HEALTH CARE EXPENDITURE AND GDP: AN AFRICAN PERSPECTIVE*

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Abstract
This paper sheds light on the income elasticity of health care expenditure in Africa. The existing literature has to date focused on developed countries due to scarcity of health expenditure data in developing countries. We herein exploit panel data techniques, combining time-series and cross-section data, which enable a substantial increase in testing power. Income elasticity of health care expenditure for 28 African countries over the decade 1991 – 2000 is investigated. In addition to aggregate health expenditure, we model public and private health expenditures separately. In both the short-run and long-run, public health expenditure is found to be a luxury while private health expenditure a necessity. This is not too surprising in the context of Africa, where the public sector has to strive hard to provide basic health care to the poor majority but where a rich minority can easily afford hi-tech private health care. Furthermore the income elasticity of public health expenditure is found to be pro-cyclical while that of private health expenditure is counter-cyclical, thereby reinforcing our previous finding.

Keywords: Health care expenditure, panel cointegration, Africa
JEL Classification: C23, I10

1. Introduction

The health care issue figures prominently among the millennium development goals set by the United Nations in September 2000 and signed by nearly 190 countries. Better health outcomes in the form of better treatment, education, nutrition and sanitation are crucial for improving economic welfare at both the micro and macro levels. A healthy population is bound to bring higher economic value added. The financing of health care expenditure (HCE) is therefore a predominant concern in any country, more so in African countries where severe budget constraints apply and where health outcomes are among the poorest in the world. The present paper estimates the income elasticity of HCE (YEHCE) in Africa with a view to understanding how the health budget is likely to respond as a result of economic growth over time. Given the scarcity of health care data for developing countries, the academic literature to date has focused on the developed world. As reported in Atella and Marini (2002), the literature can be categorized into three generations. The first-generation studies make use of cross-sectional data. The second-generation studies utilize pooled data. The third-generation studies employ panel data whilst also allowing for non-stationarity and cointegration.

The first-generation studies are based on cross-country bivariate regressions i.e. aggregate HCE and GDP. Using data from the OECD countries, Newhouse (1977), Gerdtham *et al* (1992) find that YEHCE exceeds one while Parkin *et al* (1987) observe that YEHCE

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depends on the functional form of the testing framework. Using African data, Gbesemete and Gerdtham (1992) conclude that YEHCE is very close to unity while Vasudeva (2004) reports that health care income elasticity is greater than unity. The second-generation studies make use of pooled data. Gerdtham (1992) finds that YEHCE is positive but less than one whereas Hitiris and Posnett (1992) observe an income elasticity of greater than one for the OECD countries.

The prolific advancement in econometrics in the early 1990s has lead to the third-generation studies. These have been carried out mainly for OECD countries. Hansen and King (1996) ascertain that GDP and HCE are non-stationary. McCoskey and Selden (1998) employ the same dataset as Hansen and King (1996) and conclude in favor of stationarity. Bac and Le Pen (2002) show that income elasticity of health expenditure is above unity for their least biased estimator. Dreger and Reimers (2005) find evidence of a health care income elasticity of below unity. Accounting for structural break, Jewell *et al* (2003) reject the null hypothesis of unit root for HCE and GDP. Carrion-i-Silvestre (2005) detects a stationary property for both series around a broken trend that exhibits multiple structural breaks. Employing Indian data, Bhat and Jain (2004) report an income elasticity of health expenditure of above unity. Wang and Rettenmaier (2006) find that health care income elasticity is greater than one for 50 U.S. states.

This paper exploits panel data techniques, that combine time-series and cross-section data, which enable a substantial increase in testing power. This also constitutes the first attempt to explore the income elasticity of health expenditure in Africa, using 28 African countries over the decade 1991 – 2000[1]. The paper is organized as follows: Section 2 presents the econometric model and specification tests, section 3 provides the empirical analysis, and section 4 summarizes our findings and provides some policy implications.

2. The Testing Framework

Table 1 presents average values for real HCE and GDP per capita over the decade 1991-2000. It appears that countries with high GDP per capita have relatively higher health expenditure per capita. Figure 1 illustrates the growth rate of these variables including those of disaggregated HCE per capita. The link between HCE and GDP, in particular the rate of change in health expenditure, can be assessed by the health expenditure income elasticity:

$$\text{YEHCE} = \frac{\partial(\text{HCE})}{\partial(\text{GDP})} \times \frac{\text{GDP}}{\text{HCE}} \tag{1}$$

If YEHCE = 1, HCE is changing at the same rate as GDP. If 0 < YEHCE < 1, HCE is deemed to be a necessity. If YEHCE > 1, HCE is deemed to be a luxury item. The reduced-form equation to be estimated is given as:

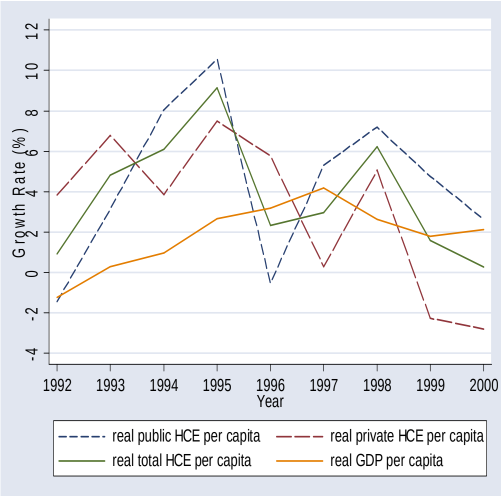
$$LTOTHPC_{it} = \beta_0 + \beta_1 LGDPPC_{it} + \beta_2 t + \varepsilon_{it} \tag{2}$$

LTOTHPC is the natural logarithm of real total HCE per capita (US$). *LGDPPC* is natural logarithm of real GDP per capita (US$). β_1 captures YEHCE. The linear time trend, t, is used as a proxy for technological progress. An improved technology may raise or reduce the cost of health care provision over time (Atella and Marini, 2002). Roberts

[1] The data were gathered from the World Development Indicators (2003). The selection of countries was done purely on the basis of data availability.

