AN ECONOMIC GROWTH MODEL FOR AUSTRIAN ECONOMY BASED ON CO-INTEGRATION ANALYSIS

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Περίληψη

Η εργασία αυτή εξετάζει το βαθμό στον οποίο το επιτόκιο μεταξύ του εθνικού νομίσματος μιας χώρας και του αμερικανικού δολαρίου επηρεάζει την οικονομική ανάπτυξη μιας χώρας. Η επιλογή της χώρας βασίζεται στο γεγονός ότι στηρίζεται σε μεγάλο βαθμό στον τουρισμό και για τον λόγο αυτό τα συμπεράσματα για τη σχέση της συναλλαγματικής ισοτιμίας θα είναι πολύ χρήσιμα. Χρησιμοποιούμε το ΑΕΠ ως εξηρτημένη μεταβλητή και το λόγο δημόσιες δαπάνες προς ΑΕΠ, επιτόκιο, προσφορά χρήματος, και όρους εμπορίου ως ανεξάρτητες μεταβλητές. Για την εκτίμηση της συνάρτησης χρησιμοποιούμε την ανάλυση της συνολικής ισοτιμίας για την οικονομία της Αυστρίας για την περίοδο 1964Q1 -1991Q4.

Abstract

This study examines the extent in which the interest rate between the national currency of a country and U.S dollar affects this country’s economic growth. The selection of this country is based on the fact that it is largely tourism based, and so the inferences about the exchange rate behavior will be very useful. We use GDP as dependent variable and the ratio of government expenditure to GDP, interest rate, money supply and terms of trade as independent variables. The estimation of the function is based on co-
integration analysis. For this purpose we use quarterly data of the Austrian economy for the period 1964Q1 1991Q4.
1. Introduction

A great part of international literature has been developed and largely concerned with economic growth of both developed and developing countries. Many authors study the issue of economic growth under a different orientation and using a variety of models according to economic and econometric theory.

Bahmani-Oskoee (1985) studied the effect of devaluation in four developing countries: Greece, Korea, India and Thailand. With the exception of Thailand, his findings indicate that devaluation in the long-run deteriorates the trade balance. In Thailand he found the long-run effect of devaluation to be favorable.

Contrary to Bahmani-Oskoee, however, Himarios (1989) in his study of 15 developing countries, found that devaluation, in general, improves trade balance in the long-run.

The theoretical framework which is used as a basis for Turay (1995) study is a modified version of the Edward’s model (1985). The objective of this paper is to empirically analyze the impact of devaluation on the Chinese economy with an emphasis on output and the average annual growth rate on the basis of OLS method. Real GDP, money supply, planned money supply, terms of trade and real devaluation are used in Turay’s model.

Paleologos (1993) tries to evaluate the impact of the exchange rate policy toward the GDP for the Greek economy. Paleologos using GDP as dependent variable and nominal government expenditure to national income, nominal money supply, terms of trade and real exchange rate as dependent ones tries to examine the effectiveness of the Greek devaluation policy. This study also tests the variables’ stationarity using the augmented Dickey-Fuller (ADF) test.
Nwanna (1994) tries to examine empirically the effect of devaluation on economic development of Low Income Economies (LIEs) measured by short-term output growth using GDP, exchange rate, price level, expected price level and an index of real GDP in industrialized countries. The last one aimed at reflecting the impact of the economic activities of developed and industrialized countries and the effect of cyclical fluctuations in these economies on output growth. The regression equation is estimated using the 2SLS technique.

Nwanna (1996) study re-examines the issue of devaluation and growth on LDCs by focusing on an economy that is not agriculture-dependent as with previous studies, but rather largely dependent on tourism. Specifically, this study tries to examine the impact of devaluation on economic development of the Bahamas as measured by short-run output growth.

Buluswar, Thompson and Upadhyaya (1996) examine the effects of devaluation on the trade balance of India using the trade balance, domestic national income, foreign income and nominal money supply. They use augmented Dickey-Fuller test (ADF) to test the stationarity of the variables and Engle-Granger methodology in co-integration analysis.

