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RESEARCH ARTICLE

Health care expenditures and GDP in Latin American and OECD countries: a comparison using a panel cointegration approach

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Abstract
This paper provides empirical evidence of the existence of a long-run causal relationship between GDP and health care expenditures, for a group of Latin American and the Caribbean countries and for OECD countries for the period 1995–2014. We estimated the income elasticity of health expenditure to be equal to unity for both groups of countries, that is, health care in Latin American and OECD countries is a necessity rather than a luxury. We did not find evidence of a causal effect in the opposite direction, i.e. from changes in health expenditure to GDP. We present conclusive evidence of the cross-country dependence of the analyzed series, and consequently we used panel unit root tests, panel cointegration tests, and long-run estimates that are robust to such dependence. Specifically, we use the CIPS panel unit root test and the panel Common Correlated Effects estimator. We also show that the results obtained by mistakenly using methods that assume cross-section independence are unstable.

Keywords Income elasticity of health care expenditures · Panel cointegration · Cross-section dependence · Latin American and the Caribbean and OECD countries

JEL Classification I15 · I18 · H51

Introduction

Total health care expenditures (HE) as a percentage of Gross Domestic Product (GDP) has increased in almost all regions of the world. Measured as a percentage of GDP and averaged

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over 192 countries, HE has increased from 5.8% in 1995 to 6.8% in 2014.[1] This increase can be seen among developed countries, such as the members of the Organization for Economic Co-operation and Development (OECD), as well as Latin American (LA) countries, most of which are categorized as developing economies.[2] However, there are clear differences in the amount of resources each country expends on health care, with higher percentages of GDP assigned to HE in richer countries. OECD countries had an average ratio of HE to GDP of 9.3% in 2014, while the figure in LA was 6.8%.[3] Among OECD countries the current discussion is related to how to contain HE, while in LA countries increases in HE are seen as positive. International institutions like the Pan American Health Organization include among their goals and strategies increasing HE as this may guarantee the crucial goal of achieving universal health care coverage in developing countries. This objective is formulated under the premise of a positive and significant correlation between HE and GDP.

There is extensive literature that empirically documents the long-run relationship between GDP and HE, mostly using data on OECD countries. This is expected given that as income levels rise, citizens demand improved quality of life, including wider access to high quality health care, which they can also afford. There is almost no such evidence on developing countries and for specific regions like Latin America. Should we expect a different result in LA from that in OECD countries? On the one hand, if health care is provided to obtain a higher level of well being in the sense that it is intended to fulfill a need, it can be expected that in poorer countries the income elasticity of HE would be lower than in richer countries.[4] On the other hand, if a country grows more rapidly and has more need to undertake health care related reforms, as is the case for LA countries compared with OECD members, we can expect changes in GDP will have more impact on HE in developing countries.[5] Hence, the overall effect could go in either direction: the HE income elasticity could be stronger or weaker in LA than in OECD countries.

It may also be the case that changes in HE have long-term effects on GDP. Higher levels of HE in a country, if reflected in a healthier population, may increase the productivity of the work force and, in turn, improve GDP. The empirical literature on OECD countries does not yield evidence in this direction on the causality between HE and GDP. The lack of effect may be because a long period of time is needed before improvements in labor productivity become evident.

The simultaneity in the relationship between HE and GDP poses a challenge to quantify it empirically. Another methodological aspect that has to be considered when using time series for the estimation is the non-stationarity of the series, which makes cointegration techniques suitable. A third methodological concern related to the use of panels of countries over time is the potential cross-country dependence of the series. Several authors have recently made important methodological contributions to accommodate cross-section dependence to the traditional tools used in panel cointegration analysis.

In this paper we provide empirical evidence for the existence of a long-run relationship between HE and GDP for a group of Latin American and the Caribbean countries (LA), and compare the results to those obtained for OECD countries. We do so using a set of panel

[1] Unweighted average computed using data from the Global Health Expenditure Database of the World Health Organization.

[2] See Fig. 1 in the Appendix.

[3] See Fig. 1 in the Appendix, for mean values in OECD and LA. See Fig. 2 in the Appendix, for country by country values.

[4] Assuming that health care costs and health status of the population are similar across countries.

[5] The growth rate of GDP over the last 20 years was (slightly but still) higher among LA countries than among OECD members.

unit root and panel cointegration tests, as well as long-run estimators that are robust to the presence of cross-section dependence.

We estimated unitary income elasticity of HE for both groups of countries analyzed, that is, we found evidence that HE is a necessity as opposed to a luxury. In line with previous results, we did not find a long-run causal effect from HE to GDP. Additionally, we present evidence supporting the hypothesis of cross-section dependence in LA and OECD, and show that the use of methods that are not robust to this feature of the data leads to inconclusive results.

The paper is organized as follows. In "Previous empirical evidence" section we review the existing empirical literature on the long-run relationship between HE and GDP. The empirical model and the methodology are outlined in "Methodology" section. "Data" section presents sources of data and descriptive statistics of the main variables. In "Results" section we discuss the results and provide evidence of their robustness. Final section presents the "Conclusions".

Previous empirical evidence

The empirical literature devoted to estimating the long-run relationship between HE and GDP has traditionally focused on a demand function approach that models the HE income elasticity with data on OECD countries. Applying unit root and cointegration tests to individual OECD member countries in different time periods over the years 1960 to 1993, Hansen and King (1996) found no evidence of a cointegrating causal relationship between GDP and HE, while Roberts (2000) found such a relationship, and Blomqvist and Carter (1997) found heterogeneous results depending on particular characteristics of the countries.[6]

With the development of unit root and cointegration techniques specifically applied to panel data, several authors have studied the long-run relationship between HE and GDP using panels of OECD countries with different sample sizes and approximately 20 years of data, ranging from 1960 to 1990. McCoskey and Selden (1998) concluded that the series are stationary, a result found also in Lago-Peñas et al. (2013), in which the authors estimated the HE income elasticity to be 0.3 in the short run and 0.7 in the long-run. In contrast, Gerdtham and Löthgren (2000), Gerdtham and Löthgren (2002), Clemente et al. (2004), and Dreger and Reimers (2005) found evidence of the non-stationarity of the series, and agreed on the existence of a cointegrating relationship between HE and GDP. Dreger and Reimers (2005) estimated unitary HE income elasticity.[7]

The tests and estimators used until now have been criticized for being based on the unrealistic assumption of cross-country independence. Following new methodological proposals to test and estimate cointegrating relationships for cross-sectional dependent observations, and using OECD data from 1971 to 2004, Baltagi and Moscone (2010) estimated HE income elasticity equal to 0.446. Narayan et al. (2011) also found evidence of a cointegrating causal relationship between GDP and HE, while French (2012) found evidence of long-run causal

[6] Sen (2005) finds a positive HE income elasticity with a panel of 15 OECD countries from 1990 to 1998, but using a different methodology. His results are obtained with Generalized Least Squares and Instrumental Variables estimators.

[7] There are at least two other related papers that used panel cointegration techniques with methodological refinements, namely Liu et al. (2011) who showed the existence of structural breaks in the causal relationship between GDP and HE, and Mehrara et al. (2010) who estimated HE income elasticity below one using a panel smooth threshold regression.

relationships between HE and GDP in both directions.[8] Halıcı-Tülüce et al. (2016) show a positive effect of public HE on GDP, while they found a negative effect of private HE on GDP, for a panel of low-income and a panel of high-income countries.[9]

Papers focused on developing countries are scarce. Using Fix Effects and Instrumental Variable estimators Farag et al. (2012) obtained an income elasticity of HE below one for 173 developed and developing countries in the period 1995–2006, and found that the elasticity in low income countries is lower than it is in high income countries. Using similar data and method Ke et al. (2011) found a positive relationship between GDP and HE. Regrettably, these authors did not discuss the stationarity of the data, a requisite for the methodology applied in their work. More recently, Kouassi et al. (2018) obtained an income elasticity of HE below one for 14 Southern African Development Community member countries over the period 1995–2012, using heterogeneous panel data model with cross sectionally correlated errors.

To our knowledge, only one paper has used cointegration techniques on a group of LA countries, but it did so to address a different question, namely how health status, measured by life expectancy, affects income. This work by Mayer (2001) found evidence of a long-term conditional Granger causality between health status and income using a panel of 18 LA countries with data from 1975 to 1990.

Methodology

We use the following linear heterogeneous panel regression model to study the long-run relationship between health care expenditures (HE) and GDP:

$$he_{it} = \alpha_i + \beta_i * gdp_{it} + u_{it}, \quad i = 1, \ldots, N, \quad t = 1, \ldots, T, \tag{1}$$

where he_{it} is the (natural logarithm of) per capita health care expenditures in the ith country at time t, gdp_{it} is the (natural logarithm of) per capita gross domestic product, and u_{it} is an error term. The parameter α_i is a country-specific intercept, and β_i, the crucial parameter in our analysis, measures the income elasticity of health care expenditures in country i.

To provide evidence of the existence of a long-run relationship between health care expenditures and GDP in a panel of countries, we first established whether the variables of interest present a unit root. Secondly, we tested the existence of a cointegrating relationship, and finally, we estimated Vector Error Correction (VEC) models to confirm the existence and study the direction of the long-run relationship of interest.

So called "first generation" panel cointegration techniques were developed under the assumption that there is independence across countries, that is, the error terms u_{it} in equation (1) are not correlated across individual units i. There are a variety of panel unit root tests that operate under the premise of cross-section independence such as those developed by Breitung (2001), Breitung and Das (2005), Choi (2001), Hadri (2000), Harris and Tzavalis (1999), Im et al. (2003), and Levin et al. (2002). Once the non-stationarity of the series had been verified, and checked that all have the same integrated order, the analysis continued with the

[8] The three papers used different methodologies. The main results in Baltagi and Moscone (2010) were based on a Common Correlated Effects estimator, Narayan et al. (2011) used Westerlund (2007) cointegration test and Dynamic OLS estimators, which are not consistent under cross-section dependence, and French (2012) used the Panel Analysis of Non-stationarity in Idiosyncratic and Common components (PANIC) approach of Bai and Ng (2004).

[9] This paper uses unitroot tests that are consistent under the assumption of cross-country dependence, GMM estimators, and test for Granger Causality.

set of panel cointegration tests developed by Pedroni (1999). An important limitation to this methodology is the validity of the hypothesis of independence of shocks that affect health care expenditures across countries. Cross-country dependence could lead to significant size distortion in the panel unit root tests. As with most macro series, the independence assumption is difficult to sustain. In our time frame a concern for cross-country dependence emerged as a consequence of the 2008 financial crisis, which may have had heterogeneous impacts across countries.

Following this critique, the methodological literature provided a solution in the form of the "second-generation" panel cointegration techniques. We followed this line of panel cointegration literature by first testing the hypothesis of cross-section dependence, and then estimating the long-run relationship of interest by applying unit root tests, cointegration tests, and computing VEC models estimates that are robust to the existence of such dependence. Additionally, we compared tests and estimation results obtained using first and second-generation methods to present further evidence of the existence and consequences of the cross-country dependence in the group of analyzed countries.

Since first generation panel cointegration methods are well known and have been thoroughly described in articles and textbooks such as Baltagi (2008), we will describe the second-generation methods in the context of our study.

Cross-section dependence test

Let ρ_{ij} be the time series correlation between country i and country j of the variable he (and gdp). Then, the Pesaran (2004) statistic to contrast the null hypothesis of cross-section independence is:

$$CD = \left[\frac{2}{N(N-1)}\right]^{(1/2)} * \left[\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\sqrt{T_{ij}\rho_{ij}}\right],$$

where T_{ij} is the number of observations used to compute the correlation coefficient.

The CD statistic has a standard normal distribution under the null hypothesis of cross-section independence.

In our study, we computed 30×29 correlations across LA countries, and 35×34 across OECD countries.