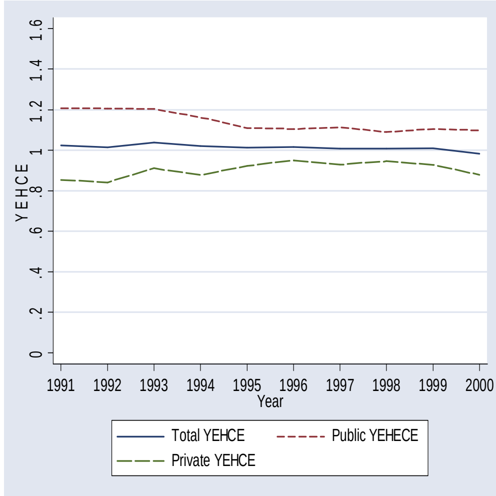
(2000) has been among the first to stress the importance of technology in the HCE function. ε_{it} is the error term.

Figure1: Average Growth Rate, 1992-2000



Source: Computed

Figure 2: Evolution of YEHCE, 1991-2000



Source: Computed

The inclusion of a time trend in unit root tests has been a central point of debate. McCoskey and Selden (1998) mention that in case of few data points, the inclusion of *t* can cause a loss of power with little improvement in fit while Hansen and King (1996) recommend the inclusion of *t*. Macroeconomic variables have a tendency to increase over time and be stationary around a deterministic trend. Results obtained without and with *t* are reported for both unit root tests and regressions. Health care heterogeneities due to differences in quality of medicine, equipment and medical staff may be an added source of misspecification. The income elasticity of public and private income health expenditure is studied separately. This is useful to policymakers because public and private health care may be of different commodity types in Africa, as elsewhere.

Various panel unit root tests have been employed in the literature. We make use of the Im, Pesaran and Shin (2003, IPS) test which is a based on the average of individual Dickey-Fuller τ-statistics. The *t*-bar statistics are defined as:

$$\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N}\tau_i \qquad , \tau_i = \frac{\hat{\rho}_i}{\hat{\sigma}_{\phi_i}} \qquad i = 1, 2, \ldots \ldots, N \tag{3a}$$

where τ_i is the ADF test statistic for the i^{th} country. The standardized *t*-bar statistic is:

$$\psi_{\bar{t}} = \frac{\sqrt{N}\left\{\bar{t}_{NT} - \frac{1}{N}\sum_{i=1}^{N}E\left[t_{iT}(\rho_i,0)\right]\right\}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}Var\left[t_{it}(\rho_i,0)\right]}} \tag{3b}$$

where N is the number of panels, $\bar{t}_{NT}$ is the average of the country-specific ADF statistics and values for $E[t_{iT}(p_i,0)]$ and $Var[t_{it}(p_i,0)]$ are obtained from Monte Carlo simulation. Ψ_t statistics are compared to critical values of the $N(0,1)$ distribution.

The second panel unit root test is Hadri's (2000) Lagrange Multiplier (LM) test which is based on the KPSS (Kwiatkowski *et al*, 1992) LM-statistics:

$$\widehat{LM}_{\mu} = \frac{1}{N}\sum_{i=1}^{N}\eta_i \tag{4a}$$

where H_0 of level or trend stationary is tested against the alternative of unit root in the panel. Assuming $\mathrm{E}\left[u_{i,t}\right] = \mathrm{E}\left[\varepsilon_{i,t}\right] = 0$, $u_{i,t}$ and $\varepsilon_{i,t}$ are independent and identically distributed (*iid*) across i and t, the limiting distribution of the test statistic is:

$$Z_{\mu} = \frac{\sqrt{N}\left(\widehat{LM}_{\mu} - \xi_{\mu}\right)}{\zeta_{\mu}} \Rightarrow N\left(0,1\right) \tag{4b}$$

where $\Rightarrow$ represents weak convergence in distribution, ξ_μ, ζ_μ are mean and variance of the standard Brownian bridge. The IPS test statistic in (3b) is based on the average of N country-specific ADF t-statistics while the Hadri test statistic in (4b) is based on the average of the N country-specific KPSS LM-statistics. Karlsson and Löthgen (2000) put forward a caveat of the IPS unit root test in that it tends to have high power in panels with large T and low power in panels with small T. In contrast, the Hadri test performs well for panel data with short time dimension (Barhoumi, 2005).

Two cointegration tests are considered in this paper. Nyblom and Harvey (2000, NH) postulate a test of common trends where H_0 is stationarity around a deterministic trend, i.e. there exists $k < n$ common trends (i.e. rank $(\Sigma\eta) = k$), against the alternative of a random walk component occurrence i.e. there exists more than k common trends (i.e. rank $(\Sigma\eta) > k$). The NH statistic tests the null of no common trend against the alternative hypothesis of common trends among the variables. No model needs to be estimated as the test is based on the rank of covariance matrix of the disturbances driving the multivariate random walk. Evidence in support of the null hypothesis implies cointegration**.** If A, the $r \times n$ matrix of cointegrating vectors is known, then the NH test statistic is:

$$\xi r(A) = tr(ASA')^{-1}ACA' \tag{5a}$$

where S is the nonparametric estimator of the spectral density at frequency zero using a Bartlett Window as stated by KPSS:

$$S = \widehat{\Gamma}_0 + \sum_{j=1}^{m}\left[1 - \frac{j}{m+1}\right]\left[\widehat{\Gamma}_j + \widehat{\Gamma}_{j'}\right] \tag{5b}$$

where m is the number of lags in the transitory component and

$$\widehat{\Gamma}_j = \frac{1}{T}\sum_{t=j+1}^{T}\left(y_t - \bar{y}\right)\left(y_{t-j} - \bar{y}\right)' \tag{5c}$$

C is an estimator of the second moments of partial sums of the time series:

$$C = \frac{1}{T^2}\sum_{i=1}^{T}\left[\sum_{i=1}^{i}\left(y_t - \bar{y}\right)\right]' \tag{5d}$$

This test is specifically a test of the pre-specified cointegrating vectors, i.e. a test of A.