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1 As defined by IMF and World Bank. GNP per capita of less than $480 (in 1987 U.S dollars)

2 Bangladesh, Burma, Nepal, Benin, Burundi, Gambia, Guinea, Madagascar, Mauritania, Niger, Rwanda, Sierra Leone, Haiti and Tongo. Common characteristic among those countries is that they are primarily agriculture dependent with per capita income (in 1987 prices) of $90-$320.

3 Using the same model as this in Nwanna (1994).
Upadhyaya and Dhakal (1997) examine the effect of devaluation in eight developing countries\(^4\) using stationary time series data and a distributed lag model, using the trade balance and real exchange variables, according to a different methodology proposed by Wickens and Breusch (1988).

Alba and Papell (1998) examine effective exchange rate determination and factors that affect domestic prices in three Southeast Asian countries: Malaysia, Philippines and Singapore from 1979 to 1995. They use the logs of the nominal effective exchange rate, the foreign prices, the foreign output and the domestic real interest rate to express the equilibrium in goods market of each country\(^5\).

In this study, we try to examine the relationship between economic growth and some economic indicators in Austria. For this purpose, we use the log of GDP (Ly) at constant prices as dependent variable to express the country’s economic growth. We also use the logs of money supply (Lm), terms of trade index (Ltt) and the ratio’s of government expenditures to GDP (Lge) as independent variables. We especially focus on positive effects of exchange rate between the national currency and U.S dollar on the country’s GDP, which is also used as independent variables. So, we use the Log of the Exchange Rate Index (Ler) to test these effects. Similarly, the effects of money supply and government expenditures are also expected to be positive according to economic theory. On the contrary, the sign of terms of trade is expected to be negative, since an increase of the variable is a result of either the increase of export prices (goods and services in Austria are more expensive) or a decrease of import prices (foreign

\(^4\)Colombia, Cyprus, Guatemala, Mexico, Morocco and Thailand.
goods and services are now less expensive). The base year for all variables is 1990. The sample period is from 1964Q1 to 1991Q4.

2. Unit root test

The cointegration test among the variables requires previously the test for the existence of unit root for each variable and especially for the money supply \( (Lm) \), the terms of trade index \( (Lt) \), the exchange rate index \( (Le) \), the ratio’s of government expenditures to GDP \( (Lge) \), and the GDP growth \( (Ly) \), using the augmented Dickey – Fuller (ADF) (1979) test and the Phillips-Perron (PP) test (1988), on the following regression:

\[
\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + u_t \quad (1)
\]

The ADF regression tests for the existence of unit root of \( X_t \), namely in the logarithm of all model variables at time \( t \). The variable \( \Delta X_{t-i} \) expresses the first differences with \( k \) lags and final \( u_t \) is the variable that adjusts the errors of autocorrelation. The coefficients \( \delta_0, \delta_1, \delta_2, \) and \( \alpha_i \) are being estimated. The null and the alternative hypothesis for the existence of unit root in variable \( X_t \) is

\[ H_0 : \delta_2 = 0 \quad H_e : \delta_2 < 0 \]

The results of ADF and PP tests for all variables appear in Table 1. The minimum values of the Akaike (AIC) (1973) and Schwartz (SC) (1978) statistics have provided the better structure of the ADF equations as well as the relative numbers of time lags. Although employing the Phillips-Perron test gives different lag profiles for the various time series, the main conclusion is qualitatively the same by Dickey-Fuller tests. In

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5 Foreign variables are weighted averages of each country’s trading partners prices, real income and interest rate. The weights are based on the volume of trade.
particular, the Philips-Perron test based on the 5 and 1 percent critical values supports the hypothesis that all series are stationary in their first differences.

