6.
Hitiris, T., Posnett, J., 1992. The determinants and effects of health expenditure in developed countries. Journal of Health Economics 11, 173–181.
Hodrick, R.J., Prescott, E.C., 1997. Postwar U.S. business cycles: an empirical investigation. Journal of Money, Credit, and Banking 29, 1–16.
Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. Journal of Econometrics 115, 53–74.
Jewell, T., Lee, J., Tieslau, M., Strazicich, M.C., 2003. Stationarity of heath expenditures and GDP: evidence from panel unit root tests with heterogeneous structural breaks. Journal of Health Economics 22, 313–323.
Kiviet, J.F., 1995. On bias, inconsistency, and efficiency of various estimators in dynamic panel data models. Journal of Econometrics 68, 53–78.
Leu, R.E., 1986. The public–private mix and international health care costs. In: Culyer, A.J., Jonsson, B. (Eds.), Public and Private health services. Basil Blackwell, Oxford.
Levin, A., Lin, C.-F., Chu, C.-S.J., 2002. Unit root tests in panel data: asymptotic and finite sample properties. Journal of Econometrics 108, 1–24.
Liu, D., Li, R., Wang, Z., 2011. Testing for structural breaks in panel varying coefficient models: with an application to OECD health expenditure. Empirical Economics 40 (1), 95–118.
Mehrara, M., Musai, M., Amiri, H., 2010. The relationship between health expenditure and GDP in OECD countries using PSTR. European Journal of Economics, Finance and Administrative Sciences 24, 1450–2275.
Newhouse, J.P., 1977. Medical care expenditure: a cross-national survey. Culyer: The Economics of Health, vol. 2.
Nickel, S., 1981. Biases in dynamic models with fixed effects. Econometrica 49, 1417–1426.
OECD, 2012. OECD Health Data File 2011.
Okunade, A.A., Murthy, V.N.R., 2002. Technology as a "major driver" of health care costs: a co integration analysis of the Newhouse conjecture. Journal of Health Economics 21 (1), 147–159.
Parkin, D., Mcguire, A., Yule, B., 1987. Aggregate health care expenditures and national income. Journal of Health Economics 6, 109–127.
Ravn, M.O., Uhlig, H., 2002. On adjusting the Hodrick–Prescott filter for the frequency of observations. The Review of Economics and Statistics 84, 371–375.
Sen, A., 2005. Is health care a luxury? New evidence from OECD Data. International Journal of Health Care Finance and Economics 5, 147–164.
Sood, N., Ghosh, A., Escarse, J.J., 2007. The Effect of Health Care Cost Growth on the U.S. Economy. Office of the Assistant Secretary for Planning and Evaluation (ASPE), U.S. Department of Health and Human Services (HHS).

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