CIPS panel unit root test

Pesaran (2007) proposed testing the null hypothesis that all the panels contain a unit root, in a Dickey Fuller regression augmented with the cross-section average of lagged levels and first-differences of the individual series as proxies for the unobserved common factors that may produce cross-country dependence. The test implies two steps: first the separate estimation of cross-sectionally augmented Dickey Fuller (CADF) regressions for each country, and second the combination of individual unit root tests.

The CADF regression is:

$$\Delta y_{it} = a_i + b_i * y_{i,t-1} + c_i * \overline{y}_{t-1} + \sum_{j=1}^{p} d_{ij} * \Delta y_{i,t-j} + \sum_{j=0}^{p} g_{ij} * \Delta\overline{y}_{t-j} + e_{it},$$

where y_{it} stands for he and gdp, and $\overline{y}_t = N^{-1}\sum_{i=1}^{N} y_{it}$.

The null hypothesis that all series contain a unit root, $H_0 : b_i = 0$ for all i, is contrasted against the alternative hypothesis that at least one of the individual series in the panel is stationary, $H_1 : b_i < 0$ for at least one i, using the following statistic:

$$CIPS = N^{-1} \sum_{i=1}^{N} \tilde{t}_i,$$

where $\tilde{t}_i$ is the ordinary least squares t-ratio of b_i. The critical values for the CIPS test are given in Pesaran (2007).

Dynamic OLS and common correlated effects methods

There are to alternatives to estimate a long-run relationship with cointegrated panel data while allowing for the potential existence of cross-country correlation, one is Dynamic OLS (DOLS) using cross-sectionally demeaned data and the other is Common Correlated Effects (CCE) estimators.

Chen et al. (1999) and Kao and Chiang (2000) studied the asymptotic and finite sample properties of the DOLS estimator applied to panel data. Both articles concluded that the DOLS estimator proposed by Stock and Watson (1993) is super consistent under cointegration, even in models that include endogenous covariates, and that DOLS outperforms OLS and Fully Modified OLS estimators when applied to small samples. Pedroni (2001) introduced the between-dimension, group-mean panel DOLS estimator, which has the advantages over the within dimension DOLS estimator of allowing for the presence of heterogeneous cointegrating relationships and improved small sample performance.

In our study, the DOLS regression is:

$$he_{it} = \alpha_i + \beta_i * gdp_{it} + \sum_{k=-K_i}^{K_i} \gamma_{ik} * \Delta gdp_{i,t-k} + u_{it}, \tag{2}$$

where we choose $K_i = 1$ for all i, as we have a relatively short time period (T) in our panels.

Let $\hat{\beta}_i$ be the OLS estimator of regression (2) and $t_{\hat{\beta}_i}$ the corresponding t-statistic, obtained using country i data. The DOLS estimator is simply:

$$\hat{\beta} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_i, \tag{3}$$

and the t-statistic is:

$$t_{\hat{\beta}} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}_i}, \tag{4}$$

where $t_{\hat{\beta}}$ is asymptotically distributed as a standard normal. The DOLS estimator was proposed under the assumption of cross-section independence, but applying the estimator to demeaned data it accommodates for cross-country dependence given by an unobserved time-specific factor common to all the countries in the panel.

A more flexible treatment of cross-country dependence is given in the CCE estimator proposed by Pesaran (2006). In our study, the CCE regression is:

$$he_{it} = \alpha_i + \beta_i * gdp_{it} + \gamma_{i1} * \overline{he}_t + \gamma_{i2} * \overline{gdp}_t + u_{it}. \tag{5}$$

This equation is the empirical counterpart of model (1) assuming that $u_{it} = g(i) * f(t) + e_{it}$, where $g(i)$ is a heterogeneous factor loading, $f(t)$ is an unobserved common factor loading, and the error, e_{it}, is iid. In the empirical model, the CCE regression, the cross-sectional averages $\overline{he}_t$ and $\overline{gdp}_t$ are proxies for the common factors. The CCE estimator is the average of the individual OLS slope coefficients of the model (5). The jackknife bias correction and the recursive mean adjustment methods were applied to correct for small T sample bias.

The advantage of the CCE estimator over the DOLS is that it allows for cross-sectional dependencies that are the result of a multi-factor error structure with heterogeneous responses across countries. However, the CCE estimator is consistent under the assumption of exogenous covariates, a requirement that is not necessary for the (super) consistency of the DOLS estimator.

Data

We used annual time series of per-capita health care expenditures and per-capita GDP in constant US dollars for 2010. Health care expenditures data were obtained from the Global health care expenditures Database of the World Health Organization (WHO), and GDP data from the World Bank's World Development Indicators database. Our sample included a balanced panel of 30 LA countries and 35 OECD countries for the period 1995–2014.[10] The LA countries included in the sample are listed in Table 1, which also reports mean values and the last record of the variables of interest, by country for the period 1995–2014. Table 2 reports similar descriptive statistics for OECD countries.

Results

First generation panel unit root tests

Tables 3 and 4 show the results of the first generation panel unit root tests, that is, tests consistent under the hypothesis of independence across cross-sections for LA and OECD countries, respectively. In the first panel of both tables we present results considering a drift in all series, and in the third panel we model the series including a drift and a trend.[11] To alleviate the restriction imposed by the cross-section independence assumption, we also present results for demeaned series in the second and fourth panels of the tables, including a drift, and a drift and a trend, respectively.

We found evidence for both LA and OECD countries of the existence of a unit root in (the natural logarithm of) GDP and HE when we used the Breitung, and the HT tests. The results with the IPS test were in the same direction in all but two cases for OECD countries. However, the LLC test rejected the null hypothesis of a unit root in all but one of the specifications. Additionally, the Hadri test in its two versions rejected the null hypothesis of the stationarity of the series in levels and in first differences in almost all models.

[10] The Latin American and the Caribbean region includes 41 countries. We omitted countries from the sample for which we did not have the complete series of both variables for the time period of interest.

[11] The graphic inspection of the series supports the use of a drift for HE and a drift and a trend for GDP. Temporal trends in HE and GDP are depicted in the Appendix in Figs. 3 and 5 for LA countries, and Figs. 4 and 6 for OECD countries.

Table 1 Descriptive statistics of health care expenditures and GDP, by country. LA countries

Country	Health care expenditures (a)		GDP (a)	
	Mean	in 2014	Mean	in 2014
Antigua and Barbuda	548	774	12,938	13,330
Argentina	595	605	8975	10,375
Bahamas, The	1353	1720	23,087	21,458
Barbados	790	1146	15,191	15,873
Belize	186	279	4050	4437
Bolivia	84	209	1794	2317
Brazil	528	947	9760	11,705
Chile	593	1137	11,342	14,480
Colombia	287	569	5578	7291
Costa Rica	495	970	6938	8978
Dominica	280	408	6080	7042
Dominican Republic	175	269	4481	6143
Ecuador	198	579	4316	5403
El Salvador	206	280	3298	3772
Grenada	371	506	6814	7811
Guatemala	137	233	2662	2991
Guyana	116	222	2685	3571
Honduras	121	212	1917	2279
Jamaica	208	266	4980	4963
Mexico	446	677	8596	9402
Panama	442	959	6640	10,326
Paraguay	193	464	2965	3762
Peru	171	359	4147	5861
Saint Kitts and Nevis	584	771	12,920	14,321
Saint Lucia	388	500	6744	6820
Saint Vincent	253	575	5542	6435
Suriname	312	589	7103	9223
Trinidad and Tobago	594	1136	12,626	16,150
Uruguay	758	1442	10,065	13,857
Venezuela, RB	368	873	12,807	13,750
All LA	393	656	7568	8804

(a) Per-capita, in constants dollars of 2010

In summary, the battery of tests applied did not provide consistent evidence of the non-stationarity of the analyzed series, which may be the result of increased size in the tests due to cross-country dependence.

Cross-section dependence and second-generation panel unit root tests

We applied the CD Pesaran (2004) statistics and found evidence supporting the hypothesis of cross-country dependence for (the natural logarithm of) HE and GDP, in levels and in first differences using LA and OECD countries. The results are shown in Table 5.

Table 2 Descriptive statistics of health care expenditures and GDP, by country. OECD countries

Country	Health care expenditures (a)		GDP (a)	
	Mean	in 2014	Mean	in 2014
Australia	3453	6031	47,390	54,233
Austria	3905	5580	43,736	47,645
Belgium	3279	4884	41,611	44,470
Canada	3517	5292	45,137	49,896
Chile	593	1137	11,342	14,480
Czech Republic	889	1379	17,243	20,161
Denmark	4540	6463	56,365	57,861
Estonia	603	1248	13,087	17,540
Finland	3056	4612	42,639	45,212
France	3612	4959	39,179	41,050
Germany	3735	5411	39,588	44,755
Greece	1793	1743	24,831	22,558
Hungary	726	1037	11,863	13,933
Iceland	3746	4662	39,096	44,141
Ireland	3146	4239	45,270	52,257
Israel	1817	2910	28,014	32,673
Italy	2544	3258	35,660	33,458
Japan	3128	3703	41,645	44,386
Korea, Republic	1009	2060	18,237	24,479
Latvia	507	921	9763	13,872
Luxembourg	5657	8138	94,676	103,924
Mexico	446	677	8596	9402
Netherlands	3750	5694	47,114	50,143
New Zealand	2445	4896	32,009	35,939
Norway	5880	9522	84,469	89,339
Poland	540	910	10,229	14,063
Portugal	1646	2097	21,332	21,537
Slovak Republic	758	1455	13,313	17,883
Slovenia	1491	2161	20,764	23,247
Spain	1979	2658	29,169	29,595
Sweden	3956	6808	47,608	53,386
Switzerland	5970	9674	69,654	75,769
Turkey	359	568	8987	11,246
United Kingdom	2759	3935	36,743	40,327
United States	6485	9403	46,361	50,662
All OECD	2678	4004	34,935	38,443

(a) Per-capita, in constants dollars of 2010

The CIPS, a panel unit root test that is robust to the presence of cross-section dependence, applied to HE and GDP, modeled with drift, and with drift and trend, does not reject the null hypothesis that all panels contain a unit root, while it does reject the null hypothesis when the test was applied to the series in first differences. We interpret these results, reported in

Table 3 First generation panel unit root tests on HE and GDP. LA countries

	Health care expenditures (a)				GDP (a)			
	Level		First difference		Level		First difference	
	Stat.	*p* value	Stat.	*p* value	Stat.	*p* value	Stat.	*p* value
Panel 1: Series with drift								
H_0: *All the panels contain a unit root*								
Breitung	9.058	1.000	– 7.276	0.000	3.655	1.000	– 8.316	0.000
HT	0.974	1.000	0.131	0.000	0.971	1.000	0.262	0.000
IPS	4.330	1.000	– 11.934	0.000	4.797	1.000	– 10.266	0.000
LLC	– 1.576	0.058	– 13.087	0.000	0.746	0.772	– 12.548	0.000
H_0: *All the panels are stationary*								
Hadri	54.761	0.000	1.611	0.054	56.675	0.000	4.908	0.000
Hadri robust	54.122	0.000	3.136	0.001	50.954	0.000	5.445	0.000
Panel 2: Demeaned series with drift								
H_0: *All the panels contain a unit root*								
Breitung	– 0.782	0.217	– 7.840	0.000	– 0.084	0.466	– 7.494	0.000
HT	0.845	0.323	0.065	0.000	0.939	0.999	0.248	0.000
IPS	1.033	0.849	– 11.643	0.000	2.974	0.999	– 9.480	0.000
LLC	– 1.190	0.117	– 12.743	0.000	1.590	0.944	– 11.105	0.000
H_0: *All the panels are stationary*								
Hadri	29.966	0.000	1.230	0.109	43.280	0.000	7.375	0.000
Hadri robust	28.810	0.000	4.309	0.000	32.790	0.000	8.179	0.000
Panel 3: Series with drift and trend								
H_0: *All the panels contain a unit root*								
Breitung	1.524	0.936	– 6.316	0.000	– 0.524	0.300	– 6.167	0.000
HT	0.757	0.995	0.153	0.000	0.823	1.000	0.330	0.000
IPS	0.515	0.697	– 9.499	0.000	1.020	0.846	– 8.326	0.000
LLC	– 3.668	0.000	– 12.123	0.000	– 3.893	0.000	– 11.665	0.000
H_0: *All the panels are stationary*								
Hadri	30.780	0.000	2.537	0.006	34.059	0.000	2.917	0.002
Hadri robust	25.472	0.000	4.133	0.000	28.423	0.000	3.087	0.001
Panel 4: Demeaned series with drift and trend								
H_0: *All the panels contain a unit root*								
Breitung	1.648	0.950	– 6.794	0.000	0.215	0.585	– 5.411	0.000
HT	0.726	0.959	0.092	0.000	0.844	1.000	0.338	0.000
IPS	0.122	0.548	– 9.681	0.000	1.429	0.924	– 9.199	0.000
LLC	– 4.336	0.000	– 12.032	0.000	– 3.430	0.000	– 11.577	0.000
H_0: *All the panels are stationary*								
Hadri	29.397	0.000	0.996	0.160	38.266	0.000	3.076	0.001
Hadri robust	26.654	0.000	3.408	0.000	31.277	0.000	3.764	0.000

