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CAUSALITY AND COINTEGRATION BETWEEN CONSUMPTION AND GDP IN 25 OECD COUNTRIES: LIMITATIONS OF THE COINTEGRATION APPROACH

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Abstract:

A critical review of cointegration is presented in this paper, emphasizing some limitations of this approach to testing causal relations in Econometrics. We present an application of cointegration tests to the relation between Private Consumption and Gross Domestic Product in 25 OECD countries, during the period 1960-97, and the results confirm those limitations and the convenience of giving more emphasis to other alternative approaches like mixed dynamic models and specification tests.

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1.- Introduction

Cointegration tests fail very often to recognise causal relations and, on the other hand, that approach does not always avoid the peril of accepting as causal relations those that really are spurious.

An application of the tests to the relation between Private Consumption and Gross Domestic Product in 25 OECD countries, in the period 1961-97, is performed and the results confirm the above mentioned limitations of cointegration tests.

The most extreme case is that of the UK where, in one of the applications, the usual tests lead to rejection of cointegration between British Private Consumption and its owns GDP and acceptance of cross-cointegration of British Private Consumption with GDP of other 23 OECD countries, so the tests lead to rejection of the true relation and do not avoid acceptance of the untrue ones.

Besides that it happens very often that a problem of no cointegration among the variables of an econometric model is simply a little problem of misspecification in the form of the relation, that can be easily avoided with some changes in the relation. For example the relation in levels between Consumption and GDP could be no cointegrated in some cases but the relation in the form of a mixed dynamic model would be cointegrated.

Those little problems are very often exaggerated when many researchers identify no cointegration with spurious, or non causal, relations, and that kind of mistake has led to the overemphasis that many journals have devoted to cointegration tests, in oblivion of many important questions of world development which rarely have received the priority that they deserve in journals pages during the last decades of the 20th century.

While many economists were very occupied in discerning cointegration between any group of variables and journals devoted a great importance to the more secondary issues in this fashion, the real economy of international development experienced great problems in many countries and very few economist´s voices gave attention to these more important questions and gave help in form of good advice policies.

We must not forget that Economics and Econometrics are social sciences, where mathematics is just an instrument that should be used in a flexible way to solve social questions and to obtain solutions to important problems, giving always priority to the relevance from the economics point of view and not to the mathematical sophistication.

The main economists of the Cowles Commission, like Lawrence R. Klein, have lead the way to making Econometrics akin to real macroeconomics, and we should follow their lessons, and obtain answers to current economic problems.

The following words written by Lawrence R. Klein at the awarding of his Nobel Prize in 1980, should be remembered more often by many econometricians in order that they assume a commitment to economic science as a service to economic development:

"From my student days, the concept of public service and the relationship of theoretical economics or econometrics with real world problems has appealed to me, and I have tried to follow the footsteps of my teachers in practicing econometrics in this way".

In section 2 we present an application of cointegration tests to the relation between Private Consumption and Gross Domestic Product, GDP, in 25 OECD countries, where cointegration tests fail in many cases to recognize true relations and also fail very often to reject spurious ones. In sections 3 we analyse some alternative methods that usually lead to better results than cointegration analysis. In section 4 we present some interesting pooling regressions and in section 5 we summarize the main conclusions.

2. Analysis of cointegration between Consumption and GDP in 25 OECD countries

In this section we present the results of the usual Augmented Dickey-Fuller, ADF, and Engle-Granger, EG, statistics to evaluate cointegration between real Consumption, C90, and real Gross Domestic Product, GDP, with data from OECD(1999) expressed in 1990 dollars according to rates of exchange of that year.

We analyze cointegration relation of C90 with own GDP, which correspond to a true relation, and also cross-cointegration with foreign GDP, which generally represent an untrue relation, in order to see the percentages of acceptance of true relation and the percentages of rejection of untrue ones.

First of all in table 1 we see the results of the ADF test of co-integration with the critical values of MacKinnon for this test, under three options, all of them including a lag in the relation of the test, corresponding to the lagged value of the residual first difference. The options are (C,1), (T,1) and (N,1), where C means that the test relation includes a constant term as intercept, T means that it also includes a time trend, and N that it does not include either of the terms. The results correspond to the study by Guisan(1999).

