LABOUR PRODUCTIVITY, WAGES AND UNEMPLOYMENT:
AN EMPIRICAL INVESTIGATION FOR GREECE
USING CAUSALITY ANALYSIS

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Abstract

In this paper an effort is made in order to investigate the nexus of dynamic interrelations between the general macroeconomic environment of Greek economy with a special reference to the real wages determination. For the causality analysis among real wages, consumer price index, labour productivity, unemployment rate and gross domestic product a multivariate autoregressive VAR model was used, covering the period 1960:I until 2000:IV. Granger causality tests based on error correction models (ECM) showed that there is a ‘strong’ Granger causal relation among labour productivity, real wages, rate of unemployment and gross domestic product as well as between real wages and unemployment rate and also among unemployment rate, real wages and gross domestic product.

keywords: labour productivity, real wages, unemployment, error correction model, Granger causality

JEL C22, E24


Introduction

The initial formulation of the Phillips curve (1958) suggested the existence of a trade-off between inflation and unemployment through the decrease of aggregate demand. The initial equation related the nominal wage inflation to unemployment. The modern approach on the Phillips curve stems from Friedman (1968). He stated that since employees bargain over real wages, there could not exist a long-run trade-off between inflation and unemployment.

Algebraically Friedman’s theory starts from the following equation:

\[ w_t - p^e_t = w_{t-1} - p_{t-1} + \Delta prod + a - b_1 u_t \]

and results in the typical accelerationist Phillips curve:

\[ \Delta p_t = \Delta p_{t-1} + a - b_1 u_t \]

Inflation would be a function of unemployment and steady only if unemployment equals to the NAIRU (non accelerating increasing rate of unemployment), which is defined as follows:

\[ u^* = a / b_1. \]

The relation between real wages, unemployment, inflation, and productivity has been extensively investigated. One possible equilibrium relationship for the real wages is the following equation:

\[ (e-p) = b_{1} + b_{2} u + b_{3} prod + b_{4} \Delta e \]

The classical theory of the firm justifies the relationship between productivity and real wages. Insider-outsider models of wage bargaining would consider unemployment as non-significant \((b_2=0)\) except for the case that it was included in the objective function of the labour unions \((b_2<0)\). The relationship between inflation and real wages depends on the nature of the wage contracts. Especially, the wage indexation is regarded as one of the major causes of inflation and its retention.
Increases in real wages could lead to unemployment growth if firms financed the cost of these increases exclusively. The wages’ growth would increase the participation of the population in the labour force thus leading to unemployment growth even with a stable number of jobs.

Productivity affects unemployment through two different mechanisms: On one hand, an increase in productivity leads to a decrease in the demand for labour for a fixed output level. An increase in unemployment would lead to a decrease in the aggregate demand. On the other hand, an increase in productivity leads to a decrease in the cost of the production and lower product prices. These lower prices could boost the aggregate demand leading to an increase in employment. The above can be described by the following equation:

\[ u = b_1 + b_2(e-p) + b_3 prod \]

Traditional empirical studies of the wage equation have specified the rate of unemployment either as a determinant of the change in the wage rate (Phillips curve-effect) or as a determinant of the wage level (wage-curve effect). The Phillips curve specification can be based on the theoretical model of Phelps (1968), where the firm is assumed to set the wages. Knoester and Van der Widt (1987) derive a Phillips curve specification from a wage bargaining process. Usually the specification of the wage–curve is also described as an outcome of a wage bargaining process between employers and trade unions. Today labour economists tend to prefer the bargaining theory to Phelp’s theory of wage setting behavior by the firms, for the specification of the wage equation. That is why, from a theoretical perspective, there is some preference to have a wage-curve effect specified in the equation rather than a Phillips-curve effect (Blanchflower and Oswald 1994).
Shapiro and Stiglitz (1984) state that unemployment plays the role of a macroeconomic “discipline device” in order to induce employees to intensify their efforts in their job. They are based on the shirking models, where the firm, differentiating from the unemployment salaries, increases the dismissal cost for the employee, thus inducing him to intensify his effort.

Turunen (1998) presents disaggregated wage curve results by individual characteristics, occupations, industries and regions in the United States, using a panel data set of young workers. The results suggest that instead of a strong aggregate wage curve there are a number of different wage curves over time and for different workers groups. The slope of the aggregate wage curve varies over time, with the strongest wage curves appearing in the late 1980s. Wage curves exist for most labour market groups: the wages of the least educated, those in relatively low-skill occupations or service industries are most sensitive to changes in unemployment. Wages of government workers and those in the mining industry increase with unemployment.