Table 1. Tests of unit roots hypothesis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Augmented Dickey-Fuller</th>
<th>Phillips-Perron</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\tau_\mu$</td>
<td>$\tau_\tau$</td>
</tr>
<tr>
<td>$Lm$</td>
<td>-1.1675</td>
<td>-1.7240</td>
</tr>
<tr>
<td>$Ltt$</td>
<td>-1.4365</td>
<td>-2.2072</td>
</tr>
<tr>
<td>$Ler$</td>
<td>-1.5032</td>
<td>-2.3218</td>
</tr>
<tr>
<td>$Lge$</td>
<td>-1.2712</td>
<td>-1.9872</td>
</tr>
<tr>
<td>$Ly$</td>
<td>-1.0342</td>
<td>-1.6438</td>
</tr>
<tr>
<td>$\Delta Lm$</td>
<td>-3.1278*</td>
<td>-3.5748*</td>
</tr>
<tr>
<td>$\Delta Ltt$</td>
<td>-5.8976**</td>
<td>-11.6074**</td>
</tr>
<tr>
<td>$\Delta Ler$</td>
<td>-4.6527**</td>
<td>-7.0175**</td>
</tr>
<tr>
<td>$\Delta Lge$</td>
<td>-2.9453*</td>
<td>-3.5842*</td>
</tr>
<tr>
<td>$\Delta Ly$</td>
<td>-2.9134*</td>
<td>-3.5768*</td>
</tr>
</tbody>
</table>

Notes: $\tau_\mu$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is not included in the equation 1 and $\tau_\tau$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is included in the equation 1. The calculated statistics are those reported in Dickey-Fuller (1981). The critical values at 5% and 1% for N=100 are –2.89 and –3.51 for $\tau_\mu$ and –3.45 and –4.04 for $\tau_\tau$, respectively. The lag length structure of $\alpha_i$ of the dependent variable $X_t$ is determined using a recursive procedure in the light of a Lagrange multiplier (LM) autocorrelation test (for orders up to four), which is asymptotically distributed as chi-squared distribution and the value t-statistic of the coefficient associated with the last lag in the estimated autoregression. The critical values for the Phillips-Perron unit root tests are obtained from Dickey-Fuller (1981). **,* indicate significance at the 1 and 5 percentage levels.

The results of Table 1 suggest that the null hypothesis of a unit root in the time series cannot be rejected at a 5% level of significance in variable levels. Therefore, no time series appear to be stationary in variable levels. However, when the logarithms of the time series are transformed into their first differences, they become stationary and consequently the related variables can be characterized integrated order one, $I(1)$. Thus, both tests are in favor of the unit root hypothesis in all variables.

3. Cointegration and Johansen test
If the time series (variables) are non-stationary in their levels, they can be integrated with integration order 1, when their first differences are stationary. These variables can be cointegrated as well, if there are one or more linear combinations among the variables that are stationary. If these variables are being cointegrated, then there is a constant long-run linear relationship among them.

Since it has been determined that the variables under examination are integrated of order 1, then the cointegration test is performed. The testing hypothesis is the null of non-cointegration against the alternative that is the existence of cointegration using the Johansen (1988) maximum likelihood procedure, Johansen and Juselious (1990, 1992). An autoregressive coefficient is used for the modelling of each variable (that is regarded as endogenous) as a function of all lagged endogenous variables of the model.

Given the fact that in order to apply the Johansen technique a sufficient number of time lags is required, we have followed the relative procedure, which is based on the calculation LR (Likelihood Ratio) test statistic (Sims 1980). The results showed that the value $\rho=3$ is the appropriate specification for the above relationship. Further on we determine the cointegration vectors of the model, under the condition that Table 2 has an order $r<n$ ($n=5$). The procedure of calculating order $r$ is related to the estimation of the characteristic roots (eigenvalues), which are the following:

$$\hat{\lambda}_1 = 0.053 \quad \hat{\lambda}_2 = 0.068 \quad \hat{\lambda}_3 = 0.162 \quad \hat{\lambda}_4 = 0.318 \quad \hat{\lambda}_5 = 0.368$$
### Table 2 - Johansen and Juselious Cointegration Tests

