Cyclical convergence between Romanian consumption and Euro Zone’s one

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Abstract. In this paper we elaborate an empirical research on the analysis of synchronization between evolutions of Romanian and Euro Zone consumption. The general purpose of the work is twofold, first we are interested in observing the degree of cyclical convergence in order to trace out some conclusions about the homogeneity, respectively the heterogeneity with Euro Zone economy and secondly, owing to the latent feature of the information we intend to obtain, we engage a range of statistical and econometric tools to provide a very deepen view of the research problem. More exactly, for the latter aim we underlined before, we have analyzed the relation between interest variables using cointegration, the Granger causality and the correlation which was estimated in various ways based on multivariate distributions or conditional covariance.

Keywords: Business Cycles, consumption expenditure, convergence, permanent income, filter, correlation.
JEL Classification: E32, F41

1. Literature Review


2. Introduction

As Muellbauer and Lattimore (1994) noted in their seminal work about consumption function, empirical analysis shows that in most world’s economies, the private consumption records a share between 50% and 70% from total spending. Also consumption is the component which owns the largest share from the use of Gross Domestic Product (GDP). But many empirical analyses such as the Backus-Kehoe-Kydland puzzle (1992) revealed that consumption is much less correlated across economies than is the aggregate production. This puzzle could be explained by several facts, as the insufficient development of financial markets, nominal rigidities (stickiness) or different ways to form expectations. On the other side, empirical work of King and Rebelo (1999) underlined a very important stylized fact, namely the
consumption’s volatility is lower than GDP’s one by about 46% for the case of United States’ economy. This fact is mainly explained by the agents’ behavior to smooth the variance of consumption. An important element in differentiating these models is how agents form their expectations. In the following lines I review the main models of consumption dynamics.

**Fisher’s Two-Period Inter-temporal Model**

Fisher’s idea was formulated as a problem of utility’s maximization for a two-period horizon, where $C_t$ is the consumption spending in each period: $\max C_1, C_2$. Therefore, the consumer face the following budget’s constraint, where $Y_t$ denotes the income in each period and $r$ is the interest rate:

\[ 2C_1 + C_2 + r = Y_1 + Y_2 + r. \]

Resolving the maximization problem it will be obtained that interest rate represents the marginal rate of substitution: $3U1C1, C2U2C1, C2 = 1 + r$.

**Keynes’s Absolute Income Hypothesis**

A few years later, the British economist John Maynard Keynes formulated a new law of motion for consumption spending: $4C_t = \alpha + \beta Y_t$, where $C_t$ and $Y_t$ denotes the real values for consumption, respectively income, $\alpha$ is the autonomous component of consumption, while $\beta$ is marginal propensity to consume.

**Modigliani’s Life Cycle Hypothesis**

Modigliani (1950), other Laureate of the Nobel Prize, supposed that in the face of forward-looking views, agents maximize their lifetime utility according to the cycle of both private consumption and income:

\[ 5C_t = \beta_1 Y_t + \beta_2 Y_{te} + \beta_3 W_t, \]

where $C_t$ is the individual consumption, $Y_t$ is current (non-property) income, $Y_{te}$ represents the expected annual income and $W_t - I$ is the net worth.

**Friedman’s Permanent Income Hypothesis**
Milton Friedman (1957) proposed a new theory about consumption’s evolution based on the fact that private consumption depends on a permanent \((Y_t^P)\) and transitory \((Y_t^T)\) component. Owning to these features, Friedman’s theory was called *Permanent Income Hypothesis (PIH)* and was defined by the following relations:

\[
6Y_t = Y_t^P + Y_t^T; \quad 7C_t = C_t^P + C_t^T; \quad 8C_t = \beta r, \quad w, u \times Y_t^P,
\]

where \(\beta\) is the marginal propensity to consume which depends on: \(r\) that is the interest rate, \(w=WiYt\) and \(u\) denotes the taste of consumers. A very interesting conclusion is that \(\beta\) doesn’t depend on permanent income. The general form of PIH model is:

\[
7Y_t^P = r1+rYt+r1+rYt−1+r1+r2Yt−2+..., \quad
\]

where the permanent income is defined as a polynomial relation with geometrically decay rate, assuming adaptive expectations.