Table 1
ADF test: Results cointegration (yes) and no cointegration (no)
At 5% significance levels, for model in levels1960-95

C90 and own GDP90	(N,1)	(C,1)	(T,1)
Australia	-3.57 yes	-3.52 yes	-3.53 no
Austria	-2.28 yes	-2.24 no	-2.23 no
Belgium	-2.41 yes	-2.39 no	-2.42 no
Canada	-4.16 yes	-4.12 yes	-4.05 yes
Denmark	-2.90 yes	-2.85 no	-2.88 no
Finland	-3.40 yes	-3.35 yes	-3.22 no
France	-2.51 yes	-2.48 no	-2.50 no
Germany	-2.84 yes	-2.80 no	-2.73 no
Greece	-1.44 no	-1.41 no	-1.36 no
Iceland	-3.36 yes	-3.31 yes	-3.17 no
Ireland	-1.93 no	-1.88 no	-1.48 no
Italy	-2.28 yes	-2.24 no	-2.17 no
Japan	-3.38 yes	-3.28 yes	-3.15 no
Luxemburg	-1.30 no	-1.26 no	-0.16 no
Mexico	-2.14 yes	-2.10 no	-2.05 no
Netherlands	-1.83 no	-1.80 no	-1.78 no
New Zealand	-2.05 yes	-2.02 no	-2.03 no
Norway	-1.94 no	-1.90 no	-1.72 no
Portugal	-2.31 yes	-2.27 no	-2.23 no
Spain	-2.05 yes	-2.01 no	-2.03 no
Sweden	-2.28 yes	-2.22 no	-2.23 no
Switzerland	-2.06 yes	-2.03 no	-1.97 no
Turkey	-2.48 yes	-2.45 no	-2.36 no
UK	-1.96 yes	-1.95 no	-1.91 no
USA	-3.44 yes	-3.39 yes	-3.51 no
Cases of cointegration	20	6	1
% of own cointegration	80%	25%	4%

Source: Guisan(1999).

MacKinnon table of critical values for table 1

MacKinnon ADF	(C,1)	(T,1)	(N.1)
1%	-3.6353	-4.2505	-2.6321
5%	-2.9499	-3.5468	-1.9510
10%	-2.6133	-3.2056	-1.6209

When the results of the test show acceptance of co-integration (actually rejecting the null hypothesis of no co-integration) we indicate “yes”, and when the results of the test show rejection of co-integration (actually, not rejecting the hypothesis of no co-integration) the usual interpretation is “no”. In the case of non-rejection, uncertainty may occur, even when there is great evidence in favour of the existence of co-integration, and so the usual interpretation is not really adequate in many cases.

Option (C,1) has only 25% of correct results and option (T,1) only 4%. Option (N,1) is the best of the three with 80% of correct results of acceptance of co-integration when the hypothesis of causal relation is true. The cases of non acceptance of cointegration were due to a result of uncertainty and should not be confused with “acceptance of no co-integration”.

The results in table 1 show that option (N,1) offers better results for non-rejection of the causal relation, between C90 and Gdp90, when it is true than the other alternatives (C,1) and (T,1). The intercept and the time trend coefficient where, generally, no significant in the integration relation of residuals.

In table 2 we compare the results of ADF(N,1) and EG(C,1) under three specification forms: relation in levels, relation in first differences, and a mixed dynamic model, MD, where C90 is a function of its own value lagged one year and the increase in GDP90. The model in first differences is a particular case of this MD model, for the circumstance where the coefficient of the lagged value of the endogenous variable is exactly equal to one.

In table 2 we use the EG test, which is similar to ADF but with higher critical levels in absolute value. EG test has into account that random shocks are unobserved variables estimated by residuals, what causes a difference in adequate critical levels.

In this table we can apply both critical values for ADF and for EG. The values of EG statistics for option (C,1) are the same as those of ADF statistics for option (N,1), for the same period 1961-97, but the tables of Mackinnon are very different, showing much higher absolute values for the EG critical values of the test. That means that the hypothesis is more easily accepted with ADF significant levels and that sometimes EG tests lead to too many rejections of true causal relations.

The use of MacKinnon tables for EG, instead of ADF, reduces the peril of acceptance of spurious regressions but increases the peril of rejection of causal relations too much, at least in the relation between levels of Consumption and GDP and other models where the autocorrelation coefficient is higher than 0.90 and less than unity.