Second, Pedroni (1999, 2004) develops seven panel cointegration test statistics based on the residuals of the Engle and Granger (1987) regression computed from:

$$y_{i,t} = a_t' + \ddot{a}_t t + \hat{a}_{1t} x_{1i,t} + \hat{a}_{2t} x_{2i,t} + \ldots + \hat{a}_{Mt} x_{Mi,t} + e_{i,t} \qquad (6a)$$

for t = 1, ..., T; i = 1,... ...,N; m = 1, ...,M . T refers to the number of observations over time, N refers to the number of individual members in the panel and M refers to the number of regression variables. The $\hat{a}_{1i}$, $\hat{a}_{2i}$, ..., $\hat{a}_{Mi}$ are permitted to vary across individual members of the panel. The parameter a' is the fixed-effects parameter which is also allowed to vary across individual members. These are specific to individuals and are captured by the term $\ddot{a}_t t$. The standardized distributions are given by:

$$\frac{x_{N,T} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1) \qquad (6b)$$

where $x_{N,T}$ is the appropriately standardized form for each of the N, T statistics and the values for μ and v are respectively the mean and variance as given by Pedroni (1999).

Pedroni (2001) proposes to apply the *fully modified* OLS (FMOLS) to obtain unbiased long-run estimates. Such methodology can account for both endogenous and serially correlated regressors. Assuming a bi-variate FMOLS model:

$$y_{it} = \alpha_i + \beta_i x_{it} + u_{it}\text{, where } x_{it} = x_{it-1} + \varepsilon_{it},\quad \varpi_{it} = \left(u_{it}, \varepsilon_{it}\right)' \qquad (8a)$$

the asymptotic distribution of the OLS depends on the long-run covariance matrix of the residual process ω. For the *i-th* panel member, the matrix is given by:

$$\Omega_i = \lim_{T\to\infty} \frac{1}{T} E\left(\sum_{t=1}^{T} \varpi_{it}\right)\left(\sum_{t=1}^{T} \varpi_{it}\right)' = \Sigma_i + \Gamma_i + \Gamma_i' = \begin{pmatrix} \varpi_{u,i} & \varpi_{u\varepsilon,i} \\ \varpi_{u\varepsilon,i} & \varpi_{\varepsilon,i} \end{pmatrix} \qquad (8b)$$

where $$\sum\nolimits_i = \lim_{T\to\infty} \frac{1}{T} \sum_{t=1}^{T} E\left(\varpi_{it}\varpi_{it}'\right) = \begin{pmatrix} \sigma_{u,i}^2 & \sigma_{u\varepsilon,i} \\ \sigma_{u\varepsilon,i} & \sigma_{\varepsilon,i}^2 \end{pmatrix} \qquad (8c)$$

and $$\sum\nolimits_i = \lim_{T\to\infty} \frac{1}{T} \sum_{k=1}^{T-1} \sum_{t=k+1}^{T} E\left(\varpi_{it}\varpi_{it-k}'\right) = \begin{pmatrix} \gamma_{u,i} & \gamma_{u\varepsilon,i} \\ \gamma_{u\varepsilon,i} & \gamma_{\varepsilon,i} \end{pmatrix} \qquad (8d)$$

respectively denote matrices of contemporaneous correlation coefficients and autocovariances. For convenience, the matrix:

$$\theta_i = \begin{pmatrix} \theta_{u,j} & \theta_{u\varepsilon,i} \\ \theta_{\varepsilon u,j} & \theta_{\varepsilon,j} \end{pmatrix} = \Sigma_i + \Gamma_i = \sum_{j=0}^{\infty} E\left(w_{ij} w_{io}\right)' \qquad (8e)$$

is defined. The endogeneity correction is achieved by the transformation:

$$y_{it}^* = y_{it} - \hat{\varpi}_{u\varepsilon,i}\hat{\varpi}_{u\varepsilon,i}^{-1}\Delta x_{it} \qquad (8f)$$

and the fully modified estimator is:

$$\hat{\beta}_i^* = \left(X_i' X_i\right)^{-1}\left(X_i' y_i^* - T\hat{\theta}_{\varepsilon u}^i\right)\text{, where } \hat{\theta}_{\varepsilon u}^* = \hat{\theta}_{eu} - \hat{\theta}_e \varpi_{\varepsilon,i}^{-1}\varpi_{\varepsilon u,i} \qquad (8g)$$

3. Results

The IPS panel unit root statistics are in Table 2(a). Mixed results in relation to the order of integration are obtained. The inclusion of a time trend seems to affect the outcome. However, referring to Hadri’s test in Table 2(b), all series are found to be I(1). Overall, based on these observations, the series appear to follow an I(1) process. We next perform the cointegration tests.

In table 3(a), the NH test statistics are reported under both the independent and identically distributed (*iid*) random walk errors (NH-*t*) and the serially correlated residuals (NH a*dj-t*) assumptions. The test is calculated under two different specifications i.e. fixed-effects without and with time trends. Under the first specification, H_0 is rejected only in the case of non-parametric adjustment (with 1 lag) to the long-run variance statistic (i.e. NH a*dj-t*). Cointegrating vectors are revealed under both assumptions when including a time trend in the autoregressive process. Moreover, the results for Pedroni's (1999, 2004) tests are presented in Table 3(b). Pedroni (2004) examined the small sample size and properties of all these tests. In terms of power when T is small, the group-adf statistic usually performs best, followed by the panel-adf statistic, whereas panel variance and the group-ρ statistics do poorly. H_0 is systematically rejected when referring to the group-adf and panel-adf statistics. Both tests therefore support the presence of cointegration.

In general, the health care elasticity does not seem to vary much across the different specifications. To estimate the short-run elasticity, an error-correction mechanism[2] (ECM) as popularized by Engle and Granger (1987) is constructed from the pooled regressions. The coefficient of ε_{it-1} has the correct sign and is statistically significant. This reinforces our conclusion of cointegration among the variables. Its small magnitude signifies a moderate speed of adjustment towards long-run equilibrium following a shock.

