A note on power comparison of panel tests of cointegration – An application on health expenditure and GDP

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Abstract

This paper presents a comparison of power of panel tests of cointegration and show how the choice of most powerful test depends on the values of the sample statistics. Country-by-country and panel stationarity and cointegration tests are performed using a panel of 20 OECD countries observed over the period 1971-2004. Residual-based tests and a cointegration rank test in the system of health care expenditure and GDP are used to test cointegration. Asymptotic normal distribution of these tests allows a straightforward comparison: for some values of the sample statistics, residual-based and rank tests are not directly comparable and the power of residual-based tests oscillates, while for other values rank test is more powerful than residual-based tests. In conclusion, a clear-cut conclusion on the most powerful test cannot be reached.

JEL classification: C12; C22; C23; I10
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1. Introduction

Since Newhouse (1977) seminal paper, research interest has shifted from the necessity to find the determinants of health care expenditure (Gerdtham et al., 1998) and check whether health care were a luxury good (Blomqvist and Carter, 1997) to the necessity to solve an issue of cointegration between health care expenditure and GDP (Hansen and King, 1996).

The main reason for this change of interests is the extended use of panel data (Gerdtham, 1992, Hitiris and Posnett, 1992, and Hitiris, 1997). Advantages and concerns on the use of panel data are discussed in various papers (Banerjee, 1999, and Gerdtham and Löthgren, 2002). One of the issues raised by the use of panel data is the cointegration of non-stationary variables. Various paper try to solve it but reach different conclusions on country-by-country and panel tests (Hansen and King, 1996, Blomqvist and Carter, 1997, McCoskey and Selden, 1998, and Gerdtham and Löthgren, 2000).

Once verified the existence of a cointegrating vector of non-stationary health care expenditure and GDP, the paper compares the power of three panel cointegration tests and shows how the choice of most powerful test depends on the empirical values of the statistics. Country-by-country and panel stationarity and cointegration tests are performed using a panel of 20 OECD countries observed over the period 1971-2004. Residual-based tests and a cointegration rank test in the system of health care expenditure and GDP are used to test cointegration. Asymptotic normal distribution of these tests allows a straightforward comparison. For some values of the statistics, residual-based and rank are not directly comparable and the power of residual-based tests oscillates, while for other values rank test is more powerful than residual-based tests.

2. Data description

Health care expenditure (HE) and GDP are measured in national currencies and expressed in 2000 prices (deflated by GDP deflator). The data is from the OECD Health Dataset (OECD, 2006). The starting dataset contains a list of 30 OECD countries with annual data covering the period 1960-2005. Due to missing data, Czech Republic, France, Greece, Hungary, Italy, Korea, Mexico, Poland, Slovak Republic, and Turkey have been excluded and the remaining unbalanced panel dataset has a total of N = 20 countries. The total number of observations is T = 34 years. Both variables are expressed in logarithm and per capita.

As graphical analysis for HE and GDP shows that both series contain a linear trend, this characteristic is incorporated both into the model specification and into the tests. Description of the model specification and tests is provided in various papers (Banerjee, 1999, Pedroni, 1999 and 2004, Kao, 1999, Hadri, 2000, Gerdtham and Löthgren, 2000, Larsson et al., 2001, Levin et al., 2002, Gerdtham and Löthgren, 2002, and Im et al., 2003). Therefore, only results for unit root and stationary tests and cointegration results are presented.

3. Results on stationarity and cointegration tests

As seen from Table 1, for HE the unit root hypothesis is only rejected for Germany and Portugal on the 1%, 5% and 10% level, for Australia and Switzerland on the 5% and 10% level, and for Belgium on the 10% level. For GDP the unit root hypothesis can be rejected for three countries (Austria, Belgium, and the USA) on the 5% and 10% level, and for three countries (Denmark, Finland and Switzerland) on the 10% level. The panel results fail to reject the $I(1)$ hypothesis for both HE and GDP.