Table 2
Engle-Granger cointegration test, option (C,1) in 1961-97:
Models in levels, first differences and mixed dynamic

C90 and GDP90 of own country	Levels	First Dif.	Mix. Dyn.
Australia	-3.01	-4.92	-4.96
Austria	-2.78	-3.81	-3.81
Belgium	-3.39	-3.71	-4.76
Canada	-2.05	-3.58	-3.56
Denmark	-2.31	-3.16	-3.38
Finland	-2.59	-4.20	-4.15
France	-2.06	-3.94	-4.11
Germany	-2.37	-5.25	-6.26
Greece	-1.42	-4.65	-4.83
Iceland	-3.50	-6.68	-6.81
Ireland	-1.52	-4.01	-4.04
Italy	-2.61	-3.83	-3.83
Japan	-3.25	-6.42	-6.55
Luxemburg	-1.34	-4.33	-4.21
Mexico	-3.11	-2.87	-3.05
Netherlands	-1.51	-3.75	-4.01
New Zeland	-1.83	-4.43	-5.20
Norway	-1.93	-3.20	-3.22
Portugal	-2.37	-3.86	-3.86
Spain	-2.14	-4.15	-4.33
Sweden	-2.70	-3.99	-4.01
Switzerland	-2.26	-4.65	-5.44
Turkey	-2.59	-4.29	-4.27
UK	-2.37	-3.81	-4.19
USA	-3.20	-3.95	-4.10
% of own cointegration EG levels	0%	88%	72%-88%
% of own cointegration ADF levels	84%	100%	100%

Source: own elaboration based on OECD National Accounts 1960-97

MacKinnon table of critical values for table 2

MacKinnon tables		EG(C,1)	ADF(N,1)
	1%	-4.2256	-2.6300
	5%	-3.5155	-1.9507
	10%	-3.1671	-1.6208

In table 2 we can see that the Engle-Granger test, EG, for variables in levels has great danger of rejecting the causal relation existing between both variables of each country, and co-integration is not accepted in any of the 25 countries, leading to 0% of correct results, which is not very beneficial for realistic conclusions, and is much worse than the 84% of correct results corresponding to ADF critical values.

The EG test in first differences shows a better result than in levels, with 88% of correct acceptance of causal relation when it is true. With ADF critical values the test in first differences lead to 100% of correct results of accepting a causal relation between C90 and PIB90 when it is true.

We present an interval for the mixed model, according to two different criteria for performing the EG test (with and without intercept in the relation between C90 and the explanatory variable). In the second case, without intercept, the results of the mixed dynamic model lead to 88% of correct results similar to the model in first differences but the number of incorrect results for cross relations is higher.

In table 3 we present a summary of own country cointegration and crossed cointegration with ADF and EG significance levels. Cross cointegration results correspond to the relation between C90 of one country with GDP90 of a foreign country.

Table 3
Percentages of cointegration acceptance for models in levels, first differences and mixed dynamic. Relation between C90 and GDP90 in 25 OECD countries, 1961-97

Summary of results	Levels	First Dif.	Mix. Dyn
own cointegration McKinnon EG	0 %	88%	72%-88%
own cointegration McKinnon ADF	84%	100%	100%
crossed cointegration McKinnon EG	19%	23%	38%-58%
crossed cointegration McKinnon ADF	66%	96%	100%

In this sample, the number of possible crossed relations between Consumption of each country and Gdp of a foreign country is 24, what implies 24 regressions for each country and a total of 600.

Generally EG test have shown lower peril of acceptance of untrue relations than ADF, but also a higher peril of rejection of true relations. None of the options have high levels of right results for both situations of true and untrue relations.

In the next section we can see that other procedures, like join regression on true and untrue explanatory variable in the context of a mixed dynamic model, led to better results than cointegration tests for the analysis of causality, with 100% of right decisions for choosing between true and untrue relations.

3.- Mixed dynamic model regressions and other methods for the analysis of causality

In table 4 we show the percentage of significant coefficients in regressions performed between C90 and GDP90 of OECD countries, corresponding to the models in levels, first differences and mixed dynamic.

We regress C90 jointly on own and foreign GDP90 and we expect that the results confirm the true relation with own coefficient and reject the generally untrue relation with foreign Gdp, given that its possible influences on own Gdp are already included in the model through GDP90i.

The three specification forms for each of the 24 regressions of each country where the following models.