**Hall’s Rational Expectation Approach of PIH Model**

Hall (1980) supposed that economic agents intend to maximize the utility function of consumption during their lifetime using a stochastic program subject to an “evolution of assets” form of the budget constraint:

\[
(8)\max VT, C_t+1, ..., C_t+T = Et0=0T−t1+\delta−iUC_t+\delta i=0T−tR−iC_t+i−wt+i=At,
\]

where \(\delta\) is the subjective time preference, \(R\) is the rate of return (equals \(1+r\)), represent the assets (excepting the human capital). Applying the first-order condition to above equation, there it is obtained the following (very useful in dynamic programming) Euler equation:

\[
9EtU'C_t+1 = 1+\delta1+rU'C_t.
\]

Assuming a quadratic form of utility and \(r=\delta\), after the substitution of resultant Euler equation into the second relation from equation no. 8 it results the following relation:

\[
(10)C_t = g_t \times W_t = Ati=0T−t1+r+i=0T−tR−i \times Etwt+i
\]

where \(C_t = Y_t^P\), because the transitory component is assumed zero and \(g_t\) denotes the share from the lifetime wealth. Evolution of consumption is assumed to follow a random walk process, due to quadratic form of utility function: \((11)C_t+1 = C_t + \epsilon t\).
As we could observe from that review on the main theoretical models related to private consumption formation, its dynamics is explained by a sum of several factors such as the agents’ expectation, population ageing, level of past, current and expected levels of income and other. A perfect model of foresight would choose those variables that are fundamental in explaining the developments of endogenous variable. But if we take into account the Backus-Kehoe-Kydland puzzle and the empirical evidence of King and Rebelo, we could conclude that consumption dynamics is explained by idiosyncratic shocks. For this purpose in this paper I called a large number of filtering techniques in order to extract the common and most relevant information provided by those ones.

3. Methodology

Considering a stochastic process $Y_t$, the filtering problem consists in the isolation of its cyclical component $X_t$ from the trend component, such that:

$$11Y_t = X_t + Y_t,$$

where $Y_t$ take values in domain $a, b \cup -a, -b \in -\pi, \pi$, while $Y_t$ is defined on $-\pi, \pi$. In the theoretical case of infinite sample of data, the so called “ideal bandpass filter” is defined as

$$12X_t = A_\mathcal{L}Y_t = \int_{-\infty}^{\infty} A_j Y_t + j ,$$

$A_\mathcal{L}$ being the filter of data and $A_j$ is the impulse-response sequence. $A_n = -12A_0 + j_1n - 1A_j$, $A_j = \sin jb - \sin ja \pi j$ and $a = 2\pi Pu$, $b = 2\pi Pl$ are the cycles frequencies ($pl, pu$ are cut-off cycle length).

Given the general framework of filtering problem, in the next lines I will shortly describe the main features of the filters that are used in this paper.

**Kolmogorov-Wiener Filter**

The two mathematicians, Kolmogorov and Wiener, defined (in the ’40) a set of conditions necessary to identify a finite-sample sequence $A_j$, which minimize the mean squared error between: (13)

$$A_j = \arg\min EXt - Xt.$$
Baxter and King proposed to use a finite MA(q) process of odd-order (q=2k+1), where the sequence of $A_j$ are obtained by imposing restrictions of symmetry and stationarity in the above mean squared error equation. The MA process is defined as:

$$14X_t=n=-qqAnYt-n=A0Yt+n=1qAn(Yt-n+Yt+n).$$

**Butterworth Filter**

On the basis of Butterworth digital filter, Pollock (2000) derived a finite-sample version of the filter in spirit with signal theory. Given a process $Y_t$, with trend and cyclical components the adapted form of Butterworth filter is defined as following:

$$15Y_t=trendt+cyclet=1-LdT1-Ln\delta t1-Ln-d\epsilon t.$$ 

**Kalman Filter**

Kalman defined a recursive method designed to update the mean and variance of the state variable. Harvey (1993) proposed the decomposition of a signal in trend, cycle and random elements and called the Kalman filter to estimate the cycle component. Given a state-space representation:

$$16Y_t=trendt+cyclet+\epsilon t;$$

$$trendt=trendt-1+\gamma t-1+\xi t;$$

$$\gamma t=\gamma t-1+\eta t;$$

$$cyclet=\alpha \cos t+\beta \sin t.$$ 

**Beveridge-Nelson decomposition**

For an ARIMA(p,d,q) representation of an integrated process, Beveridge and Nelson proposed a polynomial decomposition of the implied process in its trend and cyclical components:

$$17\Delta Y_t=\mu t+A(1)zt+A0Le t=trendt+cyclet,$$

where $\Delta zt=\epsilon t$, such $trendt=trendt-1+AL\epsilon t.$

**Hodrick-Prescott Filter**

Professors Hodrick and Prescott proposed to decompose the original signal process in a cyclical component and a smooth growth (trend component):
\[ 18 \text{cyclet}=Y_t-\text{trendt}=Y_t-j=J\sum_{j=1}^{J} \text{trendt}_j \]

\[ 19 \text{mintrendt0} t=1T \text{cyclet}+\lambda t=1T \text{trendt}_1-\text{trendt}-\text{trendt}-12, \]

where \( \lambda \) is the smoothness parameter and is set to 1600 for quarterly data.