(a) Per-capita, in constants dollars of 2010. All variables in natural logarithm. HT is the Harris-Tzavalis test. IPS is the Im-Pesaran-Shin test. LLC is the Levin-Lin-Chu test. Tests results obtained using the xtunitroot built-in command in Stata

Table 4 First generation panel unit root tests on HE and GDP. OECD countries

	Health care expenditures (a)				GDP (a)			
	Level		First difference		Level		First difference	
	Stat.	*p* value	Stat.	*p* value	Stat.	*p* value	Stat.	*p* value
Panel 1: Series with drift								
H_0: *All the panels contain a unit root*								
Breitung	8.441	1.000	− 11.088	0.000	2.581	0.995	− 7.109	0.000
HT	0.965	1.000	0.312	0.000	0.918	0.992	0.357	0.000
IPS	4.085	1.000	− 8.631	0.000	− 3.923	0.000	− 9.341	0.000
LLC	− 2.843	0.002	− 10.681	0.000	− 9.508	0.000	− 11.400	0.000
H_0: *All the panels are stationary*								
Hadri	64.822	0.000	2.761	0.003	61.442	0.000	10.984	0.000
Hadri robust	63.593	0.000	3.816	0.000	56.799	0.000	11.900	0.000
Panel 2: Series with drift and trend								
H_0: *All the panels contain a unit root*								
Breitung	2.574	0.995	− 8.681	0.000	− 0.284	0.388	− 6.552	0.000
HT	0.810	1.000	0.338	0.000	0.863	1.000	0.439	0.000
IPS	0.589	0.722	− 5.350	0.000	1.854	0.968	− 8.890	0.000
LLC	− 2.369	0.009	− 9.442	0.000	− 5.166	0.000	− 11.160	0.000
H_0: *All the panels are stationary*								
Hadri	25.587	0.000	11.650	0.000	41.809	0.000	1.646	0.050
Hadri robust	25.678	0.000	12.435	0.000	35.112	0.000	0.734	0.232
Panel 3: Demeaned series with drift								
H_0: *All the panels contain a unit root*								
Breitung	2.224	0.987	− 9.996	0.000	1.208	0.886	− 6.686	0.000
HT	0.882	0.838	0.203	0.000	0.951	1.000	0.361	0.000
IPS	− 1.902	0.029	− 11.799	0.000	1.416	0.922	− 9.662	0.000
LLC	− 5.717	0.000	− 14.113	0.000	− 1.954	0.025	− 11.324	0.000
H_0: *All the panels are stationary*								
Hadri	46.388	0.000	2.998	0.001	56.792	0.000	6.923	0.000
Hadri robust	36.356	0.000	5.097	0.000	46.472	0.000	6.679	0.000
Panel 4: Demeaned series with drift and trend								
H_0: *All the panels contain a unit root*								
Breitung	2.888	0.998	− 10.164	0.000	− 0.529	0.298	− 3.430	0.000
HT	0.772	0.999	0.261	0.000	0.842	1.000	0.505	0.000
IPS	− 0.479	0.316	− 9.991	0.000	0.262	0.603	− 7.815	0.000
LLC	− 5.131	0.000	− 12.775	0.000	− 5.398	0.000	− 10.287	0.000
H_0: *All the panels are stationary*								
Hadri	30.724	0.000	3.616	0.000	38.131	0.000	4.560	0.000
Hadri robust	27.815	0.000	2.709	0.003	30.074	0.000	5.054	0.000

(a) Per-capita, in constants dollars of 2010. All variables in natural logarithm. HT is the Harris-Tzavalis test. IPS is the Im-Pesaran-Shin test. LLC is the Levin-Lin-Chu test. Tests results obtained using the xtunitroot built-in command in Stata

Table 5 Cross-section dependence and second-generation panel unit root tests on HE and GDP. LA and OECD countries

	Health care expenditures (a)		GDP (a)	
	Level	First difference	Level	First difference
LA countries				
H_0: *Cross-section independence*				
CD	77.25 ***	9.61 ***	67.36 ***	23.09 ***
H_0: *All the panels contain a unit root*				
CIPS (with drift)	– 2.01	– 3.74 ***	– 1.47	– 3.08 ***
CIPS (with drift and trend)	– 2.46	– 3.95 ***	– 1.49	– 3.56 ***
OECD countries				
H_0: *Cross-section independence*				
CD	101.27 ***	52.22 ***	96.70 ***	62.26 ***
H_0: *All the panels contain a unit root*				
CIPS (with drift)	– 1.81	– 3.34 ***	– 1.31	– 2.82 ***
CIPS (with drift and trend)	– 1.92	– 3.72 ***	– 1.76	– 2.91 ***

(a) Per-capita, in constants dollars of 2010. All variables in natural logarithm. "CD" is the Pesaran (2004) test for cross-section dependence, implemented using the Stata command xtcd coded by Markus Eberhardt. "CIPS" is the Pesaran (2007) panel unit root test in the presence of cross-section dependence, implemented using the Stata command xtcips coded by Maximo Sangiacomo. Significance levels: *** 1%, ** 5%, * 10%

Table 6 Health equation panel estimates. LA and OECD countries

	CCE	CCE small T jacknife	CCE small T recursive	DOLS untransformed data	DOLS demeaned data
LA	1.567	1.74	1.011	3.227***	1.789 ***
	(0.425)***	(0.455)***	(0.402)**		
OECD	1.289	1.274	1.535	3.861***	1.667***
	(0.256)***	(0.269)***	(0.24)***		

"CCE" is the Common Correlated Effects method by Pesaran (2006), implemented using the Stata command xtdcce2 coded by Ditzen (2018). "DOLS" is the between-dimension, group-mean panel DOLS estimator by Pedroni (2001), implemented using the Stata command xtpedroni coded by Timothy Neal. Significance levels: *** 1%, ** 5%, * 10%

Table 5, as clear and consistent evidence that both series have a unit root, in the panels of LA and of OECD countries.

We ruled out the possibility that the results are driven by a specific country by applying the CIPS test in a sensitivity exercise excluding one country at a time from the panel of LA and OECD countries. The results are reported in Tables 12 and 13 in the Appendix.

Panel cointegration estimates

We use two approaches, CCE and DOLS panel estimates, to quantify the long-run relationship between HE and GDP. The results are reported in Table 6. We applied the DOLS estimate to the original series, which is the untransformed data, and to the demeaned data. The second alternative accommodates for some forms of cross-country dependence. We report the results obtained using untransformed data to show how different the estimates are when cross-country dependence is ignored.

The estimated income (GDP) elasticities of health care expenditures range from 1 to 1.8 for LA countries, and from 1.3 to 1.7 for OECD countries.[12] Using the CCE estimate with small T recursive correction we obtained a point estimate for the group of LA countries equal to 1.011, that is, we estimate an increase in HE equal to 1.011% when GDP increases in 1%, while for OECD countries an increase in GDP of 1% generates an estimated rise of 1.535% in HE. In all panels and methodologies points estimates are statistically significant at the 1% level, and we cannot reject the null hypothesis of a unitary elasticity at the one percent level of significance. That is, for both groups of countries analyzed we found evidence that health care is a necessity and not a luxury, and did not find significant differences in the estimated elasticities between LA and OECD countries. These results were obtained with estimates that are robust to at least some forms of cross-country correlation. However, if we neglect to address dependence across countries, we obtain estimates that are above 3, so by using these results we would mistakenly conclude that health care is a luxury. We study the sensitivity of the estimates to country exclusion and reassuringly found consistent results.[13]

We used the residuals from the previous CCE and DOLS estimations to test the existence of a cointegrating relationship between HE and GDP. We conducted the CIPS panel unit root test by Pesaran (2007) on CCE residuals, and Pedroni (2004) and Pedroni (1999) panel unit root test on DOLS residuals.[14] Table 7 presents the results of the cointegration tests. Using CCE residuals we obtained clear evidence of a cointegrating relationship between HE and GDP in both LA and OECD countries. However, the results were not conclusive with DOLS residuals. To provide further evidence on the cointegration between HE and GDP we used the cointegration test proposed by Westerlund (2007), which allowed to obtain critical values robust to cross-country dependence by bootstrapping.[15] The results obtained, reported in Table 7, are in line with those obtained using the CCE residuals along with the CIPS unit root test.

Long-run panel causality estimates

The final step in the empirical analysis of the long-run relationship between HE and GDP was to confirm the existence of the cointegrating relationship, and to establish the direction of this relationship. Both tasks were carried out by estimating the Vector Error Correction Model, that in our study is in the form of:

$$\begin{bmatrix} \Delta he_{it} \\ \Delta gdp_{it} \end{bmatrix} = \begin{bmatrix} c_{i1} \\ c_{i2} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \end{bmatrix} \times \hat{\varepsilon}_{i,t-1} + \begin{bmatrix} \phi_{11} \\ \phi_{21} \end{bmatrix} \times \Delta he_{i,t-1} + \begin{bmatrix} \phi_{12} \\ \phi_{22} \end{bmatrix} \times \Delta gdp_{i,t-1} + \begin{bmatrix} \upsilon_{i1} \\ \upsilon_{i2} \end{bmatrix}, \tag{6}$$

where $\hat{\varepsilon}_{i,t} = he_{it} - \left[\hat{\alpha}_i + \hat{\beta}_i * gdp_{it}\right]$ are the residuals from the estimation of equation (1). The long-run adjustment coefficients, δ_1 and δ_2, capture how he_{it} and gdp_{it} respond to

[12] Table 14 in the Appendix presents estimated elasticities by country, obtained with the CCE estimator.

[13] We report the results of the sensitivity analysis in Table 15 in the Appendix.

[14] We conducted Pedroni's test on the CCE residuals, with similar results.

[15] We briefly describe the test in "Westerlund (2007) cointegration test" section in the Appendix.

