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About the relationship between health expenditure and GDP: more evidence

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In this paper, the relationship between Health Care Expenditure (HCE) and Gross Domestic Product (GDP) in different developed countries with different health care systems from 1960 to 2010 were analyzed. For this purpose, unit root test and cointegration techniques were used. We showed not only the trajectory of these variables over time but also other factors associated with them, as life expectancy at birth, total expenditure on health, gross domestic product, density of general care physicians and population composition by age. The results of this research showed that these variables were not always integrated with the same order although they showed great variation across countries. We could confirm HCE varies significantly over time and across countries although there exist a number of non-income determinants which could explain this variation.

Key words. Health expenditure, GDP, unit root, cointegration.
JEL Classification Codes: I18, H51

INTRODUCTION

During the last years, health care management has become an important issue in modern societies. Thus, it is one of the most dynamic and growing fields of interest not only for researchers but also for policy makers. In 2000, all 193 United Nations member States agreed to achieve the Millennium Development Goals (MDGs) by the year 2015. The goals are: Eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality rates; improving maternal health; combating HIV/AIDS, malaria and other diseases; ensuring environmental sustainability and developing a global partnership for development. In particular, health is considered a key aspect to development and a pre-condition for an indicator of progress in sustainable development.

Empirical evidence in health economics is largely based on time series. In this sense, numerous empirical studies are focused on the relationship between Health Care Expenditure (HCE) and Gross Domestic Product (GDP). Some studies are focused on the stationary property of health expenditures while others are focused on the determinants of health expenditures. Also, a considerable amount of research focused on the relationship between health and economic growth exist. However, it has been found that most of the observed variation in HCE could

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be explained by changes in Gross Domestic Product (GDP).

For instance, Narayan and Narayan (2008) examine the evidence for common trends and common cycles among different countries over the period 1960-2003. They performed unit root tests on per capita health expenditures for each of these countries in order to establish the integration property of the data series and concluded that transitory shocks are more important in explaining per capita health expenditures in the UK, Japan and Switzerland while permanent shocks dominate variations in per capita health expenditures in the USA and Canada over short horizons. In a similar way, Wang and Rettenmaier (2007) investigate non-stationarity and co-integration of health care expenditures and gross state products utilizing a panel data set of 50 US states. Their evidence suggests that both series can be modelled as non-stationary and can form a co-integrating relationship. Also, Moscone and Tonetti (2010) investigate the non-stationarity and co-integration properties of health care expenditure and personal disposable income using a panel of 49 US States followed for more than 25 years.

Gerdtham and Löthgren (2000) examine the stationarity and the co-integration of health expenditure and GDP for a sample of 21 OECD countries using data for the period 1960-1997. Their results indicate that health expenditure and GDP are non-stationary and co-integrated. Also, they test for non-stationarity using country-by-country and panel ADF (Augmented Dickey-Fuller) tests.

Hansen and King (1996) suggest that for most OECD countries, there is no long-term relationship between HCE, GDP and a selection of non-income variables or between HCE and GDP alone. These authors suggest that the strong relationship obtained by others may be spurious. Their results are based on 20 OECD member nations covering the period 1960 to 1987. However, Clemente et al. (2004) study the stability of health care expenditure functions in a sample of OECD countries and conclude that there is a long-term relationship between HCE and GDP.

Tang and Ch'ng (2011) investigate the health-income relationship for the ASEAN-5 economies. They conclude that health expenditure and income are co-integrated in the case of Indonesia, Singapore and Thailand. However, they found that these variables are not moving together in the long term in the case of Malaysia and Philippines. So there exist important differences by country.

Also, health care financing is an important challenge in developing countries. In fact, to help improve the policy making process, we should take into consideration the following points (Ile and Garr, 2012): The need to promote a better understanding of the policy making process to enable politicians, economists and health managers work to understand the complexities of the factors related with population health.

To summarize, we can confirm HCE varies significantly over time and across countries although there exist a number of non-income determinants which could explain this variation such as the age structure of the population (Culyer, 1988), the share of young and old people (Hitiris and Posnett, 1992), the extent to which health care expenditure is financed by the government (Leu, 1986), epidemiological needs (Lu et al. 2010) and health system characteristics (Gerdtham et al., 1992).

This paper is focused on the relationship between health and Gross Domestic Product in different developed countries with different health care systems. In particular, these countries are members of the Organization for Economic Cooperation and Development and they are included in the Asia and Pacific Area group. The results reported suggest that all the variables are not integrated with the same order, so cointegration techniques are not always adequate. The rest of the paper is organized as follows: Section 2 describes the econometric methodology, data description and results are shown in Section 3 and finally, the conclusions of the paper are presented in Section 4.

