Stochastic Pattern of Health Care Spending: Evidence from Nonlinear Panel Data Analysis

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Abstract: This paper analyses the stochastic pattern of health care spending for 188 countries around the world which are categorized into four groups based on the World Bank income categories. The main motivation of this article is to evaluate whether the stochastic features of total health care expenditure varies if decomposed into private and public health care consumption. To achieve this goal, in addition to conventional empirical methods, latterly developed panel stationarity approaches are employed for both linear and nonlinear regression processes. Our results demonstrate that allowing for cross-section dependency between series and nonlinearity in the estimation process may lead to more often rejection of the null hypothesis of unit root for all series in panel data set.

Keywords: Health Care Consumption, Panel Unit Root Test, Panel Cross Section Dependence, Nonlinearity, Heterogeneous Panel Unit Root.
JEL Classification: C10, C23, I10.

INTRODUCTION

The amount of money spent on total health care and its various elements known basically as health care expenditure is one of the main subjects for the considerable number of empirical researches in health economy literature in recent decades. As McCanne (2010) points out, a successful health care system essentially aims to keep society healthy, treat the sick, and protect people from high medical bills that may cause economic tightness. Since a healthier population has a propensity for higher labour productivity and stimulate investment in physical capital, health care expenditures have crucial effects on economic welfare and growth making health policy implementations very critical for all governments (Bloom and Canning, 2000). Analysing the health care expenditure behaviour as well as its consequences on national income is fundamental for the economic growth and development process regardless of the income group that country belongs to.

Although there are numerous studies investigating health care expenditure by various country groups, periods and applied methods, there is no consensus on the particular empirical evidence as well as feasible health policy implication obtained as a result of these researches. The first study in this sphere is Groosman (1972) which claims that healthcare may be considered as a durable capital stimulating output growth process. The other consequential study is Newhouse (1977) insists that income elasticity of demand for health products may be more than one for developed economies, which through the technical definition ultimately implies that health is not necessity consumption. Nevertheless, Hitiris and Posnett (1992) reinvestigates the findings of some earlier studies and also expresses suspicions about the luxury consumption of health care products. Still, Gerdtham et al. (1992), Okunade and Karakus (2001), Musgrove et al. (2002), Murthy and Okunade (2009), Lee et al. (2019) find out that health care goods and services are luxury consumption and this sector should be shaped by the market mechanism under competitive conditions like other industries in the economy. However, Jewell et al. (2003), Dreger and Reimers (2005), Mohamed (2009), Ke et al. (2011), Pattnayak et al. (2016) Kouassi et al. (2018), Rana et al. (2020) argue that health care represents a necessity consumption and that is why the government should use more interventionist policy instruments to protect consumers and to ensure the integrity of the health care market. So, we may conclude that depending on whether an increase in health care consumption is smaller than the rising in total income in the economy, health care policy implications adopted by the government may differ.

On the other side, since early studies in this field employ more simple empirical methods, possible non-stationarities of the concerned series may be ignored in some of these studies causing statistically questionable results. According to Phillips (1986), the results obtained from the conventional time-series estimation process may be spurious if concerned series are non-integrated or include a unit root. Moreover, Okunade and Karakus (2001) states that based on whether observed time series follow a unit root process or not, indicators from the estimated model may contain biased information resulting in misguided health care policy inferences for governments. In this context, several studies as Hansen and King (1996), Gerdtham and Lothgren (2002), Baltagi et al. (2010), Mehrara et al. (2012), Rodríguez and Valdés (2019), Kouassi et al. (2018), Lee et al. (2019), Rana et al. (2020) employ newly developed applied techniques to inves-

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tigate the correlation among health care spending and GDP considering possible non-stationarities in the estimation procedure of time series or panel data and find out that both of these variables contain stochastic trend. However, McCoskey and Selden (1998), Jewell et al. (2003), Carrion-i-Silvestre (2005), Lago-Peñas (2013), obtain strong evidence of stationarity for both healthcare spending and GDP series using similar empirical methods.