In the FE models, groupwise heteroskedasticity and first-order autocorrelation are detected as pointed out by Greene's (1993) and Wooldridge's (2002) methodologies respectively. The high significance of the lagged endogenous variable of the Arellano and Bond (1991) two-step generalized methods-of-moments (GMM) estimators confirm a dependency amongst disturbances. Prais and Winsten (1954, PW) recommend a panel-corrected standard error to correct for both correlated and heteroskedastic residuals in case disturbances are not *iid*. The parameters are computed by OLS. These are estimated on the assumption that there is first-order autocorrelation and the coefficient of the AR(1) process is specific to each panel.

As tabulated below, as per the PW models, income elasticity for total and public health care is found to be above unity while that of private health care is below unity. In other words, public HCE is found to be a luxury item while private HCE a necessity. Investigation using FMOLS produces similar finding. Faced with tight budget, African states are not able to give full priority to the health sector in spite of threat of widespread pandemics. In contrast, private HCE is found to be a necessity[3]. Only the rich minority of Africans[4] can afford high-quality private health care that is costly. Technological change, proxied by t, has a significant positive impact on public HCE but a statistically insignificant impact on private HCE.

We also model health care elasticity in relation to business cycles at the international level. Business cycles are measured as the natural logarithm of the cyclical component of

[2] Appendix 1 presents the first-order panel ECM's derivation.

[3] The Spearman correlation between private and public income elasticity is -0.7212 [0.0000]*.

[4] The Gini index over the period 1991-2000 is available for 20 out of the 28 countries in our sample and averages to 47.32. This reveals the prevalence of significant income inequality.

GDP for individual countries, obtained via the Hodrick-Prescott (HP) filter[5]. A health care elasticity series is constructed by running cross-sectional regressions over the period 1991-2000. The income elasticity is statistically significant in all cases at 1% level. These are shown in Figure 2. The particular nature of our dataset set leads us to consider the population-averaged generalized estimating equations (GEE) approach (see Liang and Zeger, 1986). The GEE methodology enables modelling of complex correlation structures and accommodates individual-level or cluster-level variables which are fine-tuned for within-individual or within-cluster correlation. The number of repeated observations is allowed to vary among individual countries without affecting the interpretation of the coefficients.

A positive relationship between public YEHCE and the cyclical component is found. This denotes a pro-cyclical pattern of public HCE. Low levels of public YEHCE are associated with recession periods while high levels of public YEHCE are associated with booms. Such behavior is consistent with public HCE being a luxury. Conversely, the negative coefficient for private HCE indicates a counter-cyclical process. Low levels of private YEHCE are associated with expansion periods, while high levels of private YEHCE are associated with depressions. Such behavior is consistent with private HCE being a necessity. With regard to the effect of the trend component of GDP on YEHCE, a possible interpretation is that rising income over time would stimulate African governments to provide the public health sector with more resources, inducing individuals to shift from private to public health care. As a result, public health care in Africa would in the long-run become a necessity and private health care a luxury, same as what developed countries are currently experiencing.

4. Conclusion

In this paper, we have used panel data techniques to examine stationarity and cointegration with reference to HCE and GDP for 28 African countries over the decade 1991 – 2000. HCE and GDP per capita are found to be I(1) and cointegrated. Public HCE is found to be a luxury while private HCE a necessity. Public YEHCE is pro-cyclical while private YEHCE is counter-cyclical.

Shortage of finance means that African governments are not able to adequately meet the demand for resources by the public health sector. In the short to medium term, foreign aid will therefore continue to play a critical role in the promotion of the African public health system. Our findings also suggest that in the long term, with rising income, public health in Africa would become more affordable and turn into a necessity, just like in the developed world. Of course, governance is critical to the success of the entire process.

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[5] The smoothing parameter $\lambda = 100$, following the frequency power rule of Ravn and Uhlig (2002) i.e. the number of periods per year divided by 4, raised to a power (which is assumed to be 2 as per Hodrick and Prescott, 1997) and multiplied by 1600.

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Annex

Table 1: Average Statistics for the Period 1991-2000 in US$

Country	Per Capita Real GDP	Per Capita Real Public HCE	Per Capita Real Private HCE	*Per Capita Real Total HCE*
Benin	5.934011	5.592024	11.52603	*375.8122*
Botswana	91.16643	69.05338	160.2198	*3370.478*
Burkina Faso	4.677862	4.384059	9.061921	*225.7351*
Burundi	2.315841	3.240582	5.556423	*166.8521*
Cameron	5.71274	16.36769	22.08043	*642.4698*
Cape Verde	27.69303	8.382833	36.07586	*1297.682*
Cote d'Ivoire	9.560918	13.40645	22.96736	*742.4943*
Equatorial Guinea	3.674122	1.76097	5.435091	*159.8556*
Ethiopia	1.496984	2.590318	4.087302	*103.4019*
Gabon	93.94402	47.59852	141.5425	*4567.368*
Gambia	9.628041	4.819202	14.44724	*355.3446*
Ghana	6.71961	8.76288	15.48249	*380.3066*
Guinea	10.96231	8.395877	19.35818	*565.3259*
Kenya	7.676639	20.16719	27.84383	*339.1633*
Mali	4.60264	4.999772	9.602412	*265.8617*
Mauritania	10.24964	10.08923	20.33887	*470.0545*
Mauritius	71.52486	55.05919	126.584	*3520.698*
Mozambique	4.528641	2.194622	6.723263	*158.3123*
Namibia	85.00067	68.37229	153.373	*2185.277*
Niger	3.603307	4.177328	7.780634	*210.5678*
Nigeria	1.400823	5.122601	6.523425	*256.3651*
Rwanda	6.053032	6.128986	12.18202	*248.6077*
Senegal	14.25358	11.64188	25.89546	*559.1602*
Sudan	2.297068	6.752585	9.049653	*269.0007*
Tanzania	4.188564	4.289189	8.477753	*182.2494*
Togo	4.443514	4.859134	9.302648	*336.5925*
Zambia	10.34805	9.950671	20.29872	*413.2739*
Zimbabwe	24.07407	23.34036	47.41443	*642.2013*
Total	*18.84754*	*15.41071*	*34.25824*	*821.804*

Source: Computed. Note: GDP deflator is used to compute the real values.