Model in Levels:

(1) LS C90i / C GDP90i GDP90j

Model in First Differences:

(2) LS D(C90i) / D(GDP90i D(GDP90j)

Mixed Dynamic Model:

(3) LS C90i/ D(GDP0i) D(GDP90j) C90i(t-1)

Each variable, except otherwise specified in the case of lagged values, correspond to time t (t=1 at 1961 and t=37 in 1997). On the other hand D means First Difference (D(x) = (x(t)-x(t-1)), and subscript characters i and j indicates country number: i=1,…,25; j=1,…,25; for i≠j.

Table 4
Percentages of significant coefficients of own Gdp and foreign Gdp in join regressions on models of OECD countries, 1961-97

Percentage of significant coefficients	Levels	First Dif.	Mix.Dyn.
own GDP coefficients	100%	100%	100%
crossed GDP coefficients	54%	53%	13%

Source:Guisan(2001).

We can see that the three models present a 100% or right results in significant own coefficient, and that the mixed dynamic model is the best of the three options for recognising the usually non relevant character of cross coefficients, as in only13% of the 600 estimations the cross coefficients are statistically significant.

Models in levels and in first differences have shown worse results than the mixed dynamic model, with a higher number of significant values for crossed coefficients superior to 50% in both specifications

In the three specification forms the own coefficient resulted as highly significant in each of the 25 OECD countries relations and were always much more significant than the crossed coefficients. The crossed coefficients usually had low absolute values, and t statistics lower than that of the own coefficient.

These results show that including a relevant explanatory variable, together in the same regression, own $Gdp90_i$ or own $DGdp90_i$, and a non-relevant explanatory variable, for example Gdp_j or $DGdp_j$ of another country, lead to a clear distinction of which variable is really relevant and which is not.

The result of this is that we should re-estimate the model excluding the non-relevant variable, and the causal relations are very clear without any possibility of confusion in this analysis of the causality of the relations between the own production and own consumption levels in OECD countries.

4.- Pooled regressions between Consumption and Gdp.

In this section we present some pooled least squares results to show the great goodness of fit of the econometric relations between Consumption and Gdp. We can see how little changes in the specification of the model imply important changes in the problem of autocorrelation of residuals.

Models 1 to 4 relate Private Consumption of each country with its own country Gross Domestic Product, both variables expressed in billion of US dollars at 1990 prices and exchanges rates.

Model 5 relates Consumption per inhabitant and Gross Domestic Product per inhabitant, both variables expressed in thousand of dollars also at constant prices of 1990.

Finally graphs 1 to 3 show the relation between the variables of Model 5, in three groups, according to the value of Gdp per inhabitant in the sample.

Model 1. Static model between C90 and GDP90

Dependent Variable: C90?
Method: Pooled Least Squares
Sample: 1960 1997
Included observations: 38
Number of cross-sections used: 25
Total panel (balanced) observations: 950

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14.88071	1.527461	-9.742121	0.0000
GDP90?	0.638651	0.001438	444.2711	0.0000

R-squared	0.995220	Mean dependent var	301.7690
Adjusted R-squared	0.995215	S.D. dependent var	601.9567
S.E. of regression	41.63992	Sum squared resid	1643721.
Log likelihood	-4889.597	F-statistic	197376.8
Durbin-Watson stat	0.025550	Prob(F-statistic)	0.000000

Note: Quotation mark (?) is a symbol that indicates country number:1 to 25.

Model 2. Dynamic model in levels between C90 and GDP90

Dependent Variable: C90?
Method: Pooled Least Squares
Sample(adjusted): 1961 1997
Included observations: 37 after adjusting endpoints
Number of cross-sections used: 25
Total panel (balanced) observations: 925

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP90?	0.048481	0.004848	9.999719	0.0000
C90?(-1)	0.951181	0.007880	120.7049	0.0000

R-squared	0.999687	Mean dependent var	306.2516
Adjusted R-squared	0.999687	S.D. dependent var	607.8531
S.E. of regression	10.75565	Sum squared resid	106776.2
Log likelihood	-3508.791	F-statistic	2950261.
Durbin-Watson stat	1.093079	Prob(F-statistic)	0.000000

Model 3. Dynamic model in fist differences between C90 and GDP90

Dependent Variable: D(C90?)
Method: Pooled Least Squares
Sample(adjusted): 1961 1997
Included observations: 37 after adjusting endpoints
Number of cross-sections used: 25
Total panel (balanced) observations: 925