As it can be inferred from the studies above, there is no single evidence on the stochastic pattern of the health care expenditures series that may cause some serious problems for health care economists and policymakers from various aspects. For instance, following Hendry and Juselius (2000), parameters concerned to the level of any non-stationary parameters will inherit this feature and transfer it to other variables. In other words, if health care expenditure series follow a process with a stochastic trend or a unit root, then it may be diffused to other economic indicators. In this case, as Hasanov and Telatar (2011) states, to evaluate the appropriate empirical estimation methodology to achieve statistically meaningful results, firstly the unit root analysis should be done carefully. Moreover, if health care spending series are non-stationary, then shocks on health care consumption may have persistent effects on these series. However, if health care expenditure does not follow a stochastic trend, then fluctuations may have short-term or temporal effects and health care spending may recur to its initial equilibrium level as time progresses encouraging policymakers to take fewer interventionist actions in the healthcare market process.

Even though a stochastic pattern of health care spending series is one of the well-studied subjects, as far as we know, there are no known researches that consider eventual nonlinearities in the data generating process of these series. Following Roberts (1999), health care variables may contain non-linear properties and although it is the subject that requires specific attention, it has been ignored by researchers in previous studies. Thence, the main motivation of this study is to revise empirical evidence of unit root for total, public and private health care spending series generated both linearly and non-linearly as well as to test whether the stochastic features of total health care expenditure vary if it is disaggregated into private and public health care consumption.

The next section concisely discusses the applied estimation methodology implemented in this research. The third section provides empirical findings and the last section procures a concluding notion.

2. ANALYTICAL METHODS

Panel Linear Unit Root

Augmented Dickey-Fuller (Dickey and Fuller, 1979) technique illustrated as follows, is broadly employed in empirical literature to analyse the stochastic features of observed variables.

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} \sum_{j=1}^{k} y_i \Delta y_{t-j} + u_{it} \qquad (1)$$

where $y_{i,t}$ indicates health care expenditure and Δ is the difference operator. α_i, β_i and y_i are coefficients considered to be estimated and u_{it} is adopted as white noise (Hasanov and Telatar, 2011). The null hypothesis of non-stationarity is H0: $\beta_i = 0 \forall i$, where opposite hypothesis H1 implies that, $\beta_i \neq 0 \forall i$ is based on;

$$t_{NL} = \frac{\hat{\beta}}{s.e.(\hat{\beta})}$$

Here, $\hat{\beta}$ is the estimation of β and s.e. (β) is the multiple standard errors. Depending on the existence of correlation (ρi) across the residuals of the units in the panel data, that is whether cross-sectional dependency exists between the units or not, mainly two types of stationarity tests known as a first and second generation are employed in the empirical researchers. On the other hand, depending on whether the individuals of the panel are characterized by different dynamics or not, the first-generation panel stationarity approaches that predict cross-sectional independence among the panel can be categorized as homogeneous or heterogeneous in the panel data estimation process. The first type panel unit root analyses applied in this paper such as Hadri (2000), Breitung (2001) and Levin et al. (2002) tests require homogeneity across the series, suggesting that ρi is self-same for all cross-sectional data (ρi = ρ), whereas Maddala and Wu (1999), Choi (2001), Im et al. (2003) analyses take into consideration the heterogeneity in the dynamics of autoregressive parameters, releasing Levin et al. (2002)'s other hypothesis assumption that ρi is the same for all series.

Panel Non-Linear Unit Root

According to Taylor et al. (2001), temporal aggregation and nonlinearity may significantly impair the findings of classical stationarity tests. To eliminate this difficulty, we employ Kapetanios et al. (2003) test procedure constructed on an exponential smooth transition (ESTAR) regression system which allows for nonlinearities in the regression process as well as provides more powerful results than the traditional ADF test. It suggests a simple technique allowing to distinguish whether the data regression process is a nonlinear but globally stationary system versus the existence of non- stationarity.

