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TESTING ROBERT HALL'S RANDOM WALK HYPOTHESIS OF PRIVATE CONSUMPTION FOR THE CASE OF ROMANIA

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Abstract

The purpose of this study is to analyze private consumption in Romania from a time series modelling perspective having as a starting point the hypothesis of the random walk theory of consumption. The random walk model of consumption was initiated by the economist Robert Hall (1978) who described consumption as a function of only consumption from the previous period plus the error (innovation) term. The Box-Jenkins method was employed for the analysis by using annual data of private consumption in Romania for the period 1970-2013 measured in 1970 billion $ constant prices. The final results revealed that private consumption in Romania is better characterized by an AR(4) process thus invalidating the hypothesis of following an AR(1) model. Moreover the estimated coefficient of AR(4) was found to be negative, the result possibly indicating an adjusting effect in time of private consumption by the influence of other macroeconomic indicators.

Keywords: private consumption, random-walk consumption theory, autoregressive model, Box-Jenkins, Romania

INTRODUCTION

Private consumption is the principal component of GDP from the expenditure approach, its share in the economic output reaching almost 74% in 2008, the year with the peak of economic growth in Romania. Because it accounts more and more for a substantial part of GDP and it is seen as a proxy indicator for generating and influencing the economic welfare of the people, private consumption in Romania has been analyzed using different statistical models and methods over time, mainly regarding its relationship with other macroeconomic indicators such as the one with GDP (Anghelache, 2011), or with GDP, inflation rate and unemployment rate (Necşulescu & Şerbănescu, 2014) but also analyzed from a theoretical viewpoint concerning its indirect factors that influence it such as the demographic condition, labor conditions, the level and the evolution of population's income, the living conditions' quality, instruction, education and level of culture, the population's health condition or technological evolution as researched in a study by Popescu, Badea, Hrestic, & Popescu (2010).

Apart from these studies there is no well-grounded research in the specialized literature regarding the analysis of private consumption for the case of Romania using time series approach and/or testing the hypothesis of random walk consumption model of Hall (1978).

In his paper Hall (1978) started from the hypothesis that "in particular, no variable apart from current consumption should be of any value in predicting future consumption", using time series quarterly data on real consumption per capita of non-durables and services, for the period 1948-1977, for the postwar United States and founded evidence supporting his modified version of the life cycle-permanent income hypothesis.

Moreover Sargent (2015) stated about the Hall's consumption model version of this theory that: "imposing rational expectations produces the result that consumption is a random walk: the best prediction of future consumption is the present level of consumption".

Zakia and Tanweer (2015) found the results of time series analysis of aggregate consumption function in the case of Pakistan to empirically validate the random walk hypothesis by using quarterly data of consumption from period 1973(1)-2010(4). Also, the study by Reis (2009) has analyzed by comparison the hypotheses of Hall (1978) and Lucas (1987) regarding the autoregressive nature of aggregate consumption and his results confirm the random walk theory with a 5% significance level.

Hall's paper was nevertheless criticized by the following authors that applied his theory and have not found sufficient evidence to support his hypothesis (Blinder & Deaton, 1985). In his attempt to test Hall's model on the case of United States, Jaeger's results of using quarterly forecasting data (1992) dismissed the random walk hypothesis, this outcome being argued by some authors like Carroll (2001) to be expected from the model's shortcomings in exposing consumer preference variables such as the intertemporal elasticity of substitution. Other authors like Davidson and Hendry (1981) revealed that they introduced Hall's random walk consumption function (Davidson, Hendry, Srba, & Yeo, 1978) as a special case of estimating the UK aggregate consumption function using an Error Correction Model (ECM).

Opposed to Hall's theory, Robert Lucas Jr. (1987) assumed in his paper that shocks to consumption are serially uncorrelated, his study also being dismissed by other empirical studies that followed its presumption (Reis, 2009).

From the perspective of testing the Hall's random walk theory, the present study analyzes private consumption by using time series data and Box-Jenkins procedure trying to answer this theory question and to fill the gap that exists in the Romanian specialized literature regarding this subject.

METHODOLOGY

The variable used for the analysis of private consumption time series is the Household Final Consumption Expenditure (HFCE) defined as the households expenditure on purchasing goods and services in order to directly meet the individual needs of resident households members, government expenditure for individual consumption (education, health, social security, and welfare, culture, sport, recreation, collection of households refuse) and non-profit institutions serving households expenditure for individual consumption.