Brayton, Roberts and Williams (1999) try to investigate if the Phillips curve is valid for the 90's where low inflation and low unemployment coexist. They use quarterly data from the period 1967 to 1998. They suggest that the Phillips curve cannot explain the low inflation during the last years. The degree of capacity utilisation gives the best results for the last years, but this does not appear in the total sample. They also provide evidence for a significant decrease in the NAIRU after 1995. Finally, they present an (error-correction) adjustment model of prices in conjunction with the long run trend unit labour cost.

Marcelino and Mizon (1999) examine the relationship between wages, prices, productivity, inflation and unemployment. In their paper quarterly data have been used for the period 1965(1) to 1993(1) for Italy, Poland and the UK. They apply a
cointegrated VAR model with regime shifts. They analyse the labour markets of these three countries and conclude that there have been significant changes in the structures of the relationships between wages-prices and unemployment-inflation for the period 1979/80. According to the qualitative results they suggest that although there have been some important changes in the labour markets of these three examined economies taking into account a greater degree of flexibility, there are no common characteristics among them. Indeed, this is rationale if someone takes into consideration the different starting points and policies followed in the three examined economies.

Chletsos, Kollias, and Manolas (2000) investigate the relationship between employment, growth rate, labour productivity and wages rate in the case of Greece for the period 1970-93. This period is divided into two sub-periods 1970-1980 and 1981-1993. In the first period they indicate that the employment level is positively related to the growth rate and wages rates are negatively related to the labour productivity. The reverse result is observed in the second period, which is characterized by the restructuring of the Greek economy.

Hsing (2001), based on the augmented Phillips curve and the autoregressive conditional heteroscedasticity model, studied the impact of the union wage increases to non-union wages and found that the growth of non-union wages is positively associated with the expected inflation productivity growth and negatively correlated with the unemployment rate.

Puhani (2002) estimates the changes in the Polish wage and unemployment structures between the years 1994 and 1998 in order to identify the labour market characteristics associated with increasing and decreasing relative demand as well as relative wage
rigidities. The evidence of his paper showed that the relative demand for workers with a low level of education has been decreased.

Broersma and Butter (2002) examine the influence of labour market flows on wage formation and they apply the Johansen multivariate cointegration analysis for Netherlands. The estimation results suggest the combination of the outflow from employment to unemployment and the outflow of vacancies as indicators of labour market tightness, qualifying for inclusion into the wages equation.

The aim of this paper is to investigate the causal relationship, which might exist between the examined variables, and to answer in the following causal hypothesis in order to get useful conclusions.

The examined causal hypotheses are the following:

- Do real wages cause consumer price index?
- Do real wages cause labour productivity?
- Do real wages cause unemployment rate?
- Do real wages cause gross domestic product?
- Does consumer price index cause real wages?
- Does consumer price index cause labour productivity?
- Does consumer price index cause unemployment rate?
- Does consumer price index cause gross domestic product?
- Does labour productivity cause real wages?
- Does labour productivity cause consumer price index?
- Does labour productivity cause unemployment rate?
- Does labour productivity cause gross domestic product?
- Does unemployment rate cause real wages?
- Does unemployment rate cause consumer price index?
Does unemployment rate cause labour productivity?

Does unemployment rate cause gross domestic product?

Does gross domestic product cause real wages?

Does gross domestic product cause consumer price index?

Does gross domestic product cause labour productivity?

Does gross domestic product cause unemployment rate?

The remainder of the paper proceeds as follows: Section 2 describes the data that are used in the causal relationship among real wages, the consumer price index, labour productivity, unemployment rate and gross domestic product, of the economy in Greece, as the specification of the model. Section 3 presents the results of unit root tests. Section 4 summarises the cointegration analysis and Johansen cointegration test. Section 5 analyses the error correction models. Finally, section 6 provides the final concluding remarks of this paper.

Data specification of the model

In order to test the causal relationship discussed above (introduction) we specify the following multivariate VAR model

\[ U = (WR, CPI, LP, UR, GDP) \]  

where

WR is real wages

CPI is consumer price index

LP is labour productivity

UR is unemployment rate

GDP is gross domestic product
Further, based on the results of the above set of causal hypotheses, the corresponding bi-directional hypotheses have to be examined.

To investigate the causal relationships in a vector autoregressive VAR model popularized by Sims (1980) we formulated the vector $U$ defined in equation (1). A unique advantage of the VAR model is that it treats each variable in the system as potentially endogenous and relates each variable to its own past values and to past values of all other variables included in the model.