Table 2(a): IPS Panel Unit Root Test statistics

Variables	Data	Determi-nistics	Level Form		First Difference	
			t-bar	Ψ_t	*t*-bar	Ψ_t
LGDPPC	Raw	Constant	-1.596	-1.229 [0.109]	-3.214	-8.410 [0.000]*
		C+ Trend	-4.588	-11.093 [0.000]*	-2.926	-4.200 [0.000]*
	Demeaned	Constant	-1.682	1.610 [0.054]***	-2.214	-3.974 [0.000]*
		C + Trend	-3.039	-4.669 [0.000]*	-9.310	-30.682 [0.000]*
LTOTHPC	Raw	C	-1.809	-2.173 [0.015]**	-2.275	-4.244 [0.000]*
		C + Trend	-2.365	-1.873 [0.031]**	-12.887	-45.522 [0.000]*
	Demeaned	Constant	-1.333	-0.062 [0.475]	-3.989	-11.852 [0.000]*
		C + Trend	-4.098	-9.061 [0.000]*	-8.399	-26.903 [0.000]*
LPUBHPC	Raw	Constant	-1.407	-0.390 [0.358]	-2.467	-5.094 [0.000]*
		C + Trend	-2.663	-3.108 [0.001]*	-5.029	-12.923 [0.000]*

	Demeaned	Constant	-1.592	-1.212 [0.113]	-2.025	-3.134 [0.001]*
		C + Trend	-2.070	-0.648 [0.259]	-8.753	-28.370 [0.000]*
LPRIHPC	Raw	Constant	-3.362	-9.071 [0.000]*	-2.368	-4.656 [0.000]*
		C + Trend	-2.507	-2.459 [0.007]*	-12.052	-42.055 [0.000]*
	Demeaned	Constant	-2.017	-3.099 [0.001]*	-2.258	-4.170 [0.000]*
		C + Trend	-2.199	-1.183 [0.118]	-5.738	-15.864 [0.000]*

Source: Computed. Note: The lag order is set to 2 given T is small. There is no general rule on how to choose the maximum lag to start with. The cube root of the number of observations is used (Al Mamun and Nath, 2005). $\therefore \sqrt[3]{10} \approx 2.154$. Critical values for the t-bar statistics without trend at 1%, 5% and 10% significance levels are -1.850, -1.750 and -1.700 while with inclusion of a time trend, the critical values are -2.530, -2.420 and -2.360 respectively. Assuming no cross-country correlation and T is the same for all country, the normalized Ψ_t test statistic is computed by using the t-bar statistics. The Ψ_t tests for H_0 of joint non-stationarity and is compared to the 1%, 5% and 10% significance levels with critical values of -2.330, -1.645 and -1.282 correspondingly. p-values are in square brackets. To control for cross-section dependence, demeaned data are calculated by subtracting cross-section means from the original observations. *, **, *** denote 1%, 5% and 10% significance level respectively.

Table 2(b):Hadri Panel Unit Root Test Statistics

Variables	Level Form				*First Difference*			
	Homoskedastic Disturbances		Heteroskedastic Disturbances		Homoskedastic Disturbances		*Heteroskedastic Disturbances*	
	Z_μ	Z_t	Z_μ	Z_t	Z_μ	Z_t	Z_μ	Z_t
LGDPPC	23.022 [0.0000]*	10.340 [0.0000]*	15.842 [0.0000]*	8.412 [0.0000]*	1.489 [0.0683]***	0.807 [0.2098]	3.910 [0.0000]*	*2.805 [0.0025]**
LTOTHPC	19.643 [0.0000]*	5.926 [0.0000]*	14.501 [0.0000]*	3.648 [0.0001]*	-0.564 [0.7137]	0.817 [0.2070]	-0.721 [0.7646]	*0.263 [0.3962]*
LPUBHPC	21.172 [0.0000]*	4.730 [0.0000]*	15.709 [0.0000] *	2.564 [0.0052]*	-2.050 [0.9798]	-0.761 [0.7768]	-1.436 [0.9245]	*-0.494 [0.6893]*
LPRIHPC	*18.380 [0.0000]**	*6.475 [0.0000]**	*15.558 [0.0000]**	*4.565 [0.0000]**	*-0.837 [0.7987]*	*0.606 [0.2723]*	*-0.597 [0.7246]*	*0.163 [0.4352]*

Source: Computed. Note: Z_μ and Z_t denote the statistics without and with a deterministic trend respectively.

Table 3(a): Nyblom-Harvey Panel Cointegration Test Statistics

	Statistics	LGDPPC	LTOTHPC	LPUBHPC	LPRIHPC
Fixed Effects	NH-*t*	4.9500	4.9500	4.9500	4.9500
	NH adj-*t*	21.6333*	21.6333*	21.6333*	21.6333*
	CV 10%	4.17<CV<6.03	4.17<CV<6.03	4.17<CV<6.03	4.17<CV<6.03
	CV 5%	4.49<CV<6.41	4.49<CV<6.41	4.49<CV<6.41	4.49<CV<6.41
	CV 1%	5.11<CV<7.18	5.11<CV<7.18	5.11<CV<7.18	5.11<CV<7.18
Fixed Effects and Time Trends	NH-*t*	4.4000*	4.4000*	4.4000*	4.4000*
	NH adj-*t*	20.5333*	20.5333*	20.5333*	20.5333*
	CV 10%	1.57<CV<2.30	1.57<CV<2.30	1.57<CV<2.30	1.57<CV<2.30
	CV 5%	1.66<CV<2.39	1.66<CV<2.39	1.66<CV<2.39	1.66<CV<2.39
	CV 1%	1.84<CV<2.59	1.84<CV<2.59	1.84<CV<2.59	1.84<CV<2.59