Table 7 Cointegration tests. LA and OECD countries

	CCE	CCE small T jacknife	CCE small T recursive
CIPS unit root test on CCE residuals. H_0 : All the panels contain a unit root			
LA	– 3.15 ***	– 3.15 ***	– 2.74 ***
OECD	– 2.67 ***	– 2.67 ***	– 2.54 ***

	Panel v. statistic	Panel PP $rho-$statistic	Panel PP $t-$statistic	Panel ADF statistic	Group PP $rho-$statistic	Group PP $t-$statistic	Group ADF statistic
Pedroni unit root test on DOLS residuals. H_0 : All the panels contain a unit root							
LA (a)	0.7406	– 0.4083	– 1.219	4.108 ***	1.382	– 0.6409	4.333 ***
LA (b)	0.8725	– 0.4333	– 1.916	3.156 ***	0.7947	– 2.139 **	9.712 ***
OECD (a)	– 0.0152	0.3688	– 0.3839	4.22 ***	2.749 ***	1.022	– 1.401
OECD (b)	1.977 **	– 0.975	– 2.293 **	2.147 **	1.122	– 1.817 *	– 0.2328

	Gt	Ga	Pt	Pa
Westerlund cointegration tests. H_0 : no cointegration				
LA	– 2.19 **	– 7.01	– 8.81	– 5.41 *
OECD	– 2.52 **	– 8.76 **	– 14.05 ***	– 7.83 ***

"CIPS" is the Pesaran (2007) panel unit root test in the presence of cross-section dependence, implemented using the Stata command xtcips coded by Maximo Sangiacomo. "Pedroni unit root test" developed in Pedroni (2004) and Pedroni (1999), implemented using the Stata command xtpedroni coded by Timothy Neal. (a) is untransformed data. (b) is demeaned data. "Westerlund cointegration tests" developed in Westerlund (2007), implemented using the Stata command xtwest coded by Persyn and Westerlund (2008). Significance levels: *** 1%, ** 5%, * 10%

deviations from the equilibrium relationship. If at least one of the coefficients is significantly different from zero we confirm the existence of a long-run relationship between the two variables. We infer that causality, in the sense of Granger, is from gdp to he if δ_1 is statistically different from zero, and from he to gdp if δ_2 is significantly different from zero. We also interpret the parameters ϕ as short run effects.

We estimated the VEC models using CCE and DOLS on demeaned data panel estimates. In Table 8, we report estimates and standard errors obtained with Newey-West (HAC standard errors) and seemingly unrelated (homoskedastic standard errors) methods. We find evidence of a long-run causal relationship between GDP and HE for the group of LA and OECD countries (coefficients of CCE and DOLS residuals statistically significant at the 1% level), and no evidence in the other direction in the relationship (coefficients of residuals close to zero and not statistically significant at the usual levels).

We also found evidence of a short run effect of past values of GDP on HE, for both LA and OECD countries (point estimates between 0.369 and 0.877, statistically significant at the 1% level). The short run effect of past HE values on GDP is heterogeneous across groups of countries: the HE in OECD countries has an estimated negative effect on GDP one year ahead (point estimates – 0.034 and – 0.039, statistically significant at the 5% level), but there is no evidence of this reaction in LA countries (point estimates close to zero and not statistically significant at the usual levels). These negative short run effect for OECD countries disappears when we include covariates in the equation, as shown in "Robustness to the inclusion of covariates" section.

Table 8 Panel estimates of VEC models. LA and OECD countries

	LA		OECD	
	CCE	DOLS	CCE	DOLS
Δhe_{it} as dependent variable				
$ec_{i,t-1}$	− 0.596	− 0.317	− 0.643	− 0.348
	(0.091)***	(0.056)***	(0.071)***	(0.025)***
	(0.054)	(0.044)	(0.06)	(0.027)
$\Delta he_{i,t-1}$	0.272	0.09	0.351	0.255
	(0.088)***	(0.085)	(0.041)***	(0.043)***
	(0.047)	(0.047)	(0.038)	(0.035)
$\Delta gdp_{i,t-1}$	0.42	0.877	0.369	0.635
	(0.19)**	(0.223)***	(0.14)***	(0.158)***
	(0.167)	(0.175)	(0.127)	(0.12)
Δgdp_{it} as dependent variable				
$ec_{i,t-1}$	0.0002	0.002	− 0.019	0.0004
	(0.019)	(0.014)	(0.025)	(0.007)
	(0.015)	(0.012)	(0.018)	(0.009)
$\Delta he_{i,t-1}$	− 0.011	− 0.008	− 0.034	− 0.039
	(0.016)	(0.016)	(0.016)**	(0.016)**
	(0.013)	(0.013)	(0.012)	(0.012)
$\Delta gdp_{i,t-1}$	0.279	0.27	0.394	0.388
	(0.062)***	(0.063)***	(0.06)***	(0.062)***
	(0.047)	(0.047)	(0.039)	(0.04)

"CCE" is the Common Correlated Effects method by Pesaran (2006), implemented using the Stata command xtdcce2 coded by Ditzen (2018). "DOLS" is the between dimension panel dynamic ordinary least square estimate by Pedroni (2001), applied to demeaned data, and implemented using the Stata command xtpedroni coded by Timothy Neal. Significance levels: *** 1%, ** 5%, * 10%. The first parenthesis under the coefficient is the HAC standard error, computed using the Stata command newey2 coded by David Roodman. The second parenthesis is the homoskedastic standard error computed using the Stata build-in command sureg

Robustness to the inclusion of covariates

An important concern with the CCE estimator is that its consistency depends on the exogeneity of the covariates, that is, it suffers from omitted variables (consistency) bias. The related literature points out three main potentially relevant covariates in the health-income equation: (1) public health care expenditures, because a most predominant role of the public sector in financing health care tends to increase the total health care expenditure; (2) technological change, that generally increases health expenditure when new technology is adopted but may decrease it if it is relatively cost-efficient compared with previous technology; and (3) characteristics of the population that increase utilization of health care facilities.

To quantify the problem of potential bias in our estimations, we studied the robustness of the results to the introduction of covariates. Specifically, we augmented the health care expenditures equation by introducing as covariates public health care expenditures, measured as percentage of GDP, infant mortality rates per 1000 live births as a proxy for technological change, and, to control for pressure on health care facilities, percentage of total population living in urban areas, and dependency rates for elderly and young people, computed as the

Table 9 Second-generation panel unit root tests on controls. LA and OECD countries

	Public health care expenditures (a)		Dependency rate Old (b)		Dependency rate Young (b)		Urbanization (b)		Infant mortality rate (c)	
	Level	1st dif	Level	1st dif	Level	1st dif	Level	1st dif	Level	1st dif
LA countries										
H_0: *Cross-section independence*										
CD	23.5 ***	7.6 ***	8.6 ***	6.4 ***	5.8 ***	2.6 ***	35.8 ***	2.3 **	73.3 ***	21.8 ***
H_0: *All the panels contain a unit root*										
CIPS(d)	− 2.2 **	− 4.7 ***	− 1.1	− 2.4 ***	− 1.3	− 3.2 ***	− 2.0	− 4.9 ***	− 1.2	− 2.2 *
CIPS(e)	− 2.6	− 4.8 ***	− 1.4	− 2.8 **	− 1.9	− 3.3 ***	− 3.7 ***	− 4.8 ***	− 1.7	− 2.6
OECD countries										
H_0: *Cross-section independence*										
CD	56.1 ***	28.1 ***	33.6 ***	19.9 ***	24.1 ***	16.8 ***	1.6	1.9 *	103.3 ***	37.2 ***
H_0: *All the panels contain a unit root*										
CIPS(d)	− 2.0	− 3.8 ***	− 1.0	− 2.5 ***	− 1.9	− 3.1 ***	− 1.7	− 3.6 ***	− 1.7	− 3.9 ***
CIPS(e)	− 2.0	− 4.1 ***	− 1.5	− 2.8 **	− 2.0	− 3.4 ***	− 3.1 ***	− 3.5 ***	− 2.7 *	− 4.3 ***

(a) as percentage of GDP. (b) growth rate. (c) per 1000 live births. (d) with drift. (e) with drift and trend. "CD" is the Pesaran (2004) test for cross-section dependence, implemented using the Stata command xtcd coded by Markus Eberhardt. "CIPS" is the Pesaran (2007) panel unit root test in the presence of cross-section dependence, implemented using the Stata command xtcips coded by Maximo Sangiacomo. Significance levels: *** 1%, ** 5%, * 10%

population aged 65 and over divided by the population aged 15–64, and the population aged 0–14 divided by the population aged 15–64, respectively.

We obtained the series on public health care expenditures from the Global Health Expenditure Database of the World Health Organization, and infant mortality rates, urban population, and dependency rates from the World Bank's World Development Indicators.[16] When these controls are included the two dimensions of the sample, number of countries and number of time periods, are reduced. The list of LA countries was reduced to 28, because dependency rates were not available for Dominica and St. Kitts and Nevis. As we used growth rates for dependency rates and urban population the time span was reduced by one year.[17] Consequently, and to obtain comparable results, we estimated the model with and without controls with the same (reduced) sample.

We began the exercise by providing evidence of the cross-section dependence and non-stationarity of the covariates. The results are reported in Table 9. Using the CIPS unit root test, in almost all specifications and for LA and OECD countries, we did not reject the null hypothesis that the series in level contain a unit root, while we did reject the null hypothesis for the series in first differences. Also, the included covariates show cross-section dependence, with the exception of the percentage of urban population in OECD countries.

Once the non-stationarity of the controls was stablished, we computed CCE estimates of the health care expenditures equation without covariates and augmented with covariates. The results are reported in Table 10. The introduction of covariates reduces the estimated elasticities. The estimated elasticities ranged from 0.796 to 1.222 for LA countries, and from

[16] Tables 16 and 17 in the Appendix provide descriptive statistics of the series.

[17] Dependency rates and urban population are non-stationary in levels and also in first differences. In order to have a model in which all variables are stationary in first differences, we used the growth rate of these variables, as it is standard in the literature.

Table 10 CCE Panel estimates and cointegration tests: health equation with and without controls. LA and OECD countries

	CCE		CCE small T-jacknife		CCE small T-recursive	
	No controls	Controls	No controls	Controls	No controls	Controls
CCE estimates						
LA	1.628	1.145	1.788	0.796	0.989	1.222
	(0.441)***	(0.251)***	(0.508)***	(0.362)**	(0.426)**	(0.222)***
OECD	1.314	0.838	1.278	1.042	1.688	0.945
	(0.277)***	(0.441)*	(0.301)***	(0.518)**	(0.231)***	(0.477)**
CIPS unit root test on CCE residuals						
H_0 : *All the panels contain a unit root*						
LA	− 3.09 ***	− 5.72 ***	− 3.09 ***	− 5.72 ***	− 2.89 ***	− 5.55 ***
OECD	− 2.60 ***	− 5.45 ***	− 2.60 ***	− 5.45 ***	− 2.50 ***	− 5.30 ***

"CIPS" is the Pesaran (2007) panel unit root test in the presence of cross-section dependence, implemented using the Stata command xtcips coded by Maximo Sangiacomo. The list of controls includes public health care expenditures as percentage of GDP, growth rate of the dependency rate for old (+65) and young (less than 14) people, % of population in urban areas, and infant mortality rate. Significance levels: *** 1%, ** 5%, * 10%

0.838 to 1.042 for OECD countries. In all specifications with controls the elasticities are statistically significant at usual significance levels. Additionally, in all models with covariates and all but one without covariates, we did not reject the null hypothesis of the unitary income elasticity of health care expenditures.[18] Comparing the estimates by group of countries, we found that in most of the specifications the estimated elasticity for LA countries is higher than that for the group of OECD countries.

Turning to the points estimates for controls, in all the specifications and panels, the estimated coefficient of public health expenditures is positive, as expected, and the corresponding parameter is statistically significant at the usual significance level, while the dependency rates, urban population, and infant mortality rate are not significant.

The cointegration tests, conducted by applying the CIPS statistic to the CEE residuals, are also robust to the introduction of covariates. In all specifications the null hypothesis of non-stationarity was rejected at the 1% level of significance.

Finally, we estimated the VEC model, which includes the CCE residuals, and found evidence of a long-run causal relationship between GDP and HE, while finding no evidence of a relationship in the opposite direction. That is, the long-run causality analysis done before is robust to the introduction of the proposed controls. The results are reported in Table 11.

Turning to the discussion of short run effects, including controls we obtained positive estimated effects of HE and GDP on HE one year head, that are statistically significant. We also found a positive short run effect of GDP on GDP one year ahead, while there is no evidence of a short run effect of HE on GDP one year ahead.