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP90?)	0.601019	0.005920	101.5287	0.0000

R-squared	0.900993	Mean dependent var	9.335946
Adjusted R-squared	0.900993	S.D. dependent var	20.70545
S.E. of regression	6.515058	Sum squared resid	39220.08
Log likelihood	-3045.575	Durbin-Watson stat	1.580779

Model 4. Dynamic mixed model between C90 and GDP90

Dependent Variable: C90?				
Method: Pooled Least Squares				
Sample(adjusted): 1961 1997				
Included observations: 37 after adjusting endpoints				
Number of cross-sections used: 25				
Total panel (balanced) observations: 925				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP90?)	0.466365	0.008486	54.95861	0.0000
C90?(-1)	1.009108	0.000465	2170.799	0.0000
R-squared	0.999919	Mean dependent var		306.2516
Adjusted R-squared	0.999919	S.D. dependent var		607.8531
S.E. of regression	5.478163	Sum squared resid		27699.48
Log likelihood	-2884.729	F-statistic		11375332
Durbin-Watson stat	1.665268	Prob(F-statistic)		0.000000

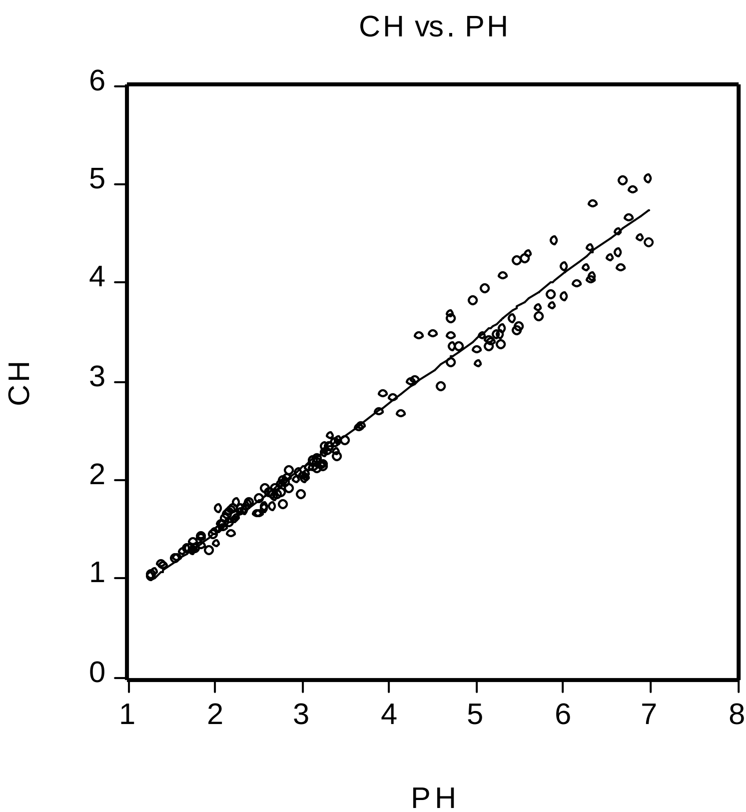
Model 5. Dynamic mixed model between CH and GDPH

Dependent Variable: CH?				
Method: Pooled Least Squares				
Sample(adjusted): 1961 1997				
Included observations: 37 after adjusting endpoints				
Number of cross-sections used: 25				
Total panel (balanced) observations: 925				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPH?)	0.448182	0.014186	31.59408	0.0000
CH?(-1)	1.003264	0.000797	1258.664	0.0000
R-squared	0.998166	Mean dependent var		8.754143
Adjusted R-squared	0.998164	S.D. dependent var		4.036961
S.E. of regression	0.172974	Sum squared resid		27.61616
Log likelihood	311.5010	F-statistic		502368.3
Durbin-Watson stat	1.731928	Prob(F-statistic)		0.000000