In order to check for possible multicollinearity, tests of stationarity were also performed (Table 2). For HE the stationarity hypothesis is rejected for six countries (Australia, Austria, Luxembourg,

Portugal, Spain, and Switzerland) on the 1%, 5% and 10% level, for five countries (Canada, Denmark, the Netherlands, Sweden and the UK) on the 1% and 5% level, and for the rest on the 1% level. For GDP the stationarity hypothesis cannot be rejected for Ireland, while it is rejected for nine countries (Belgium, Canada, Denmark, Finland, Portugal, Sweden, Switzerland, the UK and the USA) on the 1%, 5% and 10% level, for four countries (Luxembourg, New Zealand, Norway, and Spain) on the 1% and 5% level, and for the rest on the 1% level. The panel results reject the hypothesis of stationary series for both HE and GDP.

From Table 3, the hypothesis of no cointegration is rejected for ten countries on the 1%, 5% and 10% level, for the USA on the 1% and 5% level, and for nine countries on the 1% level. The panel results fail to reject the no cointegration hypothesis.

From Table 4, the hypothesis of cointegration cannot be rejected for all countries except Denmark, Japan, New Zealand and Sweden. The cointegrating rank is determined by the sequential likelihood ratio trace test procedure. Using tests at the 5% level, a rank of $r = 1$ is found for 16 countries, indicating that HE and GDP are cointegrated. For the remaining four countries the selected rank is $r = 0$, which indicate that HE and GDP are not cointegrated for these countries. For the panel rank test the hypothesis that the largest rank in the panel is $r = 0$ is rejected, but the hypothesis of a largest rank of $r = 1$ cannot be rejected.

According to results in Tables 3 and 4, HE and GDP are cointegrated around linear trends for the sample of OECD countries.

4. Power of the panel tests of cointegration

We assume that the estimated values of the three panel tests of cointegration reported at the bottom of Table 3 and 4 are the true values of the statistics associated to the data generating process (DGP). The fact that all tests are normally distributed allows comparisons.

We use the `sampsi` STATA command to draw the power function of the three tests. This command estimates the required power of a test comparing the characteristics of the DGP and the sample. Therefore, for each panel test of cointegration `sampsi` command tests whether the value of the sample statistics is equal to the value of the statistics associated to the DGP, given the level of significance of the test ($\alpha = 0.05$), the size of the population and sample, and the standard deviation.

When the value of the sample statistics is equal to the value of the statistics associated to the DGP, the test has the minimum power, 0.05. For values of the sample statistics different from the value of the statistics associated to the DGP, power of the test increases up to maximum power, 1.

Power of the three tests is represented in Figure 1. The sample statistics takes values between -8.1 and 2.5. Panel tests are directly comparable only for certain values of the statistics. For values between -7.3 and -5.1 residual-based and rank tests are not directly comparable and the power of residual-based tests oscillates. For values between -7.3 and -6.1, the IPS test is more powerful than the LLC test, and vice versa for values between -6.1 and -5.1. Over the interval -5 and -3.75, power is not defined, while between -3.75 and -3 only the residual-based IPS test and the rank LLL test are directly comparable: the latter is more powerful than the former.

5. Conclusions

This paper offers an alternative way to compare power of panel tests of cointegration based on comparisons between values of the sample statistics and statistics associated to the DGP. The choice of most powerful test depends on the values of the sample statistics. Both residual-based tests and a cointegration rank test are asymptotically normally distributed, which allows a straightforward

comparison. For some values of the statistics, the residual-based LLC test is more powerful than the IPS test, and vice versa for other values. For those value of the statistics such that residual-based and rank tests are comparable, rank LLL test is more powerful than residual-based LLC test. Therefore, the choice of the most powerful test is not only an empirical matter but also an open issue without a clear-cut choice.

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Table 1. C*ountry-by-country and panel unit root tests.*[a, b, c]

	HE		GDP	
	Lags	ADF	Lags	ADF
Australia	1	-3.772	0	-1.908
Austria	0	-2.079	0	-3.913
Belgium	0	-3.564	0	-4.109
Canada	1	-2.343	1	-2.966
Denmark	0	-2.246	0	-2.624
Finland	1	-1.957	1	-3.259
Germany	0	-4.327	0	-3.534
Iceland	1	-2.127	1	-2.562
Ireland	1	-1.231	2	-1.589
Japan	1	-2.016	1	-1.031
Luxembourg	2	-2.171	1	-2.278
Netherlands	1	-2.210	1	-2.514
New Zealand	1	-2.123	1	-2.115
Norway	1	-3.136	1	-3.078
Portugal	1	-4.558	1	-3.096
Spain	1	-2.395	1	-3.054
Sweden	1	-2.119	1	-2.736
Switzerland	1	-4.093	1	-3.394
UK	1	-2.103	1	-3.174
USA	1	-1.790	1	-4.273
Panel tests		-0.312		-1.548

*Note*s: [a] The maximum lag order for the test (8 lags) is by default calculated from the sample size, using a rule provided by Schwert (1989).
[b] For the country-by-country tests, 1%, 5% and 10% critical values are -4.316, -3.572 and -3.223, respectively.
[c] For the panel test, critical values are -2.326, -1.645 and -1.282, respectively.