In line with the CCE estimates of the health care expenditures equation, we obtained a positive and significant short run effect of increases in public health expenditures on total health expenditures for both groups of countries, LA and OECD: an increase of 1 % in the participation of public health expenditures on GDP rises total health expenditure as percentage of GDP in 0.4 to 0.5%. And only for the group of OECD countries, we found

[18] We reject the unitary income elasticity hypothesis for the panel of OECD countries when we use the specification without covariates and the recursive correction for small T.

Table 11 CCE panel estimates of VEC models: model with and without controls. LA and OECD countries

	LA		OECD	
	Without controls	With controls	Without controls	With controls
Δhe_{it} as dependent variable				
$ec_{i,t-1}$	− 0.626	− 1.484	− 0.637	− 0.952
	(0.097)***	(0.294)***	(0.073)***	(0.28)***
	(0.059)	(0.18)	(0.06)	(0.229)
$\Delta he_{i,t-1}$	0.265	0.117	0.341	0.249
	(0.093)***	(0.071)*	(0.041)***	(0.049)***
	(0.05)	(0.043)	(0.037)	(0.04)
$\Delta gdp_{i,t-1}$	0.49	0.645	0.437	0.505
	(0.195)**	(0.197)***	(0.143)***	(0.159)***
	(0.181)	(0.165)	(0.126)	(0.136)
$\Delta pubhe_{i,t}$		0.428		0.206
		(0.036)***		(0.098)**
		(0.038)		(0.075)
$\Delta old_{i,t}$		− 0.283		− 1.844
		(0.688)		(1.158)
		(0.966)		(1.207)
$\Delta young_{i,t}$		− 0.363		2.893
		(1.782)		(1.031)***
		(1.24)		(1.029)
$\Delta urban_{i,t}$		0.368		− 3.481
		(0.91)		(3.828)
		(1.71)		(3.64)
$\Delta mortality_{i,t}$		0.019		− 0.061
		(0.012)		(0.029)**
		(0.014)		(0.027)
Δgdp_{it} as dependent variable				
$ec_{i,t-1}$	− 0.004	0.031	− 0.023	0.013
	(0.021)	(0.058)	(0.027)	(0.071)
	(0.017)	(0.054)	(0.019)	(0.063)
$\Delta he_{i,t-1}$	− 0.007	− 0.011	− 0.035	− 0.023
	(0.017)	(0.017)	(0.016)**	(0.014)
	(0.014)	(0.013)	(0.012)	(0.011)
$\Delta gdp_{i,t-1}$	0.272	0.287	0.381	0.401
	(0.069)***	(0.07)***	(0.06)***	(0.06)***
	(0.051)	(0.049)	(0.04)	(0.038)
$\Delta pubhe_{i,t}$		− 0.036		− 0.202
		(0.016)**		(0.034)***
		(0.011)		(0.021)
$\Delta old_{i,t}$		0.179		− 0.471
		(0.333)		(0.351)
		(0.288)		(0.335)

Table 11 continued

	LA		OECD	
	Without controls	With controls	Without controls	With controls
$\Delta young_{i,t}$		0.063		0.499
		(0.346)		(0.32)
		(0.37)		(0.285)
$\Delta urban_{i,t}$		0.045		− 0.371
		(0.276)		(0.774)
		(0.51)		(1.009)
$\Delta mortality_{i,t}$		0.008		− 0.026
		(0.003)**		(0.009)***
		(0.004)		(0.007)

"CCE" is the Common Correlated Effects method by Pesaran (2006), implemented using the Stata command xtdcce2 coded by Ditzen (2018). The list of controls includes public health care expenditures as percentage of GDP (*pubhe*), and growth rate of the dependency rate for old (+65) (*old*) and young (less than 14) (*young*) people. The first parenthesis under the coefficient is the HAC standard error, computed using the Stata command coded by David Roodman. The second parenthesis is the homoskedastic standard error computed using the Stata build-in command sureg. Significance levels based on the HAC standard errors: *** 1%, ** 5%, * 10%

evidence that improvements in technology, as proxied by a reduction in the infant mortality rate, and higher dependency rates for young people, increase health expenditures in the short run.

We obtained an unexpected positive and significant coefficient of the short run effect of the infant mortality rate on GDP for LA countries, although the point estimate is close to zero (equal to 0.008). Also, we found a significant negative effect of public health expenditures on GDP that is higher in absolute value for OECD (point estimate equal to − 0.202) than for LA countries (point estimate equal to − 0.036). These odd results may suggest that the group of control variables used is not sufficient to overcome all the potential sources of omitted variables bias. In particular, infant mortality rates may not be a convenient proxy to technological change. An alternative proxy is life expectancy, but regrettably the series in the period under analyzes is non-stationary in first differences.[19] More appropriate measures to account for technological change are research and development in health care and surgical procedures, thought such information is not available for the group of LA countries.

Other potential confounding factors in the HE-GDP equation are related to institutional characteristics of the health system, such as health insurance coverage, and type of insurance (public vs. private) As noticed in Acemoglu et al. (2013) "... the spread of insurance coverage, have not only directly encouraged increased spending but also induced the adoption and diffusion of new medical technologies". Thus, falling to control for insurance coverage would upward-bias the income elasticity of health expenditure, under the premiss that insurance coverage is higher in countries with higher GDP. For this reason, our estimates for the income elasticity of HE should be interpreted as an upper bound of its true value, and the conclusion that HE is a necessity rather than a luxury good stands. Unfortunately, we did not find a measure of insurance coverage that is comparable across LA countries.

[19] Transformations on the life expectancy series like growth rates are also non-stationary in first differences.

Conclusions

We provide evidence of the existence of a long-run causal relationship between GDP and HE based on a group of 30 LA countries, most of them developing countries, and the 35 OECD countries for the period 1995 to 2014. We did not find significant differences between the two groups of countries. The estimated income elasticities of HE are close to the unitary value, and there is no evidence of a long-run causal effect of HE on GDP.

We used cointegration techniques that are robust to the presence of cross-country dependence, since we found conclusive evidence against the traditional assumption of cross-section independence. We also showed that if cross-country dependence is mistakenly discarded, the results of panel unit root and cointegration tests are inconsistent. Our results are robust to the exclusion of countries in the data, and to the introduction of covariates in the model.

Our results are in line with recent literature that has found a positive HE income elasticity for OECD countries, and no evidence of HE being a luxury good. A novelty of our work is that we provide similar evidence for a group of countries, those of Latin America and the Caribbean, that has not been studied before.

We also show that GDP does not react in the long-run to changes in the level of HE. This conclusion seems to contradict the call from international institutions to raise HE through increased public funding, based on the view that HE plays a key role in development and in improving the standard of living. We do not think that we are providing evidence against the role of HE in development, since GDP growth may not be the appropriate measure of development. We consider that the Human Development Index (HDI) and labor productivity measured as the growth rate of GDP per hour worked are more appropriate indicators of living standards. Regrettably, the non-availability of this information prevents us from using it in our analysis. HDI is computed from 1980 on a five years basis, and has only been available on a yearly basis since 2010. As well, the growth rate of GDP per hour worked is only available for some OECD countries. We leave the study of the long-run relationship between development and HE to the future, and hope for the availability of the necessary data.

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Compliance with ethical standards

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Conflict of interest The authors declare that they have no conflict of interest.

Appendix

Health care expenditures as percentage of GDP in the world, and in selected groups of countries

See Figs. 1 and 2.

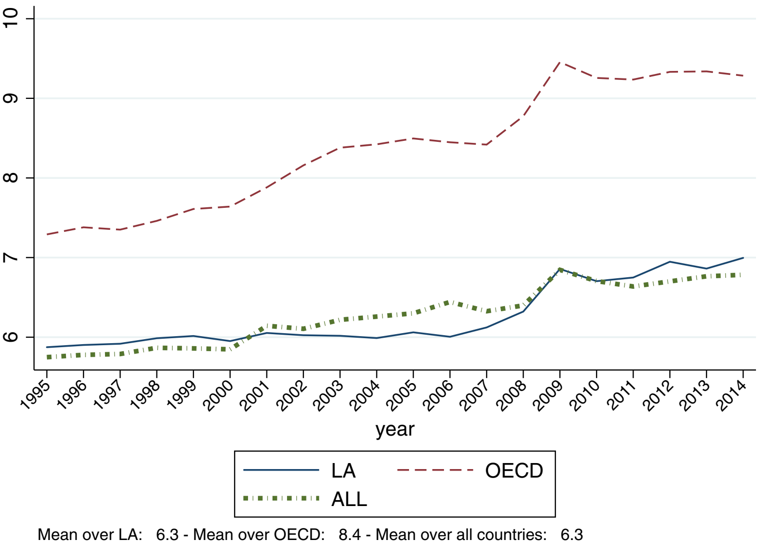

Fig. 1 Health care expenditures as percentage of GDP between 1995 and 2014. *Notes* "LA" is the group of 33 Latin American countries. "OECD" is the group of 35 Organisation for Economic Co-operation and Development member countries. "ALL" includes 192 countries for which HE data is available in the Global Health Observatory of the WHO

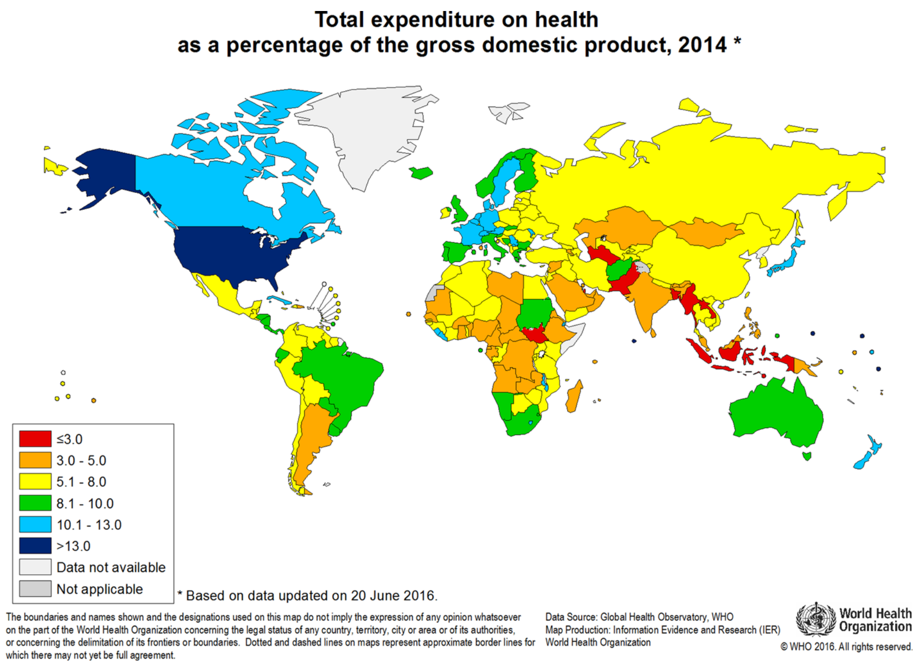

Fig. 2 Health care expenditures as percentage of GDP in 2014. *Source*: Global Health Observatory Map Gallery, WHO

Trends in health care expenditures and GDP

See Figs. 3, 4, 5 and 6.