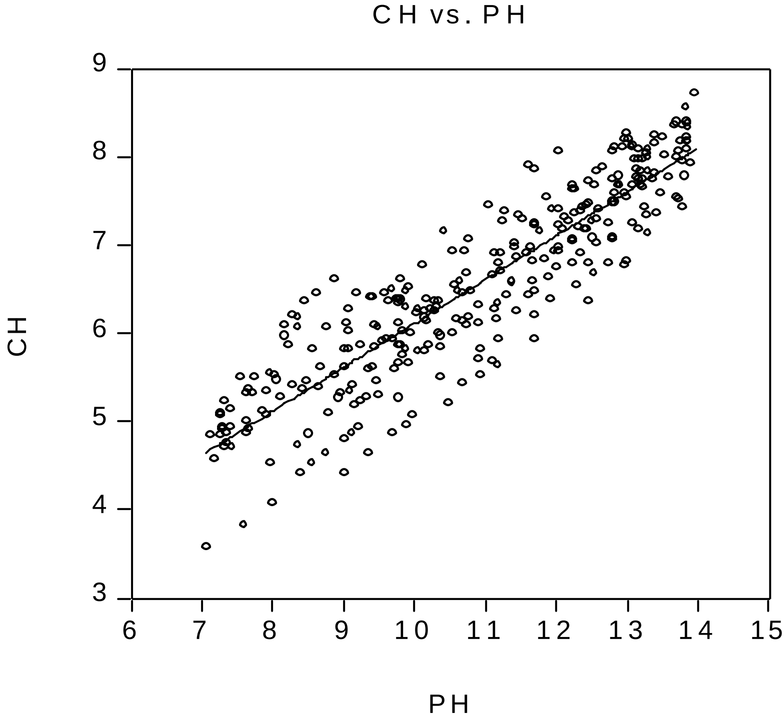
It is very frequent in applied econometrics to find that the problem of autocorrelation present in the model in levels disappears when we specify a mixed dynamic model. In those cases it happens very often that the problem of no co-integration in causal relations, if it was present, also disappears.

Goodness of fit was very high, both in these pooled samples as in the individual time series models fitted for each country.

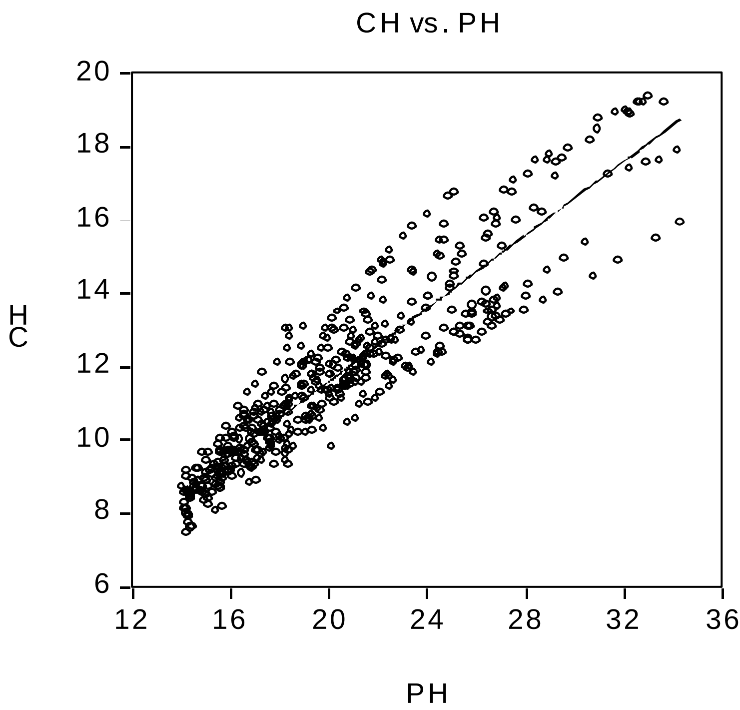
Graph 1
.Relation between CH and PH in Group 1 (PH < 7)



Graph 2
Relation between CH and PH in Group 2 (7< PH <14)



Graph 3
Relation between CH and PH in Group 3 (PH>14)



We can observe that the degree of dispersion increases with the value of PH, what is rather normal and usually it is due to two causes: 1) Because the higher possibilities of reducing the propensity to consumption that exist in richest countries and 2) because the effect of Public Consumption, as we can find in richest OECD countries more variability in the distribution of Consumption between Private and Public than in other countries.

The regressions of this section and those comparisons with other approaches included in Guisan(2001) show that the main stream of Cowles Commission continues to be worthy in Applied Econometrics, as the main emphasis of that approach in causal and contemporaneous relations between main economic variables are generally supported by empirical testing.

Other interesting approaches to the analysis of causality include causality tests, specification tests and analysis of forecasting performance. All these methods, together with mixed dynamic models are usually of great help for the specification of realistic models.