**Variables**: Lm, Ltt, Ler, Lge, Ly  
**Maximum lag in VAR = 3**

<table>
<thead>
<tr>
<th></th>
<th>Eigenvalues</th>
<th>Critical Value</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>95%</td>
</tr>
<tr>
<td><strong>Null</strong></td>
<td><strong>Alternative</strong></td>
<td><strong>Eigenvalue</strong></td>
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<tr>
<td>r = 0</td>
<td>r = 1</td>
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<tr>
<td>r = 1</td>
<td>r = 2</td>
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<tr>
<td>r = 2</td>
<td>r = 3</td>
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</tr>
<tr>
<td>r = 3</td>
<td>r = 4</td>
<td>8.3406</td>
</tr>
<tr>
<td>r = 4</td>
<td>r = 5</td>
<td>6.4046</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Trace Statistic</th>
<th>Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Null</td>
<td>Alternative</td>
</tr>
<tr>
<td>r = 0</td>
<td>r &gt; 0</td>
<td>134.9580</td>
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<tr>
<td>r ≤ 1</td>
<td>r &gt; 1</td>
<td>80.7752</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>r &gt; 2</td>
<td>35.6365</td>
</tr>
<tr>
<td>r ≤ 3</td>
<td>r &gt; 3</td>
<td>14.7452</td>
</tr>
<tr>
<td>r ≤ 4</td>
<td>r &gt; 4</td>
<td>6.4046</td>
</tr>
</tbody>
</table>

*90%, 95% critical values Mackinnon (1991)*

The results that appear in Table 2 suggest that the number of statistically significant cointegration vectors is equal to 3 and are the following:

\[
Ly = -0.199Ler + 0.125Lm + 1.997Lge - 1.074Ltt \quad (a)
\]

\[
Ly = 0.098Ler + 0.238Lm + 2.065Lge + 0.956Ltt \quad (b)
\]
\[ L_y = -0.123L_r + 0.245L_m + 0.988L_{ge} - 1.156L_{tt} \quad (c) \]

According to the signs of the vector cointegration components and based on the basis of economic theory the relationship (a) can be used as an error correction mechanism in a VAR model.

4. The VAR model with a mechanism of error correction model

After determining that the logarithms of the model variables are cointegrated, we must estimate then a VAR model in which we shall include a mechanism of error correction model (MEC). The error-correction model arises from the long-run cointegration relationship and has the following form:

\[ \Delta L_{yt} = \text{lagged}(\Delta L_{yt}, \Delta L_{r,t}, \Delta L_{m,t}, \Delta L_{ge,t}, \Delta L_{tt,t}) + \lambda \text{ECT}_{t-1} + V_t \quad (3) \]

where \( \Delta \) is reported to all variables first differences

\( \text{ECT}_{t-1} \) are the estimated residuals from the cointegrated regression (long-run relationship)

\(-1 < \lambda < 0\) short-run parameter

\( V_t \) white noise disturbance term.
As it can be easily seen from the co-integrated vector above the signs of all the coefficients are as they expected to be. We can also observe that the value of the government expenditures’ coefficient is the highest, so it takes the longest weight for the long-run equilibrium relationship. Of course, the positive signs of the exchange rate (Ler), money supply (Lm) and government expenditures (Lge) are in agreement with the relative economic theory. We can infer that a probable devaluation of the national currency against U.S. dollar (increase of Ler) would have a positive effect on the country’s economic growth.

The final form of the Error-Correction Model was selected according to the approach suggested by Hendry, which is a “top-down” or “general to specific” approach (Maddala 1992). The initial order of time lag for the model is 3 quarters, because it is large enough to enclose the system’s short-run dynamic. We also apply a number of diagnostic tests on the residuals of the model. We apply the Lagrange test (A) for the residuals’ autocorrelation, the Heteroscedasticity test (D) and the Bera-Jarque (C) normality test. We also test the functional form of the model according to the Ramsey’s Reset test. Chow’s first and second tests check the model’s predictive ability. Finally, CUSUM and CUSUMQ tests are performed. The Error-Correction Model appears in table 3.