THEORETICAL FRAMEWORK

During the last decades, three major developments in statistics have been widely discussed; vector autoregressions (VARs), unit roots and cointegration. Thus, one of the most important points when dealing with several time series is to consider the possible interdependence between them. In this sense, we can consider a time series as a collection of random variables ordered in time. Therefore, a time series is said to be stationary if statistical properties do not change over time. More formally, from a theoretical point of view a time series is a collection of randon variables X_t ordered in time. A time series is said to be strictly stationarity (Maddala, 1992) if the joint distribution of any set of n observations $X(t_1)$, $X(t_2)$,..., $X(t_n)$ is the same as the joint distribution of $X(t_1+k)$, $X(t_2+k)$, $X(t_n+k)$ for all n and k. Substituting n=1, we get $\mu(t)=\mu$ a constant and $\sigma^2(t)= \sigma^2$ a constant for all t.

It implies that mean and the variance of the stochastic process do not depend on t and the autocovariance between Y_t and Y_{t+k} only depends on the lag k (Chatfield, 2003). So a stationary series would contain no trend or seasonal variation. Furthermore, a time series is said to be integrated of order d, denoted by $I(d)$, if you have to differentiate it d times to obtain a stationary process. Consequently, a time series Y_t is integrated of order 1, $I(1)$, if Y_t is not stationary but the first difference, Y_t-Y_{t-1}, is stationary and invertible (Greene, 2003). The relevance of this result is that unless the variables are integrated to the same order, the following equation does not make sense:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \varepsilon_t$$

Table 1. Variable definitions

Name	Definition
LE_FEMALE	Life expectancy females at birth - Years
LE_MALE	Life expectancy males at birth - Years
EXPENDITURE	Total expenditure on health - /capita, US$ PPP
GDP	Gross domestic product - /capita, US$ PPP
P14	Population: 0-14 years - % total population
P65	Population: 65 and over - % total population
G_PRACTITIONER	General practitioner - Density /1000 pop. (HC)

The order of integration of a series is obtained by the application of a set of tests, usually known as tests for unit roots. The most common test in economic literature for unit roots are Augmented Dickey and Fuller (ADF) unit root test (Dickey and Fuller, 1979) and Phillips-Perron (1988). The ADF test involves estimating the following regression:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^{k} \delta_i \Delta y_{t-1} + \varepsilon_t,$$

which includes a trend t, a constant term α, as well as lagged versions of the series, and where y_t is the variable of interest. The null hypothesis for this test is $H_0: \hat{\gamma} = 0$.

On the other hand, Phillips-Perron test (PP) is a unit root test used to test the null hypothesis that a time series is integrated of order 1. PP is a non-parametric test based on asymptotic theory which works well in large samples. This test estimates autocorrelations in the error process, rather than white noise errors. For this reason, this test is more generally applicable. Davidson and MacKinnon (2006) conclude that Phillips-Perron test could perform worse in finite samples than the ADF test.

However, from a statistical point of view, we are very interested in analyzing not only the short-run dynamics but also long-run equilibrium. Cointegration techniques provide powerful tools to test if there exists a statistically significant connection between two or more variables. The concept of cointegration was introduced by Granger (1981). In the last decades, cointegration theory has generated very much interest among economists (Johansen, 1991). From a theoretical point of view, two variables x_t and y_t are said to be cointegrated if there exists a parameter α such that $y_t = \alpha x_t + u_t$ is a stationary process (Engle and Granger, 1987). So, it is necessary that all the variables have the same integration order. Otherwise, the variables would not have a direct causal connection.

METHODOLGY AND RESULTS

The data used in this study were obtained from the Organization for Economic Co-operation and Development (OECD) Health Data (OECD, 2012). This data set contains annual data from 1960 to 2010 about health status, health care resources, expenditure on health, social protection and other economic and demographic references for OECD countries. This information allows us to compare the results and the main statistics about health for different countries. In this study we have used information available from 1960 to 2009 about total expenditure on health (EXPENDITURE) and Gross domestic product (GDP), both of them, per capita purchasing power parity. As defined by the World Bank, total health expenditure is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation.

We have also included two variables for life expectancy at birth (in years) by gender, LE_FEMALE and LE_MALE. In addition, we have included in this analysis the percentage of population which is fourteen years and under (P14) and the percentage of population sixty five years and over (P65). Finally, we have included a variable (G_PRACTITIONER) to take into account, the density per thousand of general care physicians. The definition of each variable used is given in Table 1.