Cointegration analysis can be of some help but the fashion of given so high priority to this method, in oblivion of other more useful approaches, should be abandoned in favour of a higher degree of realism, relevance and right results in Applied Econometrics.

5. Conclusions

We have compared the results of applying ADF and EG tests to the relation between C90 and GDP90 in 25 OECD countries, under three models: a model in levels, a model in first differences and a mixed dynamic model. Some of the most interesting findings of this research, regarding cointegration tests, are the following:

1) In the three specification forms the ADF option (N,1) test gave better results than the options (C,1) and (T,1) of this test. Option (N,1) has a high probability of accepting true relations although it also has a high probability of accepting spurious ones.

The percentage of acceptance of true relation with option (N,1) was of 84% in the case of model in levels and of 100% both in model in first differences and in the mixed dynamic model. This percentage diminish with options (C,1) and (T,1), where the estimated probability of accepting true relations diminishes from 80% to only 25% and 4%, respectively, in case of table 1.

The percentage of acceptance of untrue relations with option (N,1) was of 66% in model in levels, of 96% in model in first differences and of 100% in the mixed dynamic model.

So ADF is a good test for acceptance of true relations but has a great probability of acceptance of spurious relations. Its results where better with first differences and mixed dynamic models than with model in levels, and the option (N,1) gave better general results than options (C,1) and (T,1).

2) The test EG in first differences performs better than test ADF for avoiding the peril of spurious relations, as its percentage of acceptance of untrue relations was only of 23%, but it gives worse results in acceptance of true relations with only 88% of cases.

For variables in levels the EG test gives very bad results as it leads to acceptance of true relations in 0% of the cases and at the same time it does not avoid the peril of accepting spurious relations which could happen in 19% of the cases.

The test EG in the case of the mixed dynamic model without intercept gives a result of 88% of right results when the hypothesis is true and has a peril of acceptance of spurious relations of 58%.

3) It seems convenient to have into account the results of both tests, with a preference for the model in first differences in first place and mixed dynamic in second place. If both ADF and EG tests lead to acceptance or to rejection the results have generally more support than where it is a discrepancy between both tests.

Besides that we have considered some alternative approaches to cointegration and we can stand out the following conclusions:

4) An interesting alternative to cointegration analysis, for distinction between true and untrue causal relations, is the analysis of significant coefficients in the joint regression of the explained variable (C90 in this article) as a joint function of two candidates to explanatory variables (in this case GDP90i and GDP90j), as in the 100% of the cases the results were completely clear about the true and untrue relations, in the three models.

In all the countries there was not doubt about the greater importance of own coefficient, as their value was always higher and usually more significant than the cross coefficients. The best results of this approach for the analysis of causal relations correspond to the mixed dynamic model.

In all the cases the results have suggested the convenience of re-estimatation, maintaining own Gdp as explanatory variable in each country, and excluding other countries Gdp.

5) We agree with several outstanding researchers that have stated the convenience of improving the contents of many journals, books and even students textbooks, in relation with applied econometrics, with a greater focus on the economic relevance of the contributions and with a more flexible interpretation of methodological questions.

Unit roots, cointegration and other econometric techniques should always be applied with flexibility understanding that although they can help in econometric research they are not usually the main question in that research and that their results always should be interpreted having into account other approaches.

There are many other questions of greater importance like the relevance of the determination of the direction of causality in changing circumstances, and the relevance of the contributions of econometric models to the solution of real economic problems. The analysis of the direction of causality between contemporaneous variables for example is generally a very important question as there are several possibilities that are relevant for economic policy purposes, like those analysed in Guisan(2001).

Economics is a social science and its quantitative analysis is of great importance if it has into account history, institutional context and economic thought, and could be merely a mathematical exercise it is devoted only to discussion about unit roots and other secondary questions. The relevance of the questions that researchers try to reply with their research and the relevance of the answers that they get from their analyses should be have into more consideration in the next future, in order to get foster relevant contributions to advice economic policies for economic development.

This positive view of the contribution of econometrics to Economics science could help also to foster more cooperative and open-minded aptitudes among researchers from many countries, than the close circles and competitive groups of defenders of several methodological fashions in the last decades. So the positive spirit of the Cowles Commission could be recuperated and guide our contributions to the analysis of the economic problems of real world.

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