Table 2. C*ountry-by-country and panel stationarity tests.* [a, b, c]

	HCE	GDP
	KPSS	KPSS
Australia	0.101	0.188
Austria	0.079	0.147
Belgium	0.157	0.092
Canada	0.144	0.090
Denmark	0.125	0.112
Finland	0.195	0.103
Germany	0.164	0.173
Iceland	0.178	0.161
Ireland	0.160	0.225
Japan	0.194	0.195
Luxembourg	0.085	0.146
Netherlands	0.132	0.148
New Zealand	0.161	0.135
Norway	0.157	0.132
Portugal	0.097	0.091
Spain	0.065	0.142
Sweden	0.129	0.072
Switzerland	0.114	0.083
UK	0.127	0.113
USA	0.173	0.041
Panel tests	11.442	13.621

*Note*s: [a] Since the tests have approximately correct size except when T is small and l is large (from Kwiatkowski et al.., 1992, p.170), we exclude the case $l = 9$. Following Gerdtham and Lothgren (2000), we set lag length to l = integer $[4(T/100)^{1/4}]$.
[b] For the country-by-country tests, 1%, 5% and 10% critical values are 0.216, 0.146 and 0.119, respectively.
[c] For Hadri (2000) test, critical values are -2.326, -1.645 and -1.282, respectively. Serial dependence in the disturbances is taken into account using a Newey-West estimator of the long run variance.

Table 3. C*ountry-by-country and panel tests of no cointegration.* [a, b]

	Lags	E.G.
Australia	1	-4.137
Austria	0	-2.155
Belgium	0	-2.647
Canada	1	-3.009
Denmark	0	-2.494
Finland	1	-3.012
Germany	0	-4.052
Iceland	0	-3.585
Ireland	1	-2.925
Japan	1	-2.354
Luxembourg	0	-1.829
Netherlands	1	-3.513
New Zealand	1	-2.907
Norway	0	-4.180
Portugal	0	-3.616
Spain	2	-3.888
Sweden	1	-2.321
Switzerland	1	-3.885
UK	1	-3.819
USA	1	-3.372
Panel tests		
for homogeneous panel		-5.422
for heterogeneous panel		-6.637

*Note*s: [a] For the country-by-country tests, 1%, 5% and 10% critical values are -4.150, -3.500 and -3.180, respectively.
[b] For panel tests, 1%, 5% and 10% critical values are -2.326, -1.645 and -1.282, respectively.

Table 4. *Country-by-country and panel tests of cointegration.* [a, b]

		Trace statistics		
	Lags	h=0	h=1	Rank
Australia	1	25.162	0.270	1
Austria	1	51.729	1.465	1
Belgium	1	91.262	3.840	1
Canada	2	16.164	0.225	1
Denmark	1	10.171	0.068	0
Finland	1	50.055	0.790	1
Germany	1	77.617	0.316	1
Iceland	1	68.978	0.154	1
Ireland	1	52.910	0.006	1
Japan	1	88.056	5.576	0
Luxembourg	1	22.148	1.016	1
Netherlands	1	51.992	0.293	1
New Zealand	1	0.347	0.014	0
Norway	1	113.989	1.367	1
Portugal	1	65.780	0.737	1
Spain	1	28.053	0.024	1
Sweden	1	8.590	0.031	0
Switzerland	1	17.122	0.467	1
UK	3	24.410	3.508	1
USA	1	48.932	0.193	1
Panel test		54.604	-0.592	

*Note*s: [a] Critical values for the trace test are tabulated in Phillips & Ouliaris (1990) and are 15.197 and 3.962 for testing h=0 and h=1, respectively.
[b] For the panel test, 1%, 5% and 10% critical values are 2.326, 1.645 and 1.282, respectively.

Figure 1. *Power of IPS, LLC and LLL tests*