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CAUSALITY TEST BETWEEN HEALTH CARE EXPENDITURE AND GDP IN U.S.: COMPARING PERIODS

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Causality test between health care expenditure and GDP in U.S.: comparing periods

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Abstract

In the literature dedicated to the "health as a luxury good" question, health care expenditure (HCE) is hypothesized to be a function of GDP without considering any other relationships. In this paper, we argue that this could be a bilateral relationship: good health is considered as an input of the macroeconomic production function, stimulating the GDP. A modified version of the Granger (1969) causality test proposed by Toda and Yamamoto (1995) is investigated between GDP per capita and HCE per capita in United States for comparing the periods of 1965_1984, 1975_1994, 1985_2004 and 1965_2004. Results show these three periods have different causal relationships. At the beginning for 1965_1984, there exists a bilateral relationship. For the following period, there is a unidirectional relationship from HCE to GDP, and for the 1985_2004, a unidirectional GDP_HCE is significant. From the start to end of periods (1965_2004), a unidirectional relation from HCE to GDP is existed.

Keywords: Health care expenditure per capita; per capital GDP; Toda-Yamamoto causality; United States

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1. Introduction

Over 90 percent in most of the studies cited real per capita health care expenditure (HCE) is hypothesized to be a function of real per capita income (GDP) (Hansen and King, 1996), and a chosen of non-income variables such as, Kleiman (1974), Gerdtham and Jonsson (1991a), Gerdtham and Jonsson (1991b) and Hitiris and Posnett (1992). Various papers have cited the performance of the health function, with most of these works being based on a simple relationship between HCE and the GDP. Some good examples are: Murthy and Ukpolo (1994), Hansen and King (1996), Blomqvist and Carter (1997), McCoskey and Selden (1998), Gerdtham and Löthgren (2000), Karatzas (2000) or Roberts (2000).

Blomqvist and Carter (1997), McCoskey and Selden (1998), Roberts (1998) and Gerdtham and Lothgren (2000) compute panel data based unit root and stationary tests results evidence of non-stationary. This reinforces previous results based on univariate time series techniques. However, the difference between these studies and the described above is that panel data cointegration tests point to the existence of a long-run relationship between HCE and GDP (see Gerdtham and Lothgren (2000)).

In some recent research – Clemente et al. (2004) adopt the cointegration analysis and show that there is a long-term relationship between total health care expenditure (HCE) and gross domestic product (GDP). By Jewell et al. (2003) and Carrion-i-Silvestre (2005) has found that these variables can be characterized as stationary processes evolving around a broken trend with permitting the presence of structural breaks which affect the level and the slope of the time series.

There are some reasons which this could be a bilateral relationship. Increasing the HCE in a country causes to rising the security, safety, and welfare of workers which favors the labor efficiency. Healthy people can work harder and longer, and also think more clearly (Bloom and Canning (2005)), all things expected to increase the productivity of people. Using microeconomic data, there are a lot of references demonstrating an impact of HCE (or health insurance benefits) on the working conditions of ill people, e.g.: Smith (1999), Bloom and Canning (2005), Dray-Spira and Lert (2007). But fewer references are available at the macro level, certainly because it seems uneasy to disentangle both directions of the HCE/GDP relationship.

Consequently, we examine the existence of causality between HCE and GDP for comparing the results of U.S. data over the period 1965-2004. Our starting assumption was that, within the bilateral relationship, the strength of causality in one direction rather than the other could change, depending on time. Then, from 40 years of observation, we decided to cut the entire period in TWO periods of 20 years. We have periods of 1965_1984 AND 1985_2004 For the entire period and the two cuts, we use an appropriate approach, allowing for bilateral causality as a hypothesis and testing it as a result. In this paper, we just want to test causality (if the lags of GDP have the effect on HCE, and vice versa).

2. Methodology

In this section causal relationships are investigated for finding the way of unidirectional relation, or existence of bilateral causal relationship between HCE and GDP for three different annual data in United States.

To infer the causal relationship between health care expenditure per capita and GDP per capita in total, the Toda and Yamamoto (1995) test for long-run causality is utilized. This procedure avoids the problems of testing for Granger-causality with respect to the power and size properties of unit root and cointegration tests (Zapata and Rambaldi, 1997). The Toda and Yamamoto (1995) requires the estimation of a VAR in levels which minimizes the risks associated with incorrectly identifying the order of integration of the respective time series

and the cointegration properties among the variables. Specifically the Toda–Yamamoto long-run causality test artificially augments the correct order of the VAR, *k*, by the maximum order of integration, d_{max}, and ensures that the usual test statistics for Granger-causality have the standard asymptotic distribution.
The data are annual observations on logarithm of GDP per capita (constant 2000 US$) and logarithm of total HCE per capita (US$ PPP). Annual data on HCE variable is available from 1965 to 2004 from OECD Health Data 2009 and GDP variable from 1965 to 2004 is available from World Development Indicators 2008.

2.1. Testing for integration

An univariate analysis of each of the two time series (GDP, HCE) was carried out by testing for the presence of a unit root. Dickey–Fuller (DF) and Augmented Dickey–Fuller (ADF) *t*-tests (Dickey and Fuller, 1979) for the individual time series and their differences are used. DF and ADF test computed using the first difference of *y*, and *hce* indicate that these tests are individually significant at the 10% level of significance. The results of integration test are available in Table 1.