Assume that, y_t is the series under consideration and follow a simple ESTAR model of order 1:

$$y_t = \beta y_{t-1} + \gamma y_{t-1} \left[1 - \exp(-\theta y_{t-d}^2)\right] + u_{it} \qquad (2)$$

which can be expressed as below after rearranging

$$\Delta y_t = \phi y_{t-1} + \gamma y_{t-1} \left[1 - \exp(-\theta y_{t-d}^2)\right] + u_{it} \qquad (3)$$

and where $\phi = \beta - 1$ and $F(\theta, y_{t-d}) = \left[1 - \exp(-\theta y_{t-d}^2)\right]$

Global stationarity of y_t is tested under the null hypothesis H_0: θ = 0, where alternative hypothesis H1: θ > 0. Since γ is not specified under the null, examining H0 in the absence of deviation is not practical. To solve this difficulty Kapetanios et al. (2003) proposes the technique recommended by Luukkonen et al. (1998) and substitute the transition process $F(\theta, y_{t-d})$ by its appropriate Taylor approximation around θ = 0 and maintain t-type test statistic. The auxiliary regression model acquired by implementing the Taylor approximation is as follows;

$$\Delta y_{i,t} = \delta y_{t-d}^3 + e_t \quad (4)$$

where e_t contains fluctuations and error term remaining from Taylor approximation. The t-test value here can be obtained as below:

$$tNL = \frac{\hat{\delta}}{s.e.(\hat{\delta})}$$

Here, $\hat{\delta}$ remarks the ordinary least squares estimation of δ and s.e.($\hat{\delta}$) denotes the standard deviation of $\hat{\delta}$. In this case, an augmented regression model can be impressed as below:

$$\Delta y_{i,t} = \sum_{j=1}^{p} \rho \Delta y_{t-j} + \delta y_{t-d}^3 + e_t \quad (5)$$

Panel Cross-Sectional Dependency

Without considering the existence of cross-section dependence in the panel regression process one may significantly affect the results obtained from this model (Breusch and Pagan, 1980; Pesaran, 2004). Cross-section independence across the parameters of the panel implies that all cross-sectional units of this data set will be affected at a similar level from any shocks on the unit. In this case, if there are any macroeconomic shocks in any countries in the panel then other countries will not be affected by these fluctuations. Following Phillips and Sul (2003), first-generation panel stationarity analysis may be biased in the existence of cross-section dependency among the panel data. To overcome this issue, we employ the test statistic denoted below.

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{J=i+1}^{N} \hat{\rho}_{i,J}\right) \underset{\rightarrow}{d} N(0,1)$$

Here, $\hat{\rho}_{i,j}$ is the estimated correlation parameter of the residuals of the ADF model (1). Within the framework of H0 which implies cross-sectional independence with T → ∞ and N → ∞, CD test value follows asymptotic distribution as standard normal (Pesaran, 2004).

Panel Linear Unit Root with Cross-Sectional Dependency

Following the conventional augmented Dickey-Fuller regression, Pesaran (2007) suggests a new test procedure that is expanded by the average of cross-section lag levels and first differences of the considered variables. CADF test statistics should be inferred from below indicated OLS regression model;

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} + y_i \bar{y}_{i,t-1} + \sum_{j=0}^{p} \eta_{ij} \Delta \bar{y}_{t-j} + \sum_{j=1}^{p} \phi_{ij} y_{i,t-1} + e_{i,t} \quad (6)$$

Here, $\bar{y}_t$ is the cross-section average at the period t. The test value for the null hypothesis of non-stationarity, against the opposite one, is derived as indicated below:

$$CIPS(N,T) = t_{N,T} = N^{-1} \sum_{i=1}^{N} t_i(N,T)$$

Here, $t_i(N,T)$ is the t-ratio of the β_i from equation (6).