Engle and Granger (1987) and Granger (1988) pointed out that a VAR model in levels with non-stationary variables may lead to spurious results and a VAR model in first differences with cointegrated variables is mis-specified. In the latter case, the error correction term, ECT, which represents the long run relationship between the variables is introduced again back into the VAR and the resulting model is known as the vector error correction model VECM.

A multivariate unrestricted VAR model (with the deterministic term) can be written as:

$$U_t = A_0 + A(L)U_t + e_t$$

where

$A(L) = [a_{ij}(L)]$ is a $5 \times 5$ matrix of the polynomial

$a_{ij}(L) = \sum a_{ij1}L^{m_{ij}}$

$m_{ij}$ is the degree of the polynomial

$A_0 = (a_{10} a_{20} a_{30} a_{40} a_{50})$ is a constant

$e_t$ is a $5 \times 1$ vector of random errors.

Model (2) can be rewritten as a VECM assuming there exists at least one cointegrating vector as follows:

$$\Delta U_t = A_0 + A(L)\Delta U_{t-1} + \delta EC_{t-1} + \mu_t$$

$$\Delta U_t = A_0 + A(L)\Delta U_{t-1} + \delta EC_{t-1} + \mu_t$$

$$\Delta U_t = A_0 + A(L)\Delta U_{t-1} + \delta EC_{t-1} + \mu_t$$
where

EC\textsubscript{t} is the error correction term

\( \mu_t \) is a 5 X 1 vector of white noise errors, \( E(\mu_t) = 0 \) and \( (\mu_t, \mu_{t-1}) = \Omega \), for \( t = s \) and zero otherwise.

After normalizing the cointegrating vector, the equation of real wages can be written as:

\[
\ln WR_t = \beta_1 \ln CPI_t + \beta_2 \ln LP_t + \beta_3 \ln UR_t + \beta_4 \ln GDP_t
\]

(4)

The error correction term obtained from equation (4) is:

\[
EC_t = \ln WR_t - \beta_1 \ln CPI_t - \beta_2 \ln LP_t - \beta_3 \ln UR_t - \beta_4 \ln GDP_t
\]

(5)

Finally, the equation of real wages in its detailed form for model (3) is written as:

\[
\Delta LWR_t = a_0 + \Sigma a_{1j} \Delta LWR_{t-j} + \Sigma a_{2j} \Delta CPI_{t-j} + \Sigma a_{3j} \Delta LLP_{t-j} + \Sigma a_{4j} \Delta LUR_{t-j} + \Sigma a_{5j} \Delta LGDP_{t-j} + \delta EC_{t-1} + \epsilon_t
\]

(6)

where \( EC_{t-1} \) represents the deviation from equilibrium in period \( t \) and the coefficient \( \delta \) represents the response of the dependent variable in each period to departures from equilibrium.

Granger (1988) pointed out that there are two channels of causality. One channel is through the lagged values of \( \Delta CPI, \Delta LLP, \Delta LUR \) and \( \Delta GDP \), i.e., \( a_{11}, a_{12}, \ldots, a_{im} \) are jointly significant, and the other is if \( \delta \) is significant. If \( \delta \) is significant in equation (6) then consumer price index, labour productivity, unemployment rate and gross domestic product, also causes real wages, through the second channel.

The data that are used in this analysis are quarterly, covering the period 1960:I-2000:IV regarding 1996 as a base year and are obtained from the database of OECD.
All data is expressed in logarithms in order to include the proliferative effect of time series and is symbolized with the letter L preceding each variable name. If these variables share a common stochastic trend and their first differences are stationary, then they can be cointegrated. Economic theory scarcely provides some guidance about which variables appear to have a stochastic trend and when these trends are common among the examined variables as well.

For the analysis of the multivariate time series that include stochastic trends, the augmented Dickey-Fuller (1979) (ADF) unit root tests are used for the estimation of individual time series, with intention to provide evidence about when the variables are integrated.

**Unit root tests**

Many macroeconomic time series contain unit roots dominated by stochastic trends as developed by Nelson and Plosser (1982). Unit roots are significant in examining the stationarity of a time series because a non-stationary regressor invalidates many empirical results. The presence of a stochastic trend is determined by testing the presence of unit roots in time series data. In this study, unit root test is tested using Augmented Dickey-Fuller (ADF) (1979, 1981).