Table 1
Tests for integration

Periods	Variables	DF(C)	DF(C+T)	ADF(C)	ADF(C+T)
1965_2004	LHCE	-0.74	-1.70	-2.51	-0.52
	ΔLHCE	-1.68*	-2.66	-1.27	-2.98
	LY	1.06	-4.75*	-0.65	-4.71*
	ΔLY	-4.23*	-4.93*	-5.18*	-5.08*
1965_1984	LHCE	-0.92	-2.69	1.75	-2.40
	ΔLHCE	-0.86	-1.67	-2.00	-3.69*
	LY	-0.12	-4.15*	-0.83	-3.91*
	ΔLY	-3.23*	-3.69*	-4.12*	-4.04*
1985_2004	LHCE	-0.75	-4.20*	-0.78	-5.40*
	ΔLHCE	-3.82*	-3.81*	-4.02*	-1.53
	LY	0.20	-2.81	-0.33	-2.64
	ΔLY	-2.82*	-2.85	-2.78*	-2.66

Notes: Statistically significantly different from zero at the 0.10 significance level. The optimal lag used for conducting the DF and ADF tests statistic were selected based on an optimal Schwarz Bayesian Information Criteria (SBIC), using a range of lags.

2.2. The Toda–Yamamoto approach to Granger causality test

Modified Wald test (MWALD) for the causality test is used as proposed by Toda and Yamamoto (1995) which avoids the problems associated with the ordinary Granger causality test by ignoring any possible non-stationary or cointegration between series when testing for causality. The Toda and Yamamoto (1995) approach fits a vector autoregressive model in the levels of the variables thereby minimizing the risks associated with the possibility of faulty identifying the order of integration of the series (Mavrotas and Kelly, 2001).
The main idea of this method is to artificially augment the correct VAR order, *k*, by the maximal order of integration, say d_{max}. Once this is done, a $(k+d_{max})^{th}$ order of VAR is calculated and the coefficients of the last lagged d_{max} vector are ignored (see Rambaldi and Doran, 1996; Rambaldi, 1997; Zapata and Rambaldi, 1997). The application of the Toda and Yamamoto (1995) procedure ensures that the usual test statistic for Granger causality has the standard asymptotic distribution for which valid inference can be made.

To undertake Toda and Yamamoto (1995) version of the Granger non-causality test, we represent the HCE-GDP model in the following VAR system:

$$LHCE_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} LHCE_{t-i} + \sum_{j=k+1}^{d_{\max}} \alpha_{2j} LHCE_{t-j} + \sum_{i=1}^{k} \delta_{1i} LY_{t-i} + \sum_{j=k+1}^{d_{\max}} \delta_{2j} LY_{t-j} + \lambda_{1t} \quad (1)$$

$$LY_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} LY_{t-i} + \sum_{j=k+1}^{d_{\max}} \beta_{2j} LY_{t-j} + \sum_{i=1}^{k} \phi_{1i} LHCE_{t-i} + \sum_{j=k+1}^{d_{\max}} \phi_{2j} LHCE_{t-j} + \lambda_{2t} \quad (2)$$

From Eq. (1), Granger causality from LY*t* to LHCE*t* implies $\delta_{1i} \neq 0 \; \forall_i$; similarly in Eq. (2), LY*t* Granger causes LE*t*, if $\varnothing_{1i} \neq 0 \; \forall_i$. The model is estimated using seemingly unrelated regression (SUR) (see Rambaldi and Doran, 1996)[1].

3. Results

In order to undertake causality tests, the order of integration ($d_{\max}$) of the series under consideration and the optimal lag, *k* has to be determined. We used the Schwarz Bayesian Information Criteria (SBIC) to select the optimal lag length of VAR (see Konya, 2000). The Granger causality tests were carried out by testing *k* from 4 to 2. For the optimal *k* selected, the residuals were also checked for white noise using the Box-Pierce *Q*-Statistic and other mis-specification tests (Enders, 1995). Results of the causality tests are presented in Table 2. As can be learned from the significance of the ρ-values of the modified Wald (MWALD) statistic, the results of these three periods are different. At the beginning for 1965_1984, there exists a bilateral relationship. For the following period, there is a unidirectional relationship from HCE to GDP, and for the last period, a unidirectional GDP_HCE is significant. From the start to end of periods (1965_2004), a unidirectional relation from HCE to DGP is existed.

Table 2
Granger non-causality test

Periods	From LY to LHCE		From LHCE to LY		Direction of causality
	Modified Wald statistics	Sum of lagged coefficients	Modified Wald statistics	Sum of lagged coefficients	
1965_2004	2.600[0.475]	0. 089	7.749[0.051] *	0.028	GDP←HCE
1965_1984	10.01208[0.019] **	0. 668	8.138[0.043] **	0.196	GDP↔HCE
1985_2004	37.183[0.00 0] ***	0. 617	3.530[0.317]	0.012	GDP→HCE

Notes: Modified Wald chi-square statistics to test whether the *k* lags are equal to zero are displayed with probability values in brackets. The sum of the lagged coefficients represents the summation of the lags in the VARs excluding the lagged coefficient with the highest order. Significance levels are as follows: *** (1%), ** (5%), and * (10%).

[1] For the shortcomings of the TY approach, see Kuzozumi and Yamamoto (2000). According to them, when 'we have a small sample, the asymptotic distribution may be a poor approximation to the distribution of the test statistic' (p. 212); but the approach is less distorted than others and may be preferable when the sample size is small.

4. Conclusions

A modified version of the Granger (1969) causality test proposed by Toda and Yamamoto (1995) is applied for testing the bilateral causality between GDP per capita and total expenditure of health per capita individually for two periods in United States. The results are so different. At the beginning for 1965_1984, there exists a bilateral relationship. For the last period, a unidirectional GDP_HCE is significant. Our interpretation of the no-causality during the last period could be that the productive effect of HCE becomes unlikely when large parts of HCE are dedicated to elderly people.

At least, this paper alerts economists to the risk of misinterpreting the relationship between GDP and HCE without considering bilateral causality as a possibility.

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