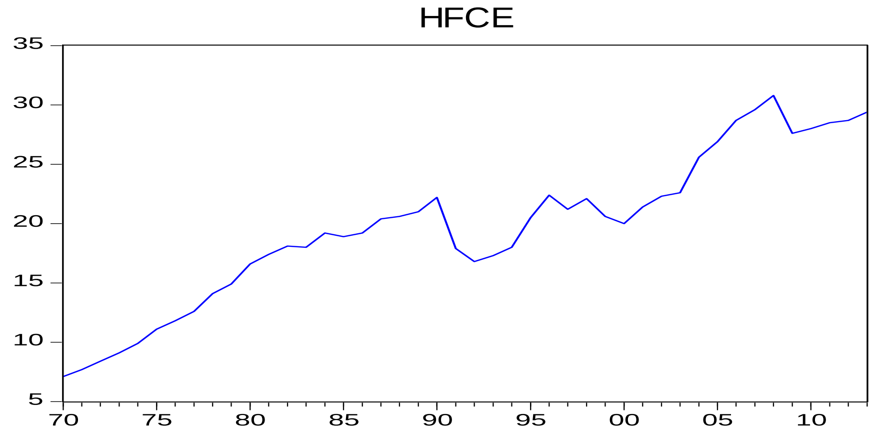
The data covers annual values of the private consumption indicator in Romania for the period 1970-2013 measured in 1970 bln. $ constant prices, that was retrieved from the World macroeconomic research, 1970-2013 e-book (Kushnir, 2015).

The methodology used for verifying the main hypothesis of the study concerning the random walk consumption theory, introduced by Hall (1978), was the Box-Jenkins procedure for time series analysis (Stancu, 2011). All the procedures were computed with the EViews version 6.0 software.

EMPIRICAL RESULTS AND DISCUSSION

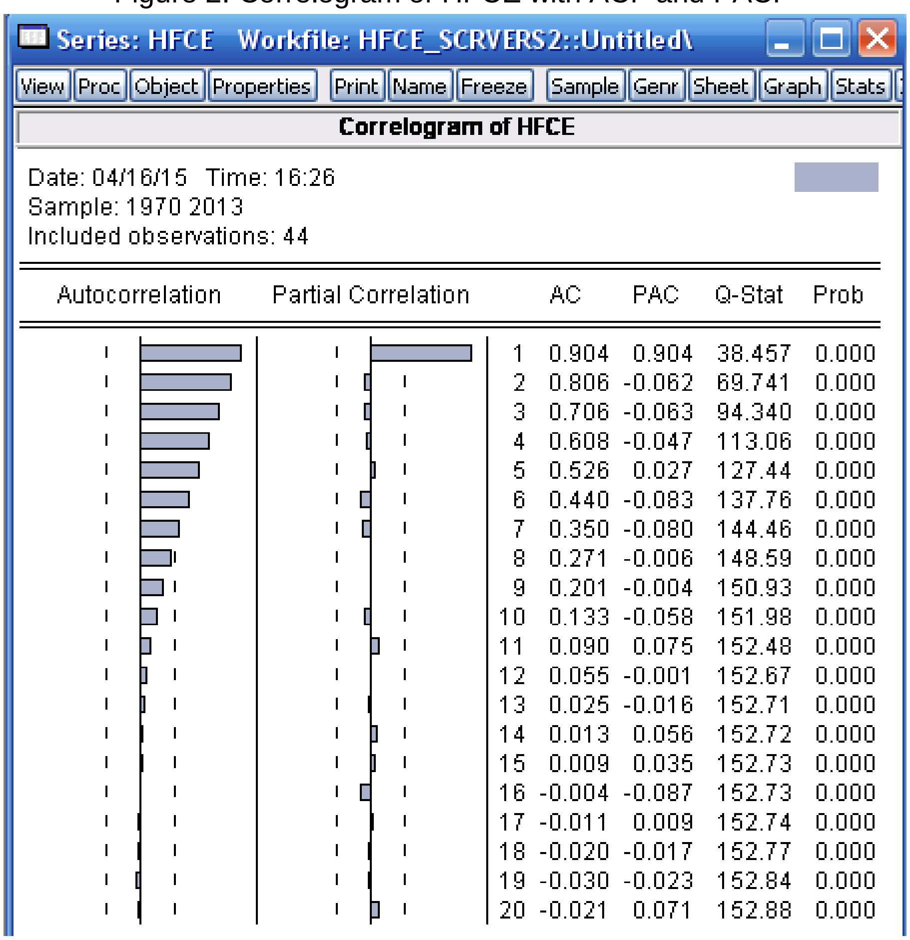
The evolution of HFCE on the period 1970-2013 that can be seen in Figure 1. was characterized by a general upward trend with a dramatic drop in level in the period 1991-1993 just after the fall of the communist regime followed by a recovery between 1994-1996, reaching and stagnating the following years almost at the level the indicator had before the changing of political system. The period between 2000 and 2008 was defined by continous and sustained economic growth thus increasing the level of private consumption (HFCE) until 2009 when the macro indicator registered a second drop in level as a consequence of the economic and financial crisis effects, but slowly recovering its upward path in the last years of the analyzed period. Considering the overall evolution of HFCE in Figure 1. and also taking into account that it represents an important macroeconomic indicator we can assume that HFCE is an inertial process which can be described by an autoregressive model.