We do not reject the estimations, which are based on the results of table 3 according to the statistical and diagnostic tests. The percentage of the total variation of the dependent variable that is described in our model is high enough (58%). The Error-Correction Term (ECT) is statistically significant and has a negative sign, which confirms the long-run equilibrium relation between the independent and dependent
variables. Additionally, its relatively high value, 0.25 (-5.626) shows a satisfactory rate of convergence to the equilibrium state per period.

If we examine more carefully our model we see again the positive effect of the increase of the exchange rate of the national currency against dollar. If we consider Austrian economy as a tourism-based economy, we could say that a possible devaluation of the national currency would increase the net exports (especially via services relative to tourism) and of course the GDP of the country. However, government expenditures, as the coefficients show, play a very important role on the economic growth of the country too. Terms of trade are also of fundamental importance due to their high coefficient (0.453), and if we take under consideration that the terms of trade are affected by the exchange rate’s influence on export and import prices we can say that a devaluation or an appreciation of the national currency has a great impact on the country’s growth as it is measured by GDP.
Table 3. Error-Correction Model

\[ \Delta L_y_t = \gamma_{048} + 0.673 \Delta L_y_{t-1} + 0.059 \Delta L_{r_t} + 0.507 \Delta L_{m_t} + 0.482 \Delta L_{ge_t} - 0.250 \Delta L_{ge_{t-2}} - 0.453 \Delta L_{tt_{t-2}} - 0.249 ECT_{t-1} \]

\[ \begin{array}{cccccccc}
\text{Term} & \text{Coefficient} & \text{t-value} & \text{p-value} \\
\Delta L_y & 0.48 & (4.265) & 0.000 \\
\Delta L_{r_t} & 0.673 & (2.873) & 0.005 \\
\Delta L_{m_t} & 0.059 & (1.815) & 0.068 \\
\Delta L_{ge_t} & 0.507 & (1.750) & 0.083 \\
\Delta L_{ge_{t-2}} & 0.482 & (1.987) & 0.050 \\
\Delta L_{tt_{t-2}} & 0.250 & (2.373) & 0.020 \\
ECT_{t-1} & 0.249 & (-1.679) & 0.096 \\
\end{array} \]

\[ R^2 = 0.58 \]

\[ F(7,101) = 13.7239 \]

\[ DW = 2.188 \]

\[ A: X^2[4] = 8.132 \quad [0.438] \]

\[ B: X^2[1] = 1.5012 \quad [0.382] \]

\[ C: X^2[2] = 2.499 \quad [0.436] \]

\[ D: X^2[1] = 1.6213 \quad [0.391] \]

\[ E: X^2[9] = 4.7953 \quad [0.852] \]

\[ F: X^2[8] = 4.8267 \quad [0.776] \]

\( \Delta \): Denotes the first differences of the variables.

\( R^2 \): Coefficient of multiple determination adjusted for the degrees of freedom (d.f).

\( DW \): Durbin-Watson statistic.

\( F(n, m) \): F-statistic with n,m d.f respectively.

A: \( X^2(n) \) Lagrange multiplier test of residual serial correlation, following \( x^2 \) distribution with n d.f.

B: \( X^2(n) \) Ramsey’s Reset test for the functional form of the model, following \( x^2 \) distribution with n d.f.

C: \( X^2(n) \) Normality test based on a test of skewness and kurtosis of residuals, following \( x^2 \) distribution with n d.f.

D: \( X^2(n) \) Heteroscedasticity test, following \( x^2 \) distribution with n d.f.

E: \( X^2(n) \) Chow’s second test for predictive failure, following \( x^2 \) distribution with n d.f.

F: \( X^2(n) \) Chow’s first test of stability of the regression coefficients, following \( x^2 \) distribution with n d.f.

( ) = We denote the t-ratio for the corresponding estimated regression coefficient.

[ ] = We denote prob. Levels.