Source: Computed. Note: The H_0 of the test is no cointegration (H_0: rank(var-cov)=K=0) against the alternative hypothesis of cointegration (H_1: rank(var-cov)=K≠0). H_0: 0 common trends among the 28 series in the panel. NH-*t*: the test is performed under the hypothesis of *iid* errors. NH *adj-t*: errors are allowed to be serially correlated and the test is performed using an estimate of the long-run variance derived from the spectral density matrix at frequency zero. The critical values (CV) pertain to N equals to 20 and 30 respectively. CV: Critical Values

Table 3(b): Pedroni Panel Cointegration Test Statistics

	Statistics	LTOTHPC	LPUBHPC	*LPRIHPC*
Without Trend	Panel ν-statistic	0.31148	0.45560	*0.00631*
	Panel ρ-statistic	-0.81499	-0.83202	*0.03614*
	Panel pp-statistic	-4.35458*	-4.64768*	*-1.92448***
	Panel adf-statistic	-2.67447	-4.16377*	*-0.82674*
	Group ρ-statistic	1.49533	1.33787	*2.12414*
	Group pp-statistic	-4.39272*	-5.70806*	*-1.49065****
	Group adf-statistic	-4.86691*	-5.70953*	*-3.56403**
With Trend	Panel ν-statistic	-1.02338	-0.39013	*-1.00569*
	Panel ρ-statistic	1.21071	1.09803	*1.62255*
	Panel pp-statistic	-5.94407*	-7.15190*	*-4.39083**
	Panel adf-statistic	-6.14661*	-6.88955*	*-3.95750**
	Group ρ-statistic	3.30592	3.09649	*3.54326*
	Group pp-statistic	-6.39957*	-8.03217*	*-5.20001**
	Group adf-statistic	*-8.55853**	*-9.47899**	*-6.60266**

Source: Computed. Note: The *panel* statistics are the within-dimension statistics while *group* statistics are between-dimension ones. Panel-ν, panel-ρ, and panel-pp represent the non-parametric variance ratio, Phillips-Perron ρ, and student's *t*-statistics respectively while panel-adf is a parametric statistic based on ADF statistic. Group-ρ, group-pp and group-adf represent Phillips-Perron ρ-statistic, Phillips-Perron t-statistic and the ADF-statistic correspondingly. The number of lag truncation is equalled to 2. These are one-sided standard normal test with critical values of 1%, 5% and 10% given by -2.330, -1.645 and -1.282. A special case is the panel ν-statistic which diverges to positive infinity under the alternative hypothesis. As such, rejection of the H_0 of no cointegration requires values larger than 2.330, 1.645 and 1.282 at 1%, 5% and 10% significance level. The critical values for the mean and variance of each statistic are obtained from Pedroni (1999).

Table 4(a): Income Elasticity of Total HCE

Variables	Pooled	Fixed-Effects	Between-Effects	Arellano-Bond	Prais-Winsten	*ECM*
Without Trend						
$LGDPPC_{it}$	1.015279 (0.0202)*	0.9290566 (0.0794)*	1.016939 (0.0572)*	-	1.006502 (0.0370)*	-
$\Delta LPRIHPC_{it-1}$	-	-	-	0.2301865 (0.0334)*	-	-
$\Delta LGDPPC_{it}$	-	-	-	0.6311235 (0.0129)*	-	*0.9563148* *(0.1180)**
ε_{it-1}	-	-	-	-	-	*-0.077472* *(0.0237)**
Time trend	-	-	-	-	-	-
Constant	-3.323613 (0.1262)*	-2.791787 (0.4904)*	-3.333851 (0.3571)*	0.0121146 (0.0033)*	-3.274781 (0.2182)*	-
Sargan Test	-	-	-	0.8632	-	-
Correlation 1st	-	-	-	0.0086	-	-
Correlation 2nd	-	-	-	0.0429	-	-
R^2	0.9007	0.3524	0.9240	-	0.9585	*0.2259*
Observations	280	280	280	224	280	*252*
Countries	28	28	28	28	28	*28*

Period	1991-2000	1991-2000	1991-2000	1993-2000	1991-2000	*1992-2000*
			With Trend			
$LGDPPC_{it}$	*1.012663 (0.0200)**	*0.7571401 (0.0799)**	-	- -	*1.005019 (0.0409)**	-
$\Delta LPRIHPC_{it-1}$	-	-	-	*0.2301865 (0.0334)**	-	-
$\Delta LGDPPC_{it}$	-	-	-	*0.6311235 (0.0129)**	-	*0.9483912 (0.1181)**
ε_{it-1}	-	-	-	-	-	*-0.0744057 (0.0240)**
Time trend	*0.0176535 (0.0067)***	*0.021912 (0.0036)**	- -	*0.0121146 (0.0033)**	*0.0189756 (0.0037)**	-
Constant	*-3.404572 (0.1286)**	*-1.851914 (0.4863)**	- -	- -	*-3.363147 (0.2218)**	-
Sargan Test	-	-	-	*0.8632*	-	-
Correlation 1st	-	-	-	*0.0086**	-	-
Correlation 2nd	-	-	-	*0.0429***	-	-
R^2	*0.9031*	*0.4327*	-	-	*0.9535*	*0.2320*
Observations	*280*	*280*	-	*224*	*280*	*252*
Countries	*28*	*28*	-	*28*	*28*	*28*
Period	*1991-2000*	*1991-2000*	-	*1993-2000*	*1991-2000*	*1992-2000*

Source: Computed. Note: The standard errors are given in parentheses. R^2 is the within-R^2 for fixed effects (FE) and betweenl-R^2 for between-effects (BE). The GMM consistency depends on the Sargan test of overidentifying restrictions, which tests the overall validity of the instruments. The absence of second order correlation in the error term is a pre-requisite. H_0 should not be rejected. Their p-values are reported below. First and second order correlation (1st and 2nd).