Figure 1. Evolution of HFCE in the period 1970-2013 (constant prices 1970 billion $)



By applying the first step of the Box-Jenkins procedure we investigated if the series is stationary by viewing the correlogram of HFCE with the values calculated for autocorrelation function (ACF) and partial autocorrelation function (PACF) listed in Figure 2. The results of both functions indicate HFCE to be best modelled by an AR(1) or at most by an AR(2) process.

Figure 2. Correlogram of HFCE with ACF and PACF


Series: HFCE Workfile: HFCE_SCRVERS2::Untitled\

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Correlogram of HFCE

Date: 04/16/15 Time: 16:26
Sample: 1970 2013
Included observations: 44

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.904	0.904	38.457	0.000
		2	0.806	-0.062	69.741	0.000
		3	0.706	-0.063	94.340	0.000
		4	0.608	-0.047	113.06	0.000
		5	0.526	0.027	127.44	0.000
		6	0.440	-0.083	137.76	0.000
		7	0.350	-0.080	144.46	0.000
		8	0.271	-0.006	148.59	0.000
		9	0.201	-0.004	150.93	0.000
		10	0.133	-0.058	151.98	0.000
		11	0.090	0.075	152.48	0.000
		12	0.055	-0.001	152.67	0.000
		13	0.025	-0.016	152.71	0.000
		14	0.013	0.056	152.72	0.000
		15	0.009	0.035	152.73	0.000
		16	-0.004	-0.087	152.73	0.000
		17	-0.011	0.009	152.74	0.000
		18	-0.020	-0.017	152.77	0.000
		19	-0.030	-0.023	152.84	0.000
		20	-0.021	0.071	152.88	0.000

To verify the results concerning the nonstationarity nature of the HFCE data series we followed with the test results of Augmented Dicky-Fuller (ADF) and Phillips-Perron (PP) unit root tests, the most known applied tests in this case. The ADF and PP test results revealed in Table 1. indicate that HFCE does have a unit root, being unable to reject the null hypothesis of nonstationarity by using a 5% significance level (p-value of ADF(with constant and trend): 0.4864>0.05 and p-value of PP(with constant and trend): 0.3914>0.05).

Table 1. Unit root testing results using ADF and PP tests for HFCE (original series)

	HFCE	
Test options	**ADF**	**PP**
Without constant or trend	I(1)*	I(1)*
With constant	I(1)*	I(1)*
With constant and trend	I(1)*	I(1)*

*Note: *significant at 5% level; I(1) – integrated of order 1 (stationary series after first differencing)*

The next step we took in the analysis was to differenciate the HFCE series and to run the ADF and PP tests again to see if the first-differenced series are now stationary or not. The results obtained in Table 2. show that the new differenced series DHFCE is now stationary by using a 5% significance level (p-value of ADF(with constant and trend): 0.0001<0.05 and p-value of PP(with constant and trend): 0.0001<0.05).

Table 2. Unit root testing results using ADF and PP tests for DHFCE (differenced series)

	DHFCE	
Test options	**ADF**	**PP**
Without constant or trend	I(0)*	I(0)*
With constant	I(0)*	I(0)*
With constant and trend	I(0)*	I(0)*

*Note: *significant at 5% level; I(0) – integrated of order zero (stationary series in level)*

Due to the fact that DHFCE data series is stationary and also considering the autoregressive models suggested by the ACF and PACF from the correlogram shown in Figure 2, the next step of the Box-Jenkins procedure that we applied was to estimate four proposed time series regression model equations to assess the inertial effect on DHFCE. All the models have a drift with the following specifications:

- model 1 includes the first five autoregressive components (AR(1)-AR(5));
- model 2 includes AR(4) and AR(5) components;
- model 3 includes only the AR(4) component;
- model 4 includes only the AR(5) component.