Panel Non-Linear Unit Root with Cross-Sectional Dependency

Following Kim and Kim (2018) next, we used Cerrato et.al. (2011) nonlinear panel stationarity analysis. This test procedure is an augmented version of the nonlinear ESTAR stationarity regression process asserted by Kapetanios et al. (2003) which takes into consideration a cross-section dependence between the series, combining it with the test procedure proposed by Pesaran (2007). Cerrato et.al. (2011) suggests a nonlinear heterogeneous panel stationarity test procedure examining the null hypothesis of non-stationarity, where the opposite one implies that the variables generated by globally stationary ESTAR procedures and the remaining parts of the series obtained by non-stationary processes. This technique accommodates both nonlinearity and cross-sectional dependence and predicts the following estimation process;

$$\Delta y_{i,t} = \alpha_i + \beta_{i0} y_{i,t}^3 + y_{i,0} \bar{y}_{i,t-1}^3 + \sum_{j=1}^{p} (\eta_{i,j} \Delta y_{i,t-j} + y_{i,j} \bar{y}_{i,t-1}^3) + e_{it} \quad (7)$$

where $\bar{y}_t$ is cross-section average at time t. The null hypothesis of stationarity, against the opposite hypothesis, is tested via Im et al. (2003) type test value which is obtained as below:

$$t_{N,T} = N^{-1} \sum_{i=1}^{N} t_i(N,T)$$

Here, $t_i(N,T)$ is the t-ratio of β_{i0} from equation (7).

3. EMPIRICAL RESULTS

This study analyses the stochastic characteristics of the health care spending series for 188 economies over the period 1995-2014 achieved from the World Bank's World Development Indicators. Private health expenditure, public health expenditure and total health expenditure as % of GDP are investigated for each country group.

Total health consumption is composed of whole public and private expenditures for whole health care goods and services, whereas public health care spending is funded by social security endowment, as well as different types of assessment to different spheres of government, and exterior agencies involving both grants and loans. However, private health care spending involves non-public premiums paid for insurance and prepaid schemes, obligated enterprise health spending and healthcare spending through non-profit health services (Poullier et al., 2002).

Firstly, we analyse stationarity properties of the health care expenditure, ignoring possible non-linearities in the observed series by implementing conventional panel unit root approaches proposed by Maddala and Wu (1999), Choi (2001) and Levin and et al. (2002).

Table 1. Panel Unit Root Test.

Health Care Expenditure HE (Raw)			LLC	ADF – Fisher	PP- Fisher
High Income Country Panel	Private	HE	4.19405	67.7966	82.2309
		ΔHE	-22.710***	637.677***	858.720***
	Public	HE	5.60143	36.8087	33.0357
		ΔHE	-20.6124***	560.649***	801.129***
	Total	HE	7.00223	31.8873	28.3938
		ΔHE	-20.3272***	564.298***	813.939***
Upper Middle-Income Country Panel	Private	HE	-0.87633	106.784	114.471
		ΔHE	-19.9388***	542.459***	874.151
	Public	HE	3.99117	45.1253	50.3443
		ΔHE	-23.5528***	662.692***	987.913***
	Total	HE	1.97395	58.7286	70.5893
		ΔHE	-23.5114***	643.134***	911.176***
Lower Middle-Income Country Panel	Private	HE	-1.7161*	90.5224	89.7103
		ΔHE	-22.6460***	602.121***	805.647***
	Public	HE	2.01451	48.6793	53.7214
		ΔHE	-20.7932***	541.052***	862.352***
	Total	HE	1.67766	58.3659	58.2418
		ΔHE	-21.7776***	569.682***	807.995***
Low Income Country Panel	Private	HE	-1.95188**	42.0486	42.2112
		ΔHE	-16.7084***	324.363***	455.893***
	Public	HE	0.40937	27.9076	27.7850
		ΔHE	-16.8877***	331.567***	478.233***
	Total	HE	0.67767	23.8586	21.8156
		ΔHE	-16.2662***	318.655***	470.711***

Note: *, **, and *** remarks rejection of the H_0 at %10, %5, 1% significance level, respectively. Here, HE demonstrates healthcare expenditure series in level and ΔHE symbolises the first differences of the series.