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Table 4. Forecasts 1992q1-1994q1

<table>
<thead>
<tr>
<th></th>
<th>1992 q1</th>
<th>1992 q2</th>
<th>1992 q3</th>
<th>1992 q4</th>
<th>1993 q1</th>
<th>1993 q2</th>
<th>1993 q3</th>
<th>1993 q4</th>
<th>1994 q1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δly</td>
<td>-0.069</td>
<td>0.145</td>
<td>0.026</td>
<td>-0.041</td>
<td>-0.100</td>
<td>0.123</td>
<td>0.089</td>
<td>0.019</td>
<td>-0.044</td>
</tr>
<tr>
<td>% Change</td>
<td>-1.1</td>
<td>2.3</td>
<td>0.4</td>
<td>-0.6</td>
<td>-1.6</td>
<td>2.0</td>
<td>1.4</td>
<td>0.2</td>
<td>-0.7</td>
</tr>
</tbody>
</table>

Table 5. Summary statistics for forecasts

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Mean Prediction Errors</td>
<td>-0.027</td>
</tr>
<tr>
<td>Mean Sum of Absolute Prediction Errors</td>
<td>0.045</td>
</tr>
<tr>
<td>Sum of Squares of Prediction Errors</td>
<td>0.002</td>
</tr>
<tr>
<td>Root Mean Sum of Squares of Prediction Errors</td>
<td>0.051</td>
</tr>
</tbody>
</table>

As we can see from table 4 there is a decline in Ly in both the first and the last quarter of the two years, that are predicted. More specifically, for year 1992 the decline in last quarter will be about half of the corresponding one in the first quarter. We also observe that in year 1993, although we will have a decline in the first quarter again, this decline will not be repeated (twice) in the last quarter of this year, but a quarter later. Additionally, in the second quarter of each of the years GDP will increase by the greatest rate.

From the results of Table 5 we infer that the model can make satisfied predictions besides those of the sample period. The positive impressions that the above prediction gives are the extension of satisfied performances of the model in prediction of economic growth. The remainder prediction statistics criteria are able to fill the positive figure of the model in its ability to predict.
5. Conclusion

The present study shows that economic variables, which influence the economic growth of Austrian economy, as measured by GDP, presented a unit root. So, on this basis we used Co-integration analysis and Error-Correction Model methodology in order to estimate short-run and long-run relations. The selected vector had as a result an Error Correction Term, which proved to be statistically significant when it was used in the short-run dynamic equation. Finally, we made forecasts for the Austrian economy (GDP) due to the predictive ability of the model.

References


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Abstract

Following Bahmani-Oskooee (1985), Himarios (1989), Paleologos (1993), Nwanna (1994-96) Turray (1995), Upadhyaya and Dhakal (1997) and Alba and Papell (1998) we try to find how some economic variables, which are strongly related with the trade balance of a country, affect the country’s economic growth. The purpose of this paper is to investigate the long-run and short-run relation between economic growth in Austria, as measured by GDP, and some economic indicators as exchange rate, government expenditures, money supply and terms of trade. We expect that all the economic variables, except terms of trade will have a positive effect on the country’s GDP. Forecasts for the country’s economic growth in a two-year period according to the estimated model’s predictive ability are also desirable. For this purpose, we use quarterly data for the period from 1964q1 to 1991q4. We also use Microfit 4.0 for Windows as an econometric analysis software in order to perform the necessary statistical tests.

First of all, we test our variables for the presence of a unit root using the Augmented Dickey-Fuller test (ADF), since if the variables are nonstationary may produce spurious results. Finding that variables are not stationary in levels, but in first differences, we try to find a linear combination of them which converges to a long run equilibrium relation. So, we use Co-integration analysis based on Johansen methodology. The co-integrated vector which arises from the procedure above confirms the long-run equilibrium relation between the variables. Using Hendry’s «general to specific» approach we select an Error-Correction Model in which Error-Correction Term is statistically significant and carries a negative sign as expected to be. The rest of the coefficients are also statistically significant, as expected to be, and carry the appropriate sign. In addition to all the above we perform autocorrelation, normality, functional form, heteroscedasticity, predictive failure, and regression coefficients stability test. We do not face any problem for every diagnostic test. Finally, we make forecasts for a two year-period due to the predictive ability of the Error-Correction model.