The countries analyzed in this paper are Australia, Canada, Chile, Japan, Korea, Mexico, New Zealand and United States, which are the Asia and Pacific Area group. All of them are members of the Organisation for Economic Co-operation and Development and represent different health care systems. The results of ADF and PP unit root tests reported in Table 2 suggest that all the variables were not integrated of order one. In fact, the order of integration for each variable and country was not the same. Variables were either *I*(2), *I*(1) or *I*(0) and results also differed by country so it was not possible to apply cointegration techniques in most of the cases. It implied that you had to differentiate the corresponding series 2, 1 or 0 times, respectively, to obtain a stationary series. In most of the countries considered (Australia, Canada,

Table 2. Results of ADF and PP unit root test

Variables	ADF	PP	Order of Integration	Variables	ADF	PP	Order of Integration
Australia:				Korea:			
LEFEMALE	-9.3409	-9.0742	I(1)	LEFEMALE	-4.4934	-4.6078	I(1)
LEMALE	-7.1117	-7.1062	I(1)	LEMALE	-2.6532	-7.9696	I(2)*
EXPENDITURE	-13.1344	-28.8057	I(2)	EXPENDITURE	-5.467	-6.3816	I(2)
GDP	-3.1078	-2.9777	I(1)	GDP	-3.7245	-3.6494	I(1)
P14	-3.5872	-3.7323	I(1)	P14	-0.3211	-3.0669	I(1)
P65	-3.5778	-3.5998	I(1)	P65	-15.4254	-27.572	I(2)
G_ PRACTITIONER	-5.9912	-7.177	I(1)	G_ PRACTITIONER	.	.	.
Canada:				Mexico:			
LEFEMALE	-4.6604	-5.6844	I(1)	LEFEMALE	-3.0723	-4.414	I(0)
LEMALE	.	-5.7325	I(1)	LEMALE	-8.6112	-8.5887	I(1)
EXPENDITURE	-7.3013	-7.6633	I(2)	EXPENDITURE	-3.8582	-5.329	I(2)
GDP	-2.8833	-2.7736	I(1)	GDP	-4.0682	-4.0085	I(1)
P14	-4.5193	-2.6385	I(1)*	P14	-12.8265	-14.4203	I(2)
P65	-3.4095	-3.3349	I(1)	P65	-6.5464	-6.5461	I(1)
G_ PRACTITIONER	-3.2841	-3.2915	I(1)	G_ PRACTITIONER	-5.5031	-6.0215	I(1)
Chile:				New Zealand:			
LEFEMALE	-3.843	-2.8834	I(0)	LEFEMALE	-3.8109	-3.7533	I(1)
LEMALE	-4.0192	-2.8447	I(2)*	LEMALE	-12.7457	-12.7457	I(2)
EXPENDITURE	-3.0937	-3.0979	I(2)	EXPENDITURE	-7.9892	-3.7071	I(2)*
GDP	-1.9224	-2.7114	**	GDP	-4.0591	-4.0408	I(1)
P14	-2.6187	-5.9024	I(2)*	P14	-7.1643	-7.156	I(2)
P65	-4.4893	-4.7158	I(2)*	P65	-3.901	-3.7884	I(1)
G_ PRACTITIONER	.	.	.	G_ PRACTITIONER	-4.4116	-4.4104	I(1)
Japan:				United States:			
LEFEMALE	-3.8082	-6.6778	I(0)	LEFEMALE	-7.4584	-7.4055	I(1)
LEMALE	-3.5078	-5.2568	I(0)	LEMALE	-6.2116	-6.2525	I(1)
EXPENDITURE	-6.6852	-15.5749	I(2)	EXPENDITURE	-3.7834	-3.7179	I(2)
GDP	-3.3204	-3.241	I(1)	GDP	-2.6859	-9.045	I(2)*
P14	-8.9385	-8.6176	I(2)	P14	-4.1889	-9.9766	I(2)*
P65	-8.6997	-31.9983	I(2)	P65	-8.6609	-3.6651	I(2)*
G_ PRACTITIONER	.	.	.	G_ PRACTITIONER	-5.1504	-5.1267	I(1)

* The order of integration is different according to the test used
** The order of integration is more than 2 with both tests
Note: P14 is defined as Population: 0-14 years - % total population and P65 as Population: 65 and over - % total population
All the variables are statistically significant at the conventional level (that is, 1, 5 and 10%)
Source: Computed from OECD (2012).

Japan, Korea, Mexico, New Zealand, United States), HCE was integrated of order 2. However, we found important differences in other variables. For instance GDP was integrated of order 2 for United States while it was integrated of order 1 for Australia, Canada, Japan, Korea, Mexico and New Zealand. Also there existed differences when we considered other variables as life expectancy at birth, density of general care physicians and population composition by age.

CONCLUSIONS

This study investigated the relationship between health

expenditure, life expectancy, gross domestic product, population ageing and general practitioners. In fact, the long run relationship was not always guaranteed. Using data from the OECD, we have tested our hypothesis and we could confirm that these variables were not integrated with the same order, so the causality effect, from a statistical point of view, was not so clear because it depends, among other factors, on the variable and country considered. The results showed that health expenditure and income were not always cointegrated. Furthermore, there were many factors such as population ageing, life expectancy and number of general practitioners which should be taken into consideration. In this way, this study has important policy implications: Health indicators must be described and observed, however, we need to understand the economic mechanisms, not only income, which could explain them.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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