**Wavelet Transformation**

Spectral theory analyses the composition of a signal process \( (Y_t) \) based on a sequence \( (X_f) \) consists of contributions of each frequency component \( (f) \) in explaining the original signal’s dynamics:

\[ 20 Y_t=12 \pi-\pi \pi X f e^{-i2\pi f t} d f. \]

Using Wavelet Transformation, the cycle component from a signal process \( Y_t \) is determined such as:

\[ 21 Y_t=\text{trendt}+\text{cyclet}=i=J+1 \sum_{i=1}^{J} \text{Ai}, t\text{t}+i=1 \sum_{i=1}^{J} \text{Di}, t, \]

where \( \text{Ai}, t \) and \( \text{Di}, t \) denotes detail coefficients at scale \( \lambda i \), \( J=\log 2 \text{n} \) and \( n \) is the length data.

**4. Data and Empirical results**

In this paper I the used final consumption expenditure series from Romania and Euro Area, available at EUROSTAT, expressed in volumes of millions of euro, chain-linked at reference year 2000 (at 2000 exchange rates). The data were seasonally adjusted and adjusted by number of working days, covering the period between 2000Q1-2011Q1. In the case of euro area, I used the restricted concept of 12 countries (EA12).

In order to achieve the assumed objectives, I considered the following economical mechanism as a framework for the analysis: EA12 is the main commercial counterparty for Romania such other countries from the Central and Eastern Europe zone; therefore, a drop in EA12’s aggregate demand (which consist also in a permanent downward shift in the EA12 consumption) will generate also a decrease in Romania’s exports to EA12 that will also determine a contraction in local economic activity, an increase of unemployment rate and a narrowing of local private consumption. Of course, this mechanism of negative shock propagation of Romanian consumption from the contraction of EA12 aggregate demand will take a while, but in this paper I consider an equilibrium mechanism. For this purpose, in the first ground I called an econometric approach designed to mimic the long-rung
relationship among the two underlined variables. Thus I used the cointegration approach of analyzing equilibrium mechanisms.

Table I. Johansen Cointegration test.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Eigenvalue</th>
<th>Trace statistics</th>
<th>P-value (0.05 level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Ct$,$RO$, $Ct$,$EA$</td>
<td>0.4860</td>
<td>31.90</td>
<td>0.078</td>
</tr>
</tbody>
</table>

Such As *Granger Representation Theorem* states that relationship between two cointegrated variables could be expressed such as an Error Correction Model (ECM), I act accordingly and estimated a ECM model with two lags for every variable:

$$
\Delta Ct\,RO = -0.0139 - 0.1879 \Delta ut−1 + 0.1083 \Delta Ct−1\,RO + 0.1645 \Delta Ct−2\,RO - 1.1837 \Delta Ct−1\,EA + 6.5036 \Delta Ct−2\,EA
$$

(0.2507) (0.0707) (0.5255) (0.3198) (0.2668) (0.0178)

From the above relation we could observe that error term (inserted in red) posts a negative coefficient, so the first difference of Romanian consumption tends to overshoot and also has to decrease in the every next period. Rather, in order to analyze the cyclical convergences between Romanian and EA’s consumption expenditures, first I extracted the cycles from analyzed data. As Canova (1998) noted, the statistical features of cyclical component are very sensitive to de-trending methods you involved. In accordance to this fact, I have engaged 14 techniques to extract consumption cycles, which are plotted bellow in figure 1. From an empirical view, it is notable that cycles for both Romanian and EA’s consumption expenditures post a very pronounced shape in during 2006Q2-2008Q2. In any case, it was underlined that variations recorded by Romanian filtered cycles are almost ten times higher than those ones of EA cycles.

**Figure 1. Evolution of Romanian’s consumption cycle between 2001Q1-2011Q1**

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1 We used the following abbreviations and specifications for engaged filtering techniques: Bk- Baxter –King filter with a lead/lag of order 3; CF- symmetric Christiano-Fitzgerald filter with a lead/lag of order 3; CF (Asym) – Asymmetric full length Christiano-Fitzgerald filter; Butterworth filter - n denotes the filter order; DB-Daubechies wavelet filter with 1, respectively 2 scale parameters.
For this purpose and taking into account the observation done by Canova, I employed a Principal Component Analysis (PCA) approach in order to return a common path of the 13 used filtering techniques. As compared with other many similar studies, in this paper we fitted a weighted moving average of the first three principal components, with the weights resulted from PCA approach. Therefore, for the rest of the analysis it was used the two resulted consumption cycles from PCA approach. But to achieve our central goal, I rather analyze the correlation between consumption cycles. In the table inserted below I reported basic statistical facts of the estimated cycles, namely standard deviations and linear correlation coefficient.