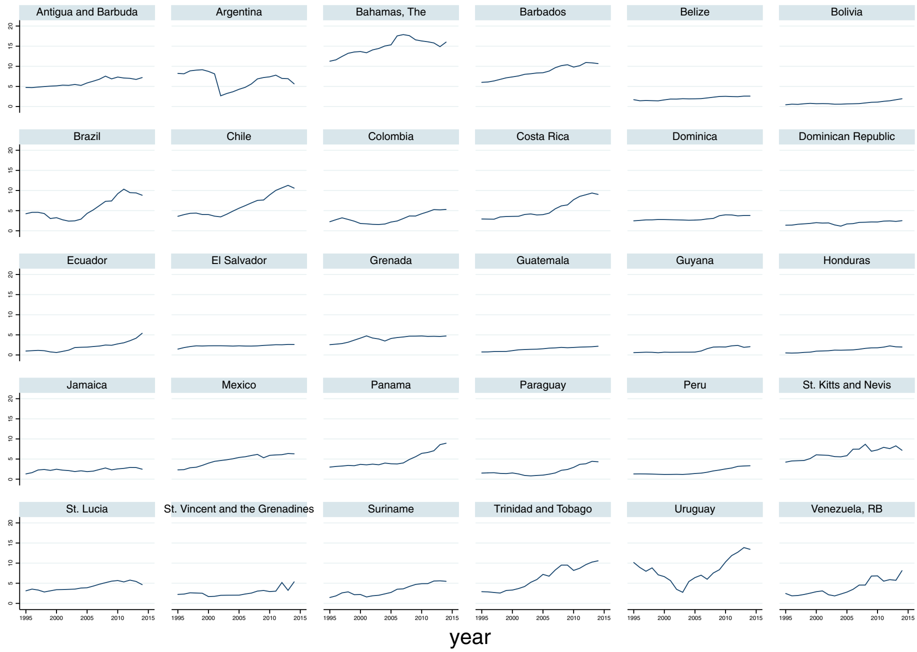

Fig. 3 Health care expenditures trends, LA countries. *Notes* Natural logarithm of health care expenditures per-capita, in constant dollars of 2010

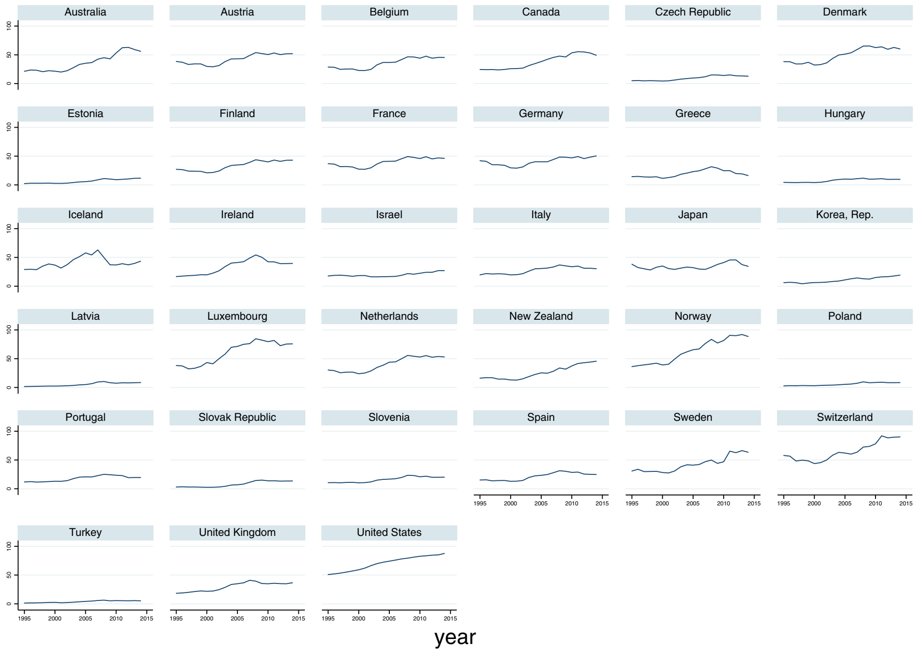

Fig. 4 Health care expenditures trends, OECD countries. *Notes* Natural logarithm of health care expenditures per-capita, in constant dollars of 2010

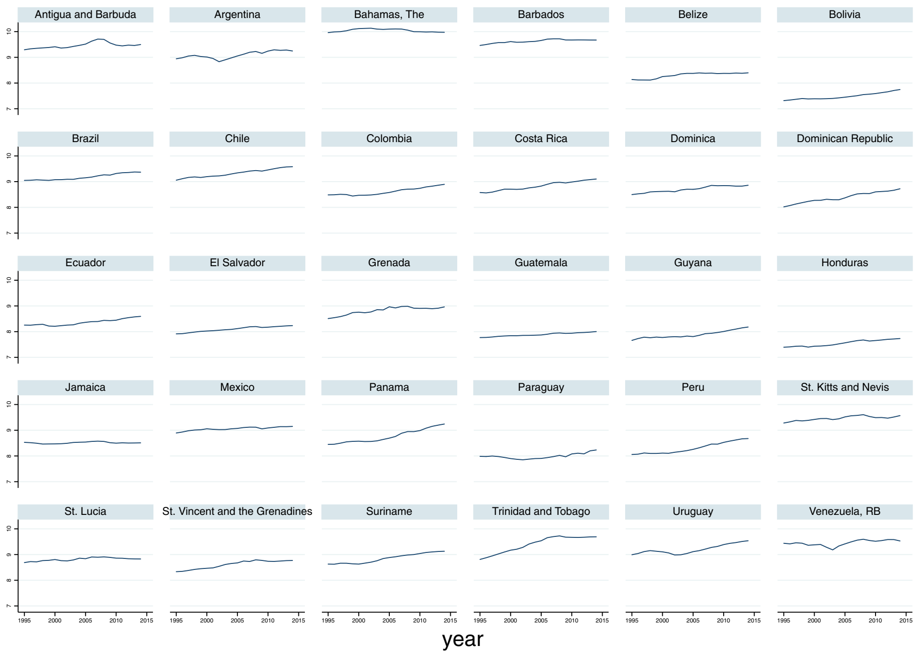

Fig. 5 GDP trends, LA countries. *Notes* Natural logarithm of GDP per-capita, in constant dollars of 2010

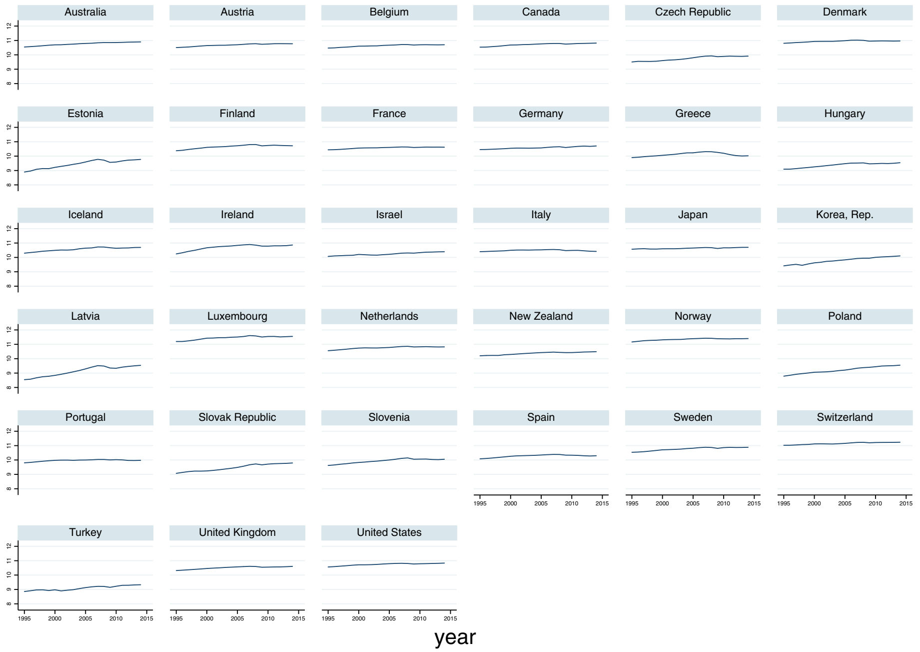

Fig. 6 GDP trends, OECD countries. *Notes* Natural logarithm of GDP per-capita, in constant dollars of 2010

Sensitivity to country exclusion: CIPS panel unit root test

See Tables 12 and 13.

Table 12 Second-generation panel unit root tests on HE and GDP excluding one country at a time. LA countries

Country	Health care expenditures (a)		GDP (a)	
excluded	Level	First difference	Level	First difference
H_0: All the panels contain a unit root				
Antigua and Barbuda	– 1.52	– 3.09 ***	– 2.02	– 3.71 ***
Argentina	– 1.51	– 3.07 ***	– 2.03	– 3.64 ***
Bahamas, The	– 1.46	– 3.11 ***	– 2.04	– 3.78 ***
Barbados	– 1.47	– 3.08 ***	– 2.05	– 3.76 ***
Belize	– 1.51	– 3.08 ***	– 2.03	– 3.72 ***
Bolivia	– 1.52	– 3.13 ***	– 1.95	– 3.63 ***
Brazil	– 1.44	– 3.08 ***	– 1.99	– 3.76 ***
Chile	– 1.47	– 3.07 ***	– 2.01	– 3.79 ***
Colombia	– 1.45	– 3.11 ***	– 2.03	– 3.75 ***
Costa Rica	– 1.42	– 3.04 ***	– 1.96	– 3.74 ***
Dominica	– 1.45	– 3.07 ***	– 1.94	– 3.74 ***
Dominican Republic	– 1.41	– 3.08 ***	– 1.97	– 3.72 ***

Table 12 continued

Country excluded	Health care expenditures (a)		GDP (a)	
	Level	First difference	Level	First difference
Ecuador	– 1.46	– 3.08 ***	– 2.06	– 3.78 ***
El Salvador	– 1.49	– 3.09 ***	– 1.86	– 3.71 ***
Grenada	– 1.50	– 3.04 ***	– 2.01	– 3.79 ***
Guatemala	– 1.45	– 3.08 ***	– 2.06	– 3.80 ***
Guyana	– 1.47	– 3.05 ***	– 2.00	– 3.75 ***
Honduras	– 1.41	– 3.07 ***	– 2.05	– 3.76 ***
Jamaica	– 1.44	– 3.11 ***	– 1.95	– 3.78 ***
Mexico	– 1.41	– 3.08 ***	– 2.04	– 3.76 ***
Panama	– 1.45	– 3.08 ***	– 1.99	– 3.73 ***
Paraguay	– 1.49	– 3.07 ***	– 2.07	– 3.75 ***
Peru	– 1.43	– 3.10 ***	– 1.97	– 3.77 ***
Saint Kitts and Nevis	– 1.47	– 3.07 ***	– 2.01	– 3.73 ***
Saint Lucia	– 1.50	– 3.01 ***	– 2.05	– 3.75 ***
Saint Vincent	– 1.52	– 3.06 ***	– 1.94	– 3.61 ***
Suriname	– 1.47	– 3.11 ***	– 1.96	– 3.73 ***
Trinidad and Tobago	– 1.56	– 3.13 ***	– 2.11	– 3.74 ***
Uruguay	– 1.48	– 3.11 ***	– 2.04	– 3.70 ***
Venezuela, RB	– 1.48	– 3.03 ***	– 1.98	– 3.69 ***

(a) Per-capita, in constants dollars of 2010. All variables in natural logarithm. Series modelled with drift (no trend). "CIPS" is the Pesaran (2007) panel unit root test in the presence of cross-section dependence, implemented using the Stata command xtcips coded by Maximo Sangiacomo. Significance levels: *** 1%, ** 5%

Table 13 Second-generation panel unit root tests on HE and GDP excluding one country at a time. OECD countries

Country excluded	Health care expenditures (a)		GDP (a)	
	Level	First difference	Level	First difference
H_0: All the panels contain a unit root				
Australia	– 1.28	– 2.79 ***	– 1.79	– 3.34 ***
Austria	– 1.30	– 2.85 ***	– 1.82	– 3.35 ***
Belgium	– 1.32	– 2.78 ***	– 1.80	– 3.33 ***
Canada	– 1.32	– 2.81 ***	– 1.78	– 3.35 ***
Chile	– 1.36	– 2.84 ***	– 1.75	– 3.38 ***
Czech Republic	– 1.27	– 2.86 ***	– 1.81	– 3.33 ***
Denmark	– 1.29	– 2.80 ***	– 1.78	– 3.29 ***
Estonia	– 1.28	– 2.84 ***	– 1.76	– 3.33 ***
Finland	– 1.38	– 2.86 ***	– 1.79	– 3.35 ***