The chosen method for estimation was Ordinary Least Squares. The estimated results of the first two models are presented in Figure 3 and Figure 4 respectively. Model 1 found only the estimated parameter of the AR(4) process to be statistically significant if we consider a 10% significance level, the overall performance of the model being invalidated by the high p-value associated to the F-test (0.195>0.05). An interesting fact to notice given the results obtained is that the AR(1) component of the HFCE is not statistically significantly (p-value AR(1): 0.90>0.05), this outcome contradicting the economic logical theory and thinking of presuming that private consumption is an AR(1) process like most of the macroeconomic indicators. We then estimated model 2 by including only the drift, the AR(4) and AR(5) components taking into account that they have the lowest p-values for the estimated coefficients in model 1. The results listed in the Figure 4. show that the estimated parameters for the AR(4) and AR(5) processes are statistically significant at 5% level and at 10% level accordingly (p-value AR(4): 0.0448<0.05; p-value AR(5): 0.0782<0.10), thus suggesting that private consumption may depend on its past value from four periods and/or five periods back in time and not by its immediate past value.

Figure 3. Estimated results of model 1

Equation: EQ1 Workfile: HFCE_SCRVERS2::Untitled\

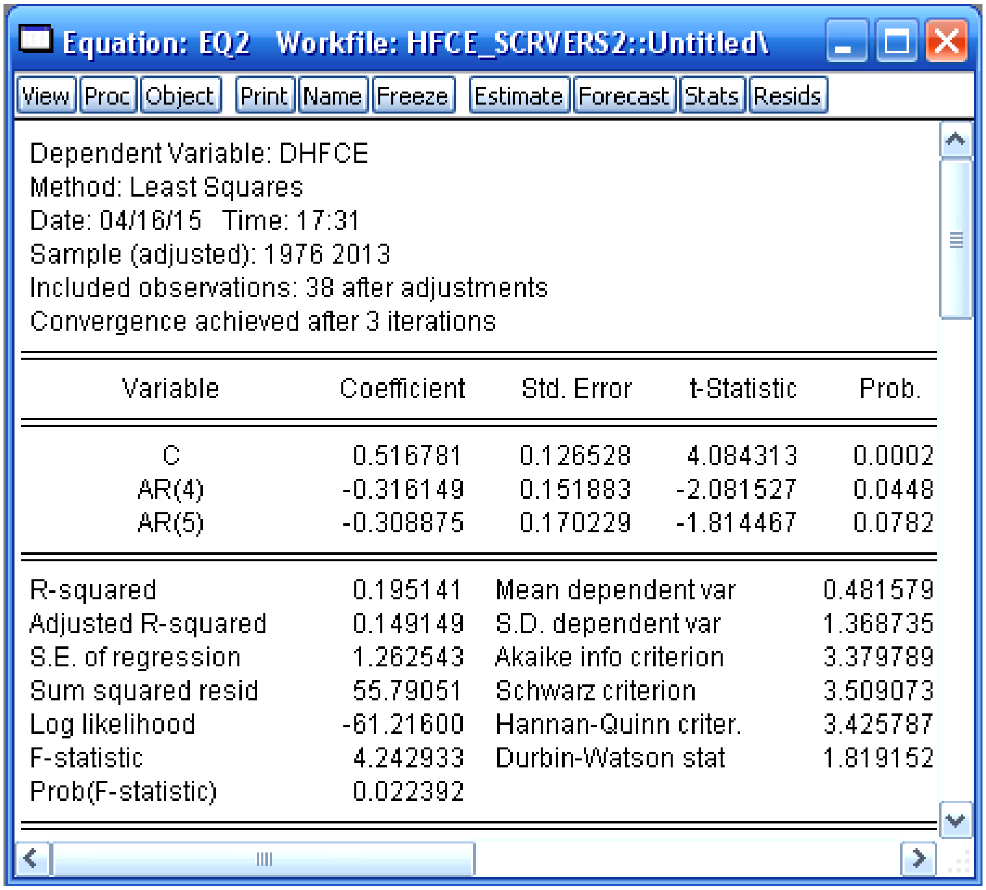
View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DHFCE
Method: Least Squares
Date: 04/16/15 Time: 17:00
Sample (adjusted): 1976 2013
Included observations: 38 after adjustments
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.517235	0.134878	3.834833	0.0006
AR(1)	-0.020838	0.171048	-0.121828	0.9038
AR(2)	0.037864	0.159330	0.237644	0.8137
AR(3)	0.027998	0.159498	0.175542	0.8618
AR(4)	-0.319727	0.159412	-2.005664	0.0534
AR(5)	-0.317221	0.191872	-1.653300	0.1080