**Figure 2. Evolution of PC cycles between 2001Q1-2011Q1**

From the basic stats I observe that cycles estimated with PCA records a linear correlation of 73%. Comparison with results from other studies on Romanian business cycles such as Dumitru (2010) shows
a higher correlation for output-gaps of Romania and Euro Zone that means our estimations confirm the Backus-Kehoe-Kydland puzzle. But further research is needed to bring more information about this puzzle in Romanian case. In the very first stage, I analyze more deeply the real dependence existing between consumption cycles. Despite the large use of linear correlation in macroeconomics, this method is invariant to non-linear changes in analyzed variable.

Table II. Basic stats of the estimated cycles.

<table>
<thead>
<tr>
<th>HP</th>
<th>BK</th>
<th>CF</th>
<th>CF-Asym</th>
<th>Cosinus-Quadratic</th>
<th>Quadratic</th>
<th>Kalman</th>
<th>Beveridge-Nelson</th>
<th>Butterworth (n=2)</th>
<th>Butterworth (n=6)</th>
<th>Kolmogorov-Wiener</th>
<th>DB1</th>
<th>DB2</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.23</td>
<td>1.81</td>
<td>2.22</td>
<td>2.38</td>
<td>5.92</td>
<td>5.92</td>
<td>6.39</td>
<td>3.04</td>
<td>1.67</td>
<td>1.80</td>
<td>2.38</td>
<td>1.63</td>
<td>1.09</td>
<td>7.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Deviations for Romanian cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Deviations for EA cycles</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Linear Correlation Coefficient for Romanian and EA cycles</td>
</tr>
</tbody>
</table>

According to previous observation, in this paper I propose for the first time, in my knowledge, the use of Copula functions to estimate the dependence between business cycles. Copulas, which accounts for the non-linear changes in data, are defined by the following theorem:

**Sklar’s Theorem (1959).** *If F is a n-dimensional joint distribution function with the continuous marginal distributions \( F_1, \ldots, F_n \), then there exist a unique \( n \)-copula \( C [0,1]^n \rightarrow [0,1] \), such that \( F(\mathbf{u}) = C(F_1(\mathbf{u}_1), \ldots, F_n(\mathbf{u}_n)) \), \( \mathbf{u} = (u_1, \ldots, u_n) \).*

In this paper I modeled the marginal distribution with Hansen’s (1994) Skewed-T distribution, this being another new approach in business cycles analysis, after my knowledge.

Table III. Estimates of Copula dependence parameter and rank correlation coefficient.

<table>
<thead>
<tr>
<th>Copula function</th>
<th>Rank Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaussian</td>
<td>Kendall’s tau</td>
</tr>
<tr>
<td>Rotated-Gumbel</td>
<td>Spearman’s rho</td>
</tr>
<tr>
<td>Student</td>
<td>71.4</td>
</tr>
<tr>
<td>79.2</td>
<td>73.2</td>
</tr>
<tr>
<td>77.0</td>
<td>76.1</td>
</tr>
</tbody>
</table>

As it can be observed from Table III, there exists an important difference between linear correlation coefficient and dependence parameters estimated with Copulas. Additionally it was estimated the linear correlation coefficient using a periodic transformation of the rank correlation coefficient. Even with Copula advantages, a static measure of correlation is not sufficient in capturing a deeply view about the real dependence.
Even there is a difference between signs, the magnitude of correlations estimated with both GaussianCopula-GARCH model and BEKK(1,1) multivariate GARCH model was mainly situated between 70% and 80% and lower than linear correlation coefficient indicated. Also the previous two methods and cointegration relation from a VEC model underlined an increasing trend of dependence between Romanian and EA consumption cycles starting with 2006. But the correlation doesn’t necessarily imply causation between variables. In this sense, I complete the analysis engaged before with a study of how the cycle of EA consumption cause Romanian consumption.

Results of Granger Causality test indicate that EA consumption cycles cause, statistically significant, Romanian cycle with an order of two lags, this fact being also underlined by ECM model.

**5. Conclusions**

Analysis of cointegration showed a small value of adjustment for Romanian consumption to movements recorded by the evolution of EA consumption. As it was expected, Romanian consumption cycle was much more volatile than EA cycle. In comparison with results from other studies on Romanian business
cycles, there exists a higher correlation for output-gaps of Romania and Euro Zone than in the case of consumption cycles that means our estimations confirm the Backus-Kehoe-Kydland puzzle. From a technical view, in this paper I underline the necessity to use a large palette of statistical and econometric tools in order to capture a deep view on the dependence evolution, which is not directly observable information. For further research I propose also to run the same methods of analysis for other countries from Central and Eastern Europe and to compare their correlation to EA12 consumption cycles.

6. References


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