Table 13 continued

Country excluded	Health care expenditures (a)		GDP (a)	
	Level	First difference	Level	First difference
France	– 1.32	– 2.84 ***	– 1.80	– 3.34 ***
Germany	– 1.36	– 2.85 ***	– 1.83	– 3.37 ***
Greece	– 1.32	– 2.85 ***	– 1.86	– 3.34 ***
Hungary	– 1.29	– 2.83 ***	– 1.83	– 3.35 ***
Iceland	– 1.27	– 2.73 ***	– 1.82	– 3.37 ***
Ireland	– 1.30	– 2.84 ***	– 1.87	– 3.38 ***
Israel	– 1.36	– 2.82 ***	– 1.81	– 3.35 ***
Italy	– 1.38	– 2.85 ***	– 1.82	– 3.32 ***
Japan	– 1.30	– 2.78 ***	– 1.78	– 3.34 ***
Korea, Republic	– 1.30	– 2.75 ***	– 1.81	– 3.31 ***
Latvia	– 1.25	– 2.83 ***	– 1.79	– 3.39 ***
Luxembourg	– 1.32	– 2.78 ***	– 1.86	– 3.32 ***
Mexico	– 1.31	– 2.83 ***	– 1.88	– 3.33 ***
Netherlands	– 1.32	– 2.84 ***	– 1.75	– 3.32 ***
New Zealand	– 1.30	– 2.81 ***	– 1.82	– 3.30 ***
Norway	– 1.27	– 2.78 ***	– 1.83	– 3.32 ***
Poland	– 1.32	– 2.83 ***	– 1.76	– 3.31 ***
Portugal	– 1.32	– 2.84 ***	– 1.84	– 3.36 ***
Slovak Republic	– 1.32	– 2.89 ***	– 1.77	– 3.28 ***
Slovenia	– 1.34	– 2.83 ***	– 1.81	– 3.33 ***
Spain	– 1.35	– 2.85 ***	– 1.83	– 3.30 ***
Sweden	– 1.25	– 2.77 ***	– 1.85	– 3.39 ***
Switzerland	– 1.33	– 2.84 ***	– 1.84	– 3.37 ***
Turkey	– 1.36	– 2.83 ***	– 1.75	– 3.32 ***
United Kingdom	– 1.32	– 2.86 ***	– 1.84	– 3.39 ***
United States	– 1.30	– 2.85 ***	– 1.96	– 3.47 ***

(a) Per-capita, in constants dollars of 2010. All variables in natural logarithm. Series modelled with drift (no trend). "CIPS" is the Pesaran (2007) panel unit root test in the presence of cross-section dependence, implemented using the Stata command xtcips coded by Maximo Sangiacomo. Significance levels: *** 1%, ** 5%

Individual country CCE estimates

See Table 14.

Table 14 CCE estimates by country. LA and OECD countries

Country	CCE	CCE small T
LA countries		
Antigua and Barbuda	0.405	0.531
	(4.65e−18)***	(1.34e−17)***
Argentina	3.81	4.191
	(9.12e−16)***	(1.20e−15)***

Table 14 continued

Country	CCE	CCE small T
Bahamas	0.628	− 0.501
	(1.22e−16)***	(9.67e−17)***
Barbados	0.639	− 0.617
	(8.90e−17)***	(1.49e−16)***
Belize	1.747	2.032
	(3.51e−16)***	(5.76e−16)***
Bolivia	4.451	4.689
	(6.12e−16)***	(6.65e−16)***
Brazil	3.965	− 1.12
	(8.23e−16)***	(3.45e−16)***
Chile	0.6	1.123
	(1.52e−16)***	(6.08e−17)***
Colombia	3.138	2.224
	(1.16e−15)***	(2.64e−16)***
Costa Rica	3.241	2.412
	(3.28e−16)***	(2.94e−16)***
Dominica	0.929	0.961
	(7.99e−17)***	(8.37e−17)***
Dominican Republic	2.366	3.452
	(3.62e−17)***	(5.52e−16)***
Ecuador	5.548	6.057
	(3.68e−16)***	(1.71e−15)***
El Salvador	3.912	− 1.847
	(4.66e−16)***	(4.45e−17)***
Grenada	2.388	0.819
	(2.71e−16)***	(3.04e−16)***
Guatemala	4.39	− 2.186
	(2.25e−16)***	(2.85e−17)***
Guyana	− 1.981	− 1.174
	(1.06e−16)***	(9.12e−17)***
Honduras	− 4.34	1.808
	(2.79e−16)***	(4.42e−16)***
Jamaica	− 4.157	− 3.929
	(5.47e−16)***	(9.94e−16)***
Mexico	2.211	− 2.141
	(2.67e−16)***	(1.39e−16)***
Panama	1.827	2.4
	(1.07e−16)***	(6.84e−16)***
Paraguay	2.031	2.479
	(7.81e−16)***	(3.57e−17)***
Peru	2.391	2.077
	(3.04e−17)***	(2.56e−16)***

Table 14 continued

Country	CCE	CCE small T
Saint Kitts and Nevis	1.224	1.273
	(2.17e−16)***	(2.04e−16)***
Saint Lucia	1.459	1.507
	(1.36e−16)***	(1.22e−16)***
Saint Vincent	− 1.34	− 0.891
	(3.15e−16)***	
Suriname	0.14	0.161
	(5.53e−17)***	(3.96e−17)***
Trinidad and Tobago	1.246	2.149
	(1.49e−16)***	(3.99e−17)***
Uruguay	3.675	2.089
	(5.27e−16)***	(5.96e−16)***
Venezuela	0.478	0.31
		(2.95e−16)***
OECD countries		
Australia	3.005	3
	(2.03e−16)***	(1.08e−16)***
Austria	− 0.383	1.277
	(1.41e−16)***	(2.35e−17)***
Belgium	0.054	1.67
	(7.67e−17)***	(6.05e−16)***
Canada	0.9	0.927
	(5.47e−17)***	(1.70e−16)***
Chile	3.235	3.127
	(2.92e−16)***	(3.34e−16)***
Czech Republic	0.827	1.112
	(2.06e−16)***	(9.57e−17)***
Denmark	1.125	1.11
	(4.89e−17)***	(1.33e−16)***
Estonia	0.051	− 0.22
	(3.99e−17)***	(4.98e−17)***
Finland	− 0.043	− 0.491
		(5.84e−18)***
France	− 0.341	1.41
	(5.30e−17)***	(5.90e−17)***
Germany	0.392	1.107
	(4.57e−17)***	(2.93e−17)***
Greece	1.716	1.617
	(2.38e−16)***	(1.87e−16)***
Hungary	4.503	4.086
	(1.15e−15)***	(1.46e−16)***

Table 14 continued

Country	CCE	CCE small T
Iceland	3.781	4.669
	(5.94e−16)***	(4.00e−16)***
Ireland	2.79	2.612
	(2.26e−16)***	(2.50e−16)***
Israel	3.482	3.146
	(3.49e−16)***	(4.00e−16)***
Italy	1.422	1.721
	(1.61e−17)***	(3.53e−17)***
Japan	− 1.778	0.778
	(1.99e−16)***	(5.06e−16)***
Korea	2.151	2.502
	(3.02e−16)***	(1.71e−16)***
Latvia	0.398	1.178
	(2.85e−17)***	(8.16e−17)***
Luxembourg	3.088	3.129
	(7.39e−16)***	(7.14e−17)***
Mexico	− 0.065	− 1.802
	(2.81e−16)***	(2.58e−16)***
Netherlands	− 0.433	− 0.046
	(6.91e−17)***	(2.17e−17)***
New Zealand	0.905	1.989
	(9.39e−17)***	(6.69e−16)***
Norway	− 1.514	− 0.656
	(4.40e−16)***	(1.24e−16)***
Poland	0.662	0.541
	(7.11e−17)***	(9.72e−17)***
Portugal	3.128	2.913
	(1.69e−17)***	(3.11e−16)***
Slovak Republic	0.686	1.042
	(1.72e−16)***	(3.38e−16)***
Slovenia	1.347	0.999
	(4.26e−17)***	(1.26e−16)***
Spain	2.347	2.057
	(4.54e−16)***	(3.42e−16)***
Sweden	2.304	0.952
		(5.81e−16)***
Switzerland	1.546	3.284
	(4.05e−17)***	(3.94e−16)***
Turkey	0.454	− 0.079
	(5.32e−17)***	(3.79e−17)***

Table 14 continued

Country	CCE	CCE small T
United Kingdom	2.558	2.771
	(3.85e−16)***	(3.02e−16)***
United States	0.822	0.297
	(4.57e−16)***	(3.41e−16)***

As in Table 6

Sensitivity to country exclusion: CCE estimates

See Table 15.

Table 15 Robustness of CCE estimates to country exclusion. LA and OECD countries

Country excluded	CCE	CCE small T
LA countries		
Antigua and Barbuda	1.583	1.065
	(0.427)***	(0.426)**
Argentina	1.47	0.873
	(0.451)***	(0.401)**
Bahamas	1.611	1.066
	(0.451)***	(0.41)***
Barbados	1.587	1.067
	(0.44)***	(0.414)***
Belize	1.62	1.013
	(0.432)***	(0.414)**
Bolivia	1.423	0.885
	(0.42)***	(0.387)**
Brazil	1.5	1.096
	(0.434)***	(0.403)***
Chile	1.644	1.007
	(0.445)***	(0.412)**
Colombia	1.55	0.981
	(0.438)***	(0.405)**
Costa Rica	1.484	0.977
	(0.433)***	(0.413)**
Dominica	1.598	1.035
	(0.439)***	(0.416)**
Dominican Republic	1.542	0.926
	(0.449)***	(0.403)**
Ecuador	1.439	0.836
	(0.406)***	(0.376)**
El Salvador	1.487	1.141
	(0.427)***	(0.4)***
Grenada	1.532	1.031
	(0.44)***	(0.421)**

Table 15 continued

Country excluded	CCE	CCE small T
Guatemala	1.435	1.101
	(0.426)***	(0.402)***
Guyana	1.693	1.019
	(0.439)***	(0.406)**
Honduras	1.705	0.945
	(0.377)***	(0.419)**
Jamaica	1.734	1.21
	(0.37)***	(0.374)***
Mexico	1.501	1.082
	(0.442)***	(0.402)***
Panama	1.516	0.966
	(0.435)***	(0.408)**
Paraguay	1.509	0.92
	(0.443)***	(0.406)**
Peru	1.552	0.98
	(0.434)***	(0.41)**
Saint Kitts and Nevis	1.575	0.99
	(0.443)***	(0.419)**
Saint Lucia	1.572	0.997
	(0.445)***	(0.422)**
Saint Vincent	1.762	1.159
	(0.42)***	(0.409)***
Suriname	1.668	1.07
	(0.428)***	(0.41)***
Trinidad and Tobago	1.699	1.039
	(0.436)***	(0.425)**
Uruguay	1.484	0.939
	(0.463)***	(0.407)**
Venezuela	1.536	0.989
	(0.427)***	(0.416)**
OECD countries		
Australia	1.232	1.501
	(0.256)***	(0.239)***
Austria	1.334	1.552
	(0.259)***	(0.244)***
Belgium	1.317	1.534
	(0.261)***	(0.246)***
Canada	1.307	1.559
	(0.262)***	(0.246)***
Chile	1.258	1.539
	(0.26)***	(0.237)***
Czech Republic	1.299	1.546
	(0.265)***	(0.248)***