Table 4(b): Income Elasticity of Public HCE

Variables	Pooled	Fixed-Effects	Between-Effects	Arellano-Bond	Prais-Winsten	*ECM*
			Without Trend			
$LGDPPC_{it}$	1.143029 (0.0293)*	0.9290566 (0.0794)*	1.137065 (0.0836)*	-	1.207685 (0.0491)*	-
$\Delta LPUBHPC_{it-1}$	-	-	-	0.3089 (0.0219)*	-	-
$\Delta LGDPPC_{it}$	-	-	-	0.7824476 (0.0387)*	-	*1.355536 (0.1680)**
ε_{it-1}	-	-	-	-	-	*-0.063012 (0.0233)**
Time trend	-	-	-	-	-	-
Constant	-4.889389 (0.1829)*	-2.791787 (0.4904)*	-4.852601 (0.5219)*	0.0210246 (0.0019)*	-5.298093 (0.2981)*	-
Sargan Test	-	-	-	0.8718	-	-
Correlation 1st	-	-	-	0.0522***	-	-
Correlation 2n	-	-	-	0.1205	-	-
R^2	0.8449	0.3524	0.8767	-	0.8980	*0.2168*
Observations	280	280	280	224	280	*252*
Countries	28	28	28	28	28	*28*

Period	1991-2000	1991-2000	1991-2000	1993-2000	1991-2000	*1992-2000*
			With Trend			
$LGDPPC_{it}$	*1.137745*	*0.7571401*	-	-	*1.193983*	-
	*(0.0286)**	*(0.0799)**	-	-	*(0.0401)**	-
$\Delta LPUBHPC_{it-1}$	-	-	-	*0.3089*	-	-
	-	-	-	*(0.0219)**	-	-
$\Delta LGDPPC_{it}$	-	-	-	*0.7824476*	-	*1.342193*
	-	-	-	*(0.0387)**	-	*(0.1681)**
ε_{it-1}	-	-	-	-	-	-
	-	-	-	-	-	*0.0591475*
Time trend	*0.0356559*	*0.021912*	-	*0.0210246*	*0.0424175*	*(0.0239)***
	*(0.0096)**	*(0.0036)**	-	*(0.0019)**	*(0.0104)**	
Constant	*-5.052907*	*-1.851914*	-	-	*-5.446804*	-
	*(0.1842)**	*(0.4863)**	-	-	*(0.2628)**	
Sargan Test	-	-	-	*0.8718*	-	-
Correlation 1st	-	-	-	*0.0522****	-	-
Correlation 2nd	-	-	-	*0.1205*	-	-
R^2	*0.8517*	*0.4327*	-	-	*0.9496*	*0.2246*
Observations	*280*	*280*	-	*224*	*280*	*252*
Countries	*28*	*28*	-	*28*	*28*	*28*
Period	*1991-2000*	*1991-2000*	-	*1993-2000*	*1991-2000*	*1992-2000*

Source: Computed

Table 4(b): Income Elasticity of Private HCE

Variables	Pooled	Fixed-Effects	Between-Effects	Arellano-Bond	Prais-Winsten	*ECM*
			Without Trend			
$LGDPPC_{it}$	0.9040957	0.6610747	0.908774	-	0.8875344	-
	(0.0311)*	(0.1435)*	(0.0820)*		(0.0255)	
$\Delta LPUBHPC_{it-1}$	-	-	-	0.2830059	-	-
				(0.0187)*		
$\Delta LGDPPC_{it}$	-	-	-	0.4928754	-	*0.6376801*
				(0.0307)*		*(0.2026)**
ε_{it-1}	-	-	-	-	-	*-0.0937816*
						*(0.0263)**
Time trend	-	-	-	-	-	-
Constant	-3.369322	-1.870357	-3.398178	0.0001477	-3.284948	-
	(0.19471)*	(0.8858)**	(0.5118)*	(0.0009)	(0.1654)*	
Sargan Test	-	-	-	0.8907	-	-
Correlation 1st	-	-	-	0.0073*	-	-
Correlation 2nd	-	-	-	0.1193	-	-
R^2	0.7514	0.0779	0.8253	-	0.8643	*0.0834*
Observations	280	280	280	224	280	*280*
Countries	28	28	28	28	28	*28*

Period	1991-2000	1991-2000	1991-2000	1993-2000	1991-2000	*1992-2000*
With Trend						
$LGDPPC_{it}$	*0.9037482 (0.0312)**	*0.6034059 (0.1539)**	-	-	*0.8880379 (0.0252)**	-
$\Delta LPUBHPC_{it-1}$	-	-	-	*0.2830059 (0.0187)**	-	-
$\Delta LGDPPC_{it}$	-	-	-	*0.4928754 (0.0307)**	-	*0.6365529 (0.2026)**
ε_{it-1}	-	-	-	-	-	*-0.0935339 (0.0263)**
Time trend	*0.0023448 (0.0104)*	*0.0073503 (0.0070)*	-	*0.0001477 (0.0009)*	*0.0003021 (0.0067)*	-
Constant	*-3.380076 (0.2008)**	*-1.55508 (0.9366)****	-	-	*-3.286954 (0.1648)**	-
Sargan Test	-	-	-	*0.8907*	-	-
1^{st} Order	-	-	-	*0.0073**	-	-
Correlation	-	-	-	*0.1193*	-	-
2^{nd} Order	*0.7514*	*0.0818*	-	-	*0.8657*	*0.0832*
Correlation	*280*	*280*	-	*224*	*280*	*252*
R^2	*28*	*28*	-	*28*	*28*	*28*
Observations	*1991-2000*	*1991-2000*	-	*1993-2000*	*1991-2000*	*1992-2000*
Countries						
Period						