R-squared	0.197747	Mean dependent var	0.481579
Adjusted R-squared	0.072395	S.D. dependent var	1.368735
S.E. of regression	1.318259	Akaike info criterion	3.534441
Sum squared resid	55.60984	Schwarz criterion	3.793007
Log likelihood	-61.15437	Hannan-Quinn criter.	3.626436
F-statistic	1.577536	Durbin-Watson stat	1.772169
Prob(F-statistic)	0.194592		

Figure 4. Estimated results of model 2



Dependent Variable: DHFCE
Method: Least Squares
Date: 04/16/15 Time: 17:31
Sample (adjusted): 1976 2013
Included observations: 38 after adjustments
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.516781	0.126528	4.084313	0.0002
AR(4)	-0.316149	0.151883	-2.081527	0.0448
AR(5)	-0.308875	0.170229	-1.814467	0.0782

R-squared	0.195141	Mean dependent var	0.481579
Adjusted R-squared	0.149149	S.D. dependent var	1.368735
S.E. of regression	1.262543	Akaike info criterion	3.379789
Sum squared resid	55.79051	Schwarz criterion	3.509073
Log likelihood	-61.21600	Hannan-Quinn criter.	3.425787
F-statistic	4.242933	Durbin-Watson stat	1.819152
Prob(F-statistic)	0.022392		

The p-value of the F-test for the model 2 (Figure 4) is under 0.05 but the estimated parameters are almost statistically insignificant for a 5% level so we advanced the analysis by estimating two other models 3 and 4, each one of them including separately just one component from the model 2 as it is listed in Figure 5 and Figure 6, respectively. By comparison, the model 3 is more appropriate to explain DHFCE as the estimated parameter for the AR(4) component is statistically significant at 5% level (p-value AR(4): 0.0322<0.05) and the F-test validates the overall performance of the model at the same significance level (p-value F-test: 0.0322<0.05). Moreover the value for the Durbin Watson (DW) statistic (d_{DW}=1.96) is higher than the upper critical value of this test d_U=1.53963 showing that the error terms are not positively autocorrelated or negative autocorrelated as the relation (4-d_{DW}) > d_U is verified as well. As opposed to these results, the ones estimated for the model 4 were not found to be statistically significant at 5% level as the p-values of both the estimated parameter for AR(1) and for the F-test were 0.059 > 0.05 but with a robust value of DW statistic.

Figure 5. Estimated results of model 3

Equation: EQ3 Workfile: HFCE_SCRVERS2::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DHFCE
Method: Least Squares
Date: 04/16/15 Time: 17:32
Sample (adjusted): 1975 2013
Included observations: 39 after adjustments
Convergence achieved after 3 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.506556	0.153773	3.294181	0.0022
AR(4)	-0.343527	0.154376	-2.225261	0.0322

R-squared	0.118035	Mean dependent var	0.500000
Adjusted R-squared	0.094198	S.D. dependent var	1.355496
S.E. of regression	1.290074	Akaike info criterion	3.397197
Sum squared resid	61.57878	Schwarz criterion	3.482508
Log likelihood	-64.24534	Hannan-Quinn criter.	3.427806
F-statistic	4.951787	Durbin-Watson stat	1.960651
Prob(F-statistic)	0.032242		

Figure 6. Estimated results of model 4

Equation: EQ4 Workfile: HFCE_SCRVERS2::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: DHFCE
Method: Least Squares
Date: 04/16/15 Time: 17:34
Sample (adjusted): 1976 2013
Included observations: 38 after adjustments
Convergence achieved after 3 iterations