Table 15 continued

Country excluded	CCE	CCE small T
Denmark	1.292	1.547
	(0.264)***	(0.248)***
Estonia	1.352	1.59
	(0.262)***	(0.25)***
Finland	1.301	1.567
	(0.261)***	(0.244)***
France	1.331	1.545
	(0.259)***	(0.245)***
Germany	1.326	1.582
	(0.265)***	(0.243)***
Greece	1.184	1.424
	(0.268)***	(0.265)***
Hungary	1.207	1.452
	(0.246)***	(0.24)***
Iceland	1.21	1.407
	(0.254)***	(0.229)***
Ireland	1.253	1.485
	(0.259)***	(0.251)***
Israel	1.225	1.516
	(0.257)***	(0.237)***
Italy	1.258	1.51
	(0.265)***	(0.25)***
Japan	1.429	1.605
	(0.247)***	(0.247)***
Korea	1.265	1.515
	(0.267)***	(0.244)***
Latvia	1.339	1.523
	(0.26)***	(0.254)***
Luxembourg	1.234	1.471
	(0.258)***	(0.246)***
Mexico	1.354	1.638
	(0.264)***	(0.227)***
Netherlands	1.323	1.57
	(0.258)***	(0.241)***
New Zealand	1.288	1.526
	(0.264)***	(0.247)***
Norway	1.367	1.592
	(0.249)***	(0.238)***
Poland	1.315	1.597
	(0.262)***	(0.236)***
Portugal	1.223	1.483
	(0.256)***	(0.244)***

Table 15 continued

Country excluded	CCE	CCE small T
Slovak Republic	1.316	1.574
	(0.262)***	(0.24)***
Slovenia	1.259	1.517
	(0.263)***	(0.251)***
Spain	1.231	1.492
	(0.26)***	(0.25)***
Sweden	1.244	1.547
	(0.264)***	(0.249)***
Switzerland	1.276	1.496
	(0.265)***	(0.24)***
Turkey	1.366	1.629
	(0.266)***	(0.24)***
United Kingdom	1.253	1.492
	(0.26)***	(0.246)***
United States	1.308	1.577
	(0.264)***	(0.245)***

As in Table 6

Westerlund (2007) cointegration test

The following description of the test was taken from the help file that accompanies the Stata command xtwest coded by Persyn and Westerlund (2008).

The panel cointegration tests developed by Westerlund (2007) contrast the absence of cointegration by determining whether there is error correction for individual panel members or for the panel as a whole. Consider the following error correction model, where all variables in levels are assumed to be I(1):

$$\begin{aligned}\Delta y_{it} &= c_i + a_{i1} * \Delta y_{it-1} + a_{i2} * \Delta y_{it-2} + \cdots + a_{ip} * \Delta y_{it-p} \\ &\quad + b_{i0} * \Delta x_{it} + b_{i1} * \Delta x_{it-1} + \cdots + b_{ip} * \Delta x_{it-p} \\ &\quad + a_i (y_{it-1} - b_i * x_{it-1}) + u_{it}\end{aligned}$$

where a_i provides an estimate of the speed of error-correction towards long-run equilibrium $y_{it} = -(b_i/a_i) * x_{it}$ for the series i.

The Ga and Gt test statistics contrast $H_0 : a_i = 0$ for all i against $H1 : a_i < 0$ for at least one i. These statistics start from a weighted average of the individually estimated a_i's and their t-ratio's respectively. Rejection of H_0 should therefore be taken as evidence of cointegration of at least one of the cross-sectional units.

The Pa and Pt test statistics pool information over all the cross-sectional units to test $H_0 : a_i = 0$ for all i vs $H_1 : a_i < 0$ for all i. Rejection of H_0 should therefore be taken as evidence of cointegration for the panel as a whole.

If the cross-sectional units are suspected to be correlated, robust critical values can be obtained through bootstrapping.

Controls

See Tables 16 and 17.

Table 16 Descriptive statistics of covariates, by country. LA countries

Country	Public health expenditures as % of GDP		Dependency rate Old in %		Dependency rate Young in %		% of population in urban areas		Infant mortality rate per 1000	
	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014
Antigua and Barbuda	3.1	3.8	11.3	10.4	42.8	35.9	29.4	24.2	10.8	5.7
Argentina	4.1	2.7	16.1	16.9	43.1	39.7	90.0	91.6	15.5	10.8
Bahamas, The	2.9	3.6	9.0	11.2	39.0	29.7	82.1	82.8	12.7	9.4
Barbados	3.8	4.7	17.7	20.6	31.2	29.1	32.8	31.6	13.3	12.0
Belize	2.9	3.9	6.6	5.9	67.1	52.4	46.2	44.1	18.6	14.0
Bolivia	3.5	4.6	9.4	10.4	63.5	54.1	63.9	68.1	49.0	31.5
Brazil	3.3	3.8	8.8	11.0	42.1	34.1	82.3	85.4	25.5	14.7
Chile	3.1	3.9	12.9	15.5	36.5	29.7	87.2	89.4	8.4	7.4
Colombia	4.9	5.4	8.1	9.9	45.0	36.0	73.4	76.2	18.9	14.0
Costa Rica	6.0	6.8	10.0	12.5	43.0	33.0	65.0	75.9	10.0	8.2
Dominica	3.6	3.8					66.7	69.3	16.9	28.7
Dominican Republic	2.0	2.9	9.1	10.3	55.0	47.8	67.2	78.1	31.2	26.7
Ecuador	2.0	4.5	8.9	10.2	53.6	45.8	61.2	63.5	25.5	18.9
El Salvador	3.8	4.5	10.5	12.4	55.9	42.9	61.1	66.3	22.6	13.8
Grenada	3.1	2.8	12.5	10.8	52.3	40.1	35.6	35.6	13.4	13.9

Table 16 continued

Country	Public health expenditures as % of GDP		Dependency rate Old in %		Dependency rate Young in %		% of population in urban areas		Infant mortality rate per 1000	
	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014
Guatemala	2.1	2.3	7.7	8.2	75.7	63.9	47.0	51.1	35.8	25.4
Guyana	4.4	3.1	7.2	7.4	56.9	45.6	28.5	28.5	34.2	28.3
Honduras	3.7	4.4	7.3	7.5	70.3	51.9	48.3	54.1	26.0	17.1
Jamaica	2.8	2.8	13.1	13.4	48.7	36.1	52.7	54.6	17.4	14.0
Mexico	2.6	3.3	8.6	9.6	52.2	42.8	76.2	79.0	19.3	13.3
Panama	5.1	5.9	9.6	11.4	48.2	42.2	63.1	66.3	19.5	14.9
Paraguay	3.0	4.5	8.2	9.2	60.2	48.1	56.6	59.4	24.5	18.1
Peru	2.7	3.3	8.8	10.2	51.6	43.3	74.8	78.3	24.0	12.9
Saint Kitts and Nevis	2.4	2.1					32.4	32.0	14.6	8.2
Saint Lucia	3.3	3.6	12.5	13.1	46.5	34.8	23.5	18.5	14.5	12.4
Saint Vincent	3.6	4.4	10.9	10.5	46.0	36.5	46.8	50.2	19.0	16.3
Suriname	3.8	2.9	9.5	10.3	48.8	41.1	66.4	66.1	25.9	19.0
Trinidad and Tobago	2.6	3.2	10.6	13.1	34.5	29.7	9.7	8.6	22.2	17.7
Uruguay	4.5	6.1	21.4	22.4	37.5	33.7	93.1	95.2	12.6	8.1
Venezuela, RB	1.9	1.5	7.7	9.3	51.1	43.4	88.2	88.9	17.0	14.5
All LA	3.4	3.8	10.5	11.6	49.9	40.8	58.4	60.4	20.6	15.7

Table 17 Descriptive statistics of covariates, by country. OECD countries

Country	Public health expenditures as % of GDP		Dependency rate Old in %		Dependency rate Young in %		% of population in urban areas		Infant mortality rate per 1000	
	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014
Australia	5.7	6.3	19.3	22.1	29.8	28.1	87.8	89.3	4.6	3.4
Austria	7.8	8.7	24.3	27.7	23.6	21.3	65.8	65.9	4.2	3.0
Belgium	7.0	8.2	25.9	27.7	26.2	25.9	97.3	97.8	4.4	3.3
Canada	6.8	7.4	19.4	23.0	26.2	23.5	80.0	81.7	5.1	4.6
Chile	3.1	3.9	12.9	15.5	36.5	29.7	87.2	89.4	8.4	7.4
Czech Republic	6.0	6.3	20.8	25.9	22.3	22.0	73.7	73.0	3.9	2.5
Denmark	8.2	9.2	24.0	28.7	27.4	26.5	85.9	87.5	4.1	3.5
Estonia	4.6	5.0	24.3	28.2	24.7	24.1	68.8	67.6	6.6	2.6
Finland	6.1	7.3	24.3	31.0	26.3	25.6	82.7	84.1	3.1	2.0
France	8.3	9.0	25.7	29.7	28.9	29.5	77.0	79.3	4.0	3.3
Germany	8.2	8.7	27.4	31.9	21.6	19.7	73.7	75.1	4.0	3.3
Greece	5.3	5.0	27.0	32.4	22.5	22.7	74.5	77.7	4.5	3.2
Hungary	5.3	4.9	23.2	25.8	23.2	21.4	66.8	70.8	7.1	4.7
Iceland	7.3	7.2	18.1	20.1	33.8	30.8	92.9	94.0	2.6	1.7
Ireland	5.3	5.1	16.2	19.3	31.5	33.0	60.4	63.0	4.7	3.2
Israel	4.7	4.8	16.4	18.0	45.1	45.4	91.5	92.1	4.8	3.1
Italy	6.3	7.0	28.9	34.3	21.4	21.5	67.7	68.8	4.2	3.0
Japan	6.8	8.6	30.1	41.9	21.3	21.1	84.9	93.0	2.9	2.0
Korea, Republic	2.8	4.0	12.6	17.4	26.2	19.6	80.7	82.4	5.3	3.1
Latvia	3.7	3.7	24.9	29.1	24.2	22.1	68.0	67.4	9.5	4.7
Luxembourg	6.1	5.8	20.9	20.1	27.0	24.0	86.2	89.9	3.2	2.1
Mexico	2.6	3.3	8.6	9.6	52.2	42.8	76.2	79.0	19.3	13.3

Table 17 continued

Country	Public health expenditures as % of GDP		Dependency rate Old in %		Dependency rate Young in %		% of population in urban areas		Infant mortality rate per 1000	
	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014	Mean	in 2014
Netherlands	6.9	9.5	21.6	27.0	26.6	25.5	81.6	89.9	4.5	3.4
New Zealand	7.1	9.1	18.8	22.1	32.9	31.1	85.9	86.3	5.7	4.7
Norway	7.5	8.3	23.2	24.3	29.6	27.4	77.2	80.2	3.3	2.3
Poland	4.4	4.5	18.6	21.4	25.5	21.2	61.3	60.6	7.1	4.3
Portugal	6.2	6.2	26.0	31.1	23.4	21.8	57.1	62.9	4.4	2.9
Slovak Republic	5.4	5.8	16.8	18.8	25.4	21.1	55.5	53.8	7.2	5.2
Slovenia	6.3	6.6	21.9	26.0	21.6	21.5	50.4	49.7	3.8	2.0
Spain	6.0	6.4	24.5	27.7	21.8	22.3	77.3	79.4	3.9	2.8
Sweden	7.8	10.0	27.5	31.0	27.3	27.0	84.5	85.7	3.0	2.4
Switzerland	6.3	7.7	23.6	26.5	24.1	21.9	73.5	73.8	4.3	3.7
Turkey	3.6	4.2	9.9	11.1	45.3	38.9	67.5	72.9	25.2	12.5
United Kingdom	6.6	7.6	24.7	27.0	28.1	27.3	80.0	82.3	5.1	3.8
United States	6.8	8.3	19.1	21.6	30.8	28.6	79.7	81.4	6.8	5.8
All OECD	6.0	6.7	21.5	25.0	28.1	26.2	76.0	77.9	5.9	4.0

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