Source: Computed

Table 5: Diagnostic Tests

	Tests	*Health Equations*		
		LTOTHPC	LPUBHPC	*LPRIHPC*
Without Trend	Green Groupwise Heteroskedasticity Test (FE) Wooldridge First-Order Autocorrelation Test	$\chi^2(279)$ = 473.41 [0.000]* F(1,27) = 93.421 [0.000]*	$\chi^2(279)$ = 445.82 [0.000]* F(1,27) = 31.754 [0.000]*	*$\chi^2(279)$ = 492.35 [0.000]* F(1,27) = 301.909 [0.000]**
With Trend	*Green Groupwise Heteroskedasticity Test (FE) Wooldridge First-Order Autocorrelation Test*	*$\chi^2(279)$ = 441.09 [0.000]* F(1,27) = 109.884 [0.000]**	*$\chi^2(279)$ = 386.72 [0.000]* F(1,27) = 26.416 [0.000]**	*$\chi^2(279)$ = 489.56 [0.000]* F(1,27) = 311.923 [0.000]**

Source: Computed. Note: As derived by Greene's groupwise heteroskedasticity test, H_0: homoskedasticity, while for under Wooldridge's test, H_0: no first-order autocorrelation.

Table 6: Panel FMOLS estimates

Method	LTOTHPC		LPUBHPC		*LPRIHPC*	
	$\hat{\beta}$	t-statistic	$\hat{\beta}$	t-statistic	$\hat{\beta}$	*t-statistic*
FMOLS	*0.72*	*16.90**	*1.20*	*8.73**	*0.86*	*6.57**

Source: Computed. Note: Note: The selection of bandwidth for kernels is automatically computed. Given evidence of correlated residuals across countries, these models include common time dummies.

Table 7: The GEE Estimation of YEHCE with Business Cycles

Variables	*Health Equations (Semi-Robust Estimates)*		
	LTOTHPC	LPUBHPC	*LPRIHPC*
Cyclical component of natural logarithm of GDP	*-0.000091 (0.0008701)*	*0.0044905 (0.0009984)**	*-0.0012363 (0.0005026)***
Long-run component of natural logarithm of GDP	*-0.0001063 (0.0000379)**	*-0.0000425 (0.0000255)****	*0.0000323 (0.0000161)***
Constant	*1.017015 (0.000819)**	*1.159848 (0.000551)**	*0.8899491 (0.0003476)**
Overall observations	*280*	*280*	*280*
Number of groups	*28*	*28*	*28*
Observations per group	*10*	*10*	*10*

Source: Computed. Note: Since the time span is rather small, an unstructured intra-individual or intra-cluster correlation matrix *R* which imposes no restriction on the pairwise correlations is applied.

Appendix 1: Derivation of the First-Order Panel ECM model

Consider the equation below:

$$LTOTHPC_{it} = \beta_0 + \beta_1 LGDPPC_{it} + \beta_2 t + \varepsilon_{it} \tag{2}$$

To derive the long run equilibrium dynamics we re-write equation (2) as follows, while assuming $LTOTHPC_{it}$ and $LGDPPC_{it}$ are integrated of the order one, while ε_{it} is white-noise:

$$LTOTHPC_{it} = \beta_0 + \beta_1 LGDPPC_{it} + \beta_2 t + \beta_3 LGDPPC_{it-1} + \beta_4 LTOTHPC_{it-1} + \varepsilon_{it}$$

Subtracting $LTOTHPC_{it-1}$ on both sides:

$$LTOTHPC_{it} - LTOTHPC_{it-1} = \beta_0 + \beta_1 LGDPPC_{it} + \beta_3 LGDPPC_{it-1} + \beta_4 LTOTHPC_{it-1} - LTOTHPC_{it-1} + \beta_2 t + \varepsilon_{it}$$

$$\Delta LTOTHPC_{it} = \beta_0 + \beta_1 \mathrm{LGDPPC}_{it} + \beta_3 LGDPPC_{it-1} + (\beta_4 - 1) LTOTHPC_{it-1} + \beta_2 t + \varepsilon_{it}$$

Reparametrizing the above equation:

$$\Delta \mathrm{LTOTHPC}_{it} = \beta_0 + \beta 1 LGDPPC_{it} - \beta_1 LGDPPC_{it-1} + \beta_1 LGDPPC_{it-1} + \beta_3 LGDPPC_{it-1} + (\beta_4 - 1) LTOTHPC_{it-1} + \beta_2 t + \varepsilon_{it}$$

$$\Delta LTOTHPC_{it} = \beta_0 + \beta_1 \Delta LGDPPC_{it} + (\beta_1 + \beta_3) LGDPPC_{it-1} + (\beta_4 - 1) LTOTHPC_{it-1} + \beta_2 t + \varepsilon_{it}$$

$$\Delta LTOTHPC_{it} = \beta_1 \Delta LGDPPC_{it} + (\beta_1 + \beta_3) LGDPPC_{it-1} + \beta_0 + (\beta_4 - 1) LTOTHPC_{it-1} + \beta_2 t + \varepsilon_{it}$$

$$\Delta LTOTHPC_{it} = \beta_1 \Delta LGDPPC_{it} - (1 - \beta_4)\left[LTOTHPC_{it-1} - \frac{\beta_0}{1-\beta_4} - \frac{\beta_1 + \beta_3}{1-\beta_4} LGDPPC_{it-1} - \frac{\beta_2}{1-\beta_4} t \right] + \varepsilon_{it}$$

$$\Delta LTOTHPC_{it} = \beta_1 \Delta LGDPPC_{it} - \lambda \left[LTOTHPC_{it-1} - \lambda_0 - \lambda_1 LGDPPC_{it-1} - \lambda_2 t \right] + \varepsilon_{it}$$

$$\therefore \Delta LTOTHPC_{it} = \beta_1 \Delta LGDPPC_{it} - \lambda \varepsilon_{it,-1} + \varepsilon_{it},$$

The disequilibrium error $\varepsilon_{it,-1} = LTOTHPC_{it-1} - \lambda_0 - \lambda_1 LGDPPC_{it-1} - \lambda_2 t$ and is assumed to be I(0). λ measures the speed of adjustment towards the long-run equilibrium.