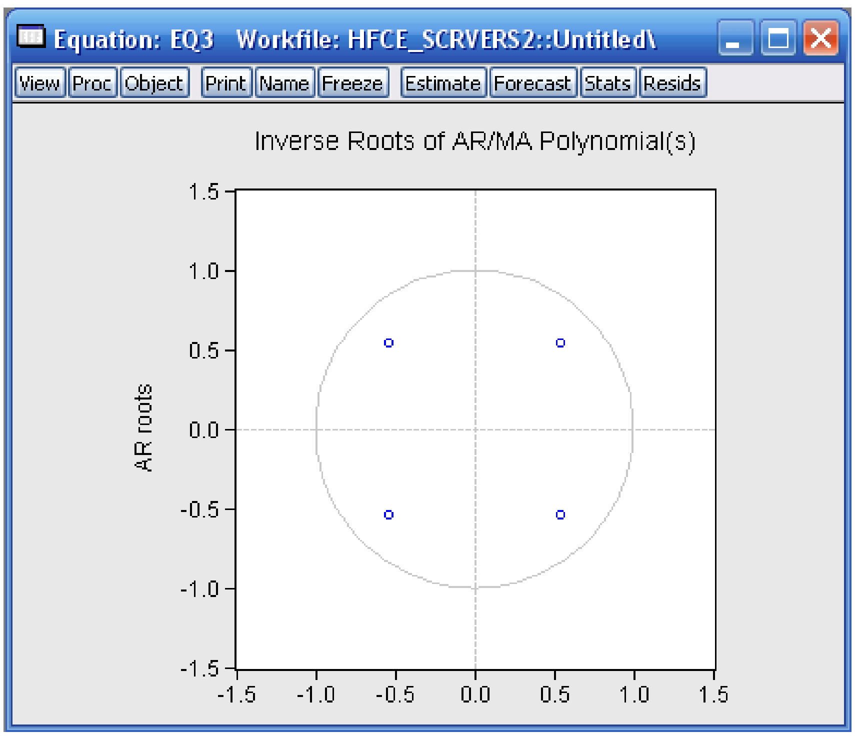
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.518037	0.159763	3.242526	0.0026
AR(5)	-0.345096	0.177002	-1.949669	0.0590

R-squared	0.095505	Mean dependent var	0.481579
Adjusted R-squared	0.070380	S.D. dependent var	1.368735
S.E. of regression	1.319690	Akaike info criterion	3.443867
Sum squared resid	62.69699	Schwarz criterion	3.530056
Log likelihood	-63.43348	Hannan-Quinn criter.	3.474533
F-statistic	3.801207	Durbin-Watson stat	1.848843
Prob(F-statistic)	0.059038		

Nevertheless, model 3 explains only 12% of the variation of the dependent variable (DHFCE) as the coefficient of determination R-squared is 0.118. Also, the sign of the estimated parameter of AR(4) component is negative which implies that if the value of the consumption from four-periods back in time increases with a monetary unit then the value of the current consumption will decrease by almost 0.34 monetary units. This result suggests there may be an inertial effect on private consumption due to the investments influence. However all the obtained outcomes are rejecting the Hall's random walk consumption theory that implied private consumption to be an AR(1) process, for the case of Romania.

We further tested for the stability and robustness of the estimated model 3 by visualizing the inverse roots of AR/MA as it is shown in Figure 7. The inverse roots lie within the unit circle, they are less than 1, so these results indicate that the model is dynamically stable and thus pertinent for performing forecasts.

Figure 7. The inverse roots of AR/MA Polynomial(s)



Considering the previously outcomes, there is strong evidence that private consumption follows an autoregressive process of order 4 which implies the fact that the current values of this consumption are dependent on the past values from four periods back in time. The model that describes this process is:

Model 3: DHFCE = 0.50656 - 0.34353*DHFCE(t-4).

CONCLUSIONS

Private consumption (HFCE) is an inertial macroeconomic process and in this paper was analyzed from the viewpoint of Hall's random walk consumption theory (1978). The hypothesis of the study that private consumption in Romania is an AR(1) process (the current value of private consumption is based on the immediately preceding value) was invalidated by the statistical results which indicate that private consumption is an AR(4) process with an estimated parameter of -0.34, thus overruling the random walk consumption model sustained by Hall (1978) and indicating also an inertial effect on private consumption due presumably to the investments or income influence. This result is common with the one achieved by Mei (2012) who found the consumption to be explained by an AR(3) component with a high negative estimated coefficient in a vector error-correction model which included also as independent variables the Gini Index for households, Standard & Poor Index 500, disposable income, debt-income ratio and some dummy variables using US data for the period 1967-2009.

The present study has its limitations regarding the size of the sample that is an important factor in obtaining more reliable results especially when performing time series analysis. Another shortage of the paper would be the value of the coefficient of determination R-squared of almost 0.12 which leaves unexplained an amount of nearly 88% of the variation of the dependent variable. This outcome may be due to the fact that this type of model only includes one exogenous factor thus making necessary to add more variables to the initial model in order to increase the value of R-squared and thus the model's performance. More research is necessary in order to predict with higher accuracy the autoregressive nature of private consumption in Romania, when more data become available.

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