Based on the findings in Table **1**, it can be concluded that total health consumption series are non-stationary in the level for all country groups. However, disaggregating these series as public and private does not demonstrate strong evidence of non-stationarity providing mixed results. In this case, results obtained from health care expenditure series may lead to specious inferences.

As Getzen and Poullier (1992) states health care spending is actually based on both permanent and transitory items of income as well as determined by several aspects which include organizational dynamics, technological developments and expectations. Moreover, according to Roberts (1999) electoral cycles and macroeconomic fluctuations also may have a remarkable impact on the public expenditure on health care. These facts cause health care spending series to be dynamic, which in its own turn may lead to the questioning of the linearly obtained test results. So, investigating stochastic features of health care expenditure by allowing for nonlinearities in the estimation process may prove beneficial. For this purpose, the LM-type test proposed by Luukkonen et. al. (1988) and Granger and Terasvirta (1993) is employed in this analysis.

Table 2. Panel Linearity Test.

	Health Care Expenditure HE	d = 1	d = 2	d = 3
High Income Country Panel	Private	67.66993***	0.518026	1.509915
	Public	-0.719799	1.632995	2.304058**
	Total	-0.916257	0.681261	1.461784
Upper Middle-Income Country Panel	Private	-2.178852**	-2.5199*	-2.0896**
	Public	-11.07258***	-0.374220	0.170351
	Total	-9.117303***	0.693293	0.987588
Lower Middle-Income Country Panel	Private	-2.093191**	-2.093191***	-0.650211
	Public	-0.136506	0.649801	-0.423113
	Total	-0.458984	0.055016	-0.582896
Low Income Country Panel	Private	-2.308535**	-0.185913	0.447127
	Public	0.326674	1.094084	2.162798**
	Total	-1.510829	0.991956	0.884460

Note: *, **, and *** remarks rejection of H0 at %10, %5, 1% significance level, respectively.

From the results in the table above, the null hypothesis of linearity may be ignored only for private health care spending in each country group. The possible cause for this is the uncertainty and competitive conditions which are deeply rooted in the private health sector. For instance, consumption of private health care goods and services may decrease drastically in periods of intense economic uncertainty leading to prominent fluctuations in private health care spending series. On the other side, according to our results, this is not the case for the public sector. Limited competitive conditions along with the policy makers' motivation for getting the majority of votes in upcoming elections, may stabilize healthcare spending in the public sector inducing these series to follow a linear pattern.

Table 3. Panel Nonlinear Unit Root Test.

	Health Care Expenditure HE	Raw	Demeaned	De-trended
High Income Country Panel	Private	-3.336088***	-2.515621	-2.745147
	Public	-1.669191	-3.139765**	-3.438078**
	Total	-1.272411	-0.318787	-0.655018
Upper Middle-Income Country Panel	Private	-3.711149***	-4.274890***	-4.278765***
	Public	-1.677118	-16.11016***	-16.16882***
	Total	-2.637025***	-14.74665***	-11.91655***
Lower Middle - Income Country Panel	Private	-5.439227***	-3.324080**	-3.2382*
	Public	-13.94380***	-1.256550	-1.391627
	Total	-12.74557***	-2.102899	-2.176530
Low Income Country Panel	Private	-4.284956***	-5.208941***	-4.934337***
	Public	-3.633259***	-2.7849*	-2.945812
	Total	-4.162593***	-4.828667***	-4.268870***

Note: *, **, and *** remarks rejection of H0 at %10, %5, 1% significance level, respectively.

Next, we implement Kapetanios et al. (2003) panel stationarity approach which accommodates ESTAR type of nonlinearity in the data generating procedure. From the results in Table **3**, it is clearly can be stated that public health care spending is non-stationary for high and upper-middle-income countries whereas private health care consumption is non-stationary only for high-income country groups. The possible reason for it may be more efficiently and rapidly integration of technological progress into the health care sector in the countries with the higher income level.

As Stephan (1934) argues, social data in consequence of their very social character, persons, groups and their features are intersectional and not unconnected. Moreover, expanding economic and financial integration across the countries also causes strong interdependencies between countries in the recent decades leading to cross-section dependence among the elements of the panel. So, since results obtained from the estimated regression model may involve biased inferences, we employ Pesaran (2004) to explore whether series cross-sectionally depended or not.

Table 4. Panel Cross-Section Dependence Test.

	Health Care Expenditure HE	CSD
High Income Country Panel	Private	-1.4307
	Public	-2.4172
	Total	119.591
Upper Middle-Income Country Panel	Private	3.7625
	Public	8.0538
	Total	2.0742
Lower Middle-Income Country Panel	Private	3.3605
	Public	0.6725
	Total	0.0069**

Low Income Country Panel	Private	-0.4042
	Public	-2.8717
	Total	-2.7008

Note: ** remarks rejection of H0 at %5 significance level.

According to the results in Table **4**, cross-sectional independence between the series may be ignored only for total health care expenditure series in the lower-middle-income country group. This evidence requires implementing second-generation panel stationarity analyses as Pesaran (2007) which considers possible cross-sectional dependence among the variables during the investigation of stationarity properties. From the results obtained, as presented in Table 5, the null hypothesis of non-stationarity may be ignored for total health care expenditure series in the reference country group, implying that health consumption series are stationary when we consider linear data generating process involving cross-sectional dependence.

Table 5. Panel Linear Unit Root Test Results.

Lower-Middle- Income Country Panel	**Health Care Expenditure HE**	**CSD**
	Total	-2.1249**

Note: ** remarks rejection of H0 at %5 significance level.

These findings encouraged us finally to employ a nonlinear heterogeneous panel unit root test, suggested by Cerrato et al. (2011). Taking into account the results represented in Table **6**, the null hypothesis which states that observed series follow non-stationary processes against the alternative hypothesis can be rejected for series in the lower-middle-income country group.

Table 6. Panel Nonlinear Unit Root Test Results.

Lower Middle-Income Country Panel	**Health Care Expenditure HE**	**NLPADF**
	Total	-2.1458**

Note: ** remarks rejection of H0 at %5 significance level.

Based on the last two tables, when cross-section dependence is taken into account, total health care expenditures series also in lower-middle-income countries appear to be either linear or non-linear stationary.

4. CONCLUDING REMARKS

Incontrovertible effect of health care spending on economic growth and development process makes health care policy implementations critical for all economies independently income level of countries. The fact that health care variables may follow a non-linear pattern and it may be ignored in the previous studies encourages us to revise empirical evidence of unit root for health care spending series generated both linearly and non-linearly as well as to test whether the stochastic features of total health expenditure varies if it disaggregated into private and public consumption. For this purpose, we employ a data set for 188 countries over the period 1995-2014 which are categorized into four groups based on the World Bank income categories.

The findings obtained from linear unit root tests suggest that total health care expenditure series are non-stationary in the level for all country groups, whereas disaggregating these series as public and private does not demonstrate strong evidence of non-stationarity. Moreover, allowing for cross-section dependency among the series and nonlinearity in the estimation procedure leads to more frequent rejection of the null hypothesis of unit root, as well as fading of differences among public and private series for each country group. It may be explained by the fact that health care consumption is crucial for the population irrespective of the countries' income level and people demand stability in health care policies. Additionally, policymakers' purposes of getting the majority of votes in upcoming elections may motivate them to keep the public sector's technological advancement in line with private sectors leading to public health care spending series being stationary.

Furthermore, since health care spending does not follow a stochastic trend, then any shocks on health care consumption will have temporal effects and health care spending may recur to its initial equilibrium level as time progresses. We may conclude that it may be better for the policymakers to take non-interventionist or more liberal actions in the health care market process to eliminate the results of particular cyclical fluctuations.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

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