Augmented Dickey-Fuller (ADF) test

The augmented Dickey-Fuller test (ADF) (1979) refers to the t-statistic of $\delta_2$ coefficient on the following regression:
\[ \Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + u_t \] (7)

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:

\[ \text{H}_0 : \delta_2 = 0 \quad \text{H}_e : \delta_2 < 0 \]

This paper follows the suggestion of Engle and Yoo (1987) using the Akaike information criterion (AIC) (1974), to determine the optimal specification of Equation (7). The appropriate order of the model is determined by computing Equation (7) over a selected nexus of values of the number of lags \( k \) and has been found that value of \( k \) at which the AIC attains its minimum. The distribution of the ADF statistic is non-standard and the critical values tabulated by Mackinnon (1991) are used.

Take in Table I

Table I presents the results of the ADF test of real wages, consumer price index, labour productivity, unemployment rate and gross domestic product. The results of ADF test are compared with critical values, which we have obtained from Mackinnon (1991) tables. The results of ADF statistic for the examined time series exceed the critical values, because the null hypothesis of a unit root is not rejected. Taking first differences renders each series stationary, with the ADF statistics in all cases being less than the critical value at the 1%, 5% and 10% level of significance.
Cointegration test

Following the maximum likelihood procedure of Johansen (1988) and Johansen and Juselious (1990), a p-dimensional \((p \times 1)\) vector autoregressive model with Gaussian errors is expressed by its first-differenced error correction form as:

\[
\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-1} + u_t \tag{8}
\]

where:

- \(Y_t\) is a \(p \times 1\) vector containing the variables.
- \(\mu\) is the \(p \times 1\) vector of constant terms.
- \(\Gamma_i = -I + A_1 + A_2 + \ldots + A_i\) (\(i = 1, 2, \ldots, p-1\)) is the \(p \times p\) matrix of coefficients.
- \(\Pi = I - A_1 - A_2 - \ldots - A_p\) is the \(p \times p\) matrix of coefficients.
- \(u_t\) is the \(p \times 1\) vector of the disturbance terms coefficients.

The \(\Pi\) matrix provides information about the long-run relationship between \(Y_t\) variables whereas the rank of \(\Pi\) is the number of linearly independent and stationary linear combinations of variables studied. Thus, testing for cointegration involves testing for the rank \(r\) of \(\Pi\) matrix by examining whether the eigenvalues of \(\Pi\) are significantly different from zero. Johansen (1988) and Johansen and Juselious (1990) propose two test statistics for testing the number of cointegrating vectors (or the rank of \(\Pi\)) in the VAR model. These are the trace (\(Tr\)) test and the maximum eigenvalue (\(L-max\)) test. The likelihood ratio statistic for the trace test is:

\[
-2 \ln Q = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i) \tag{9}
\]
where $\hat{\lambda}_{r+1}, \hat{\lambda}_p$ are the estimated $p - r$ smallest eigenvalues. The null hypothesis to be tested is that there are the most $r$ cointegrating vectors. That is, the number of cointegrating vectors is less than or equal to $r$, where $r$ is 0, 1, or 2… and so forth. In each case, the null hypothesis is tested against the alternative.

Alternatively, the $L$-max statistic is:

$$-2 \ln Q = -T \ln(1 - \hat{\lambda}_{r+1})$$  \hspace{1cm} (10)$$

In this test, the null hypothesis of $r$ cointegrating vectors is tested against the alternative hypothesis of $r+1$ cointegrating vectors. Thus, the null hypothesis $r = 0$ is tested against the alternative that $r = 1$, $r = 1$ against the alternative $r = 2$, and so forth. It is well known the cointegration tests are very sensitive to the choice of lag length. The Schwarz Criterion (SC) and the likelihood ratio test are used to select the number of lags required in the cointegration test.

Take in Table II

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

$$LRW = 2.5554 \text{LCPI} + 2.4613 \text{LLP} + 0.0801 \text{LUR} - 1.4269 \text{LGDP}$$ \hspace{1cm} (11)$$

$$LRW = 6.7936 \text{LCPI} + 7.0409 \text{LLP} - 0.00118 \text{LUR} + 5.7755 \text{LGDP}$$ \hspace{1cm} (12)$$

$$LRW = -1.8216 \text{LCPI} - 3.2813 \text{LLP} + 0.17942 \text{LUR} + 3.0230 \text{LGDP}$$ \hspace{1cm} (13)$$
According to the signs of the vector cointegration components and based on the basis of economic theory relationship (12) can be used as an error correction mechanism in a VAR model.

**A VAR model with an error correction mechanism**

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 (equation 3) is used to investigate the causal relationships among the variables real wages, consumer price index, labour productivity, unemployment rate and gross domestic product. Such analysis provides the short – run dynamic adjustment towards the long – run equilibrium. The significance levels of the F – statistics for the lagged variables and the t – statistics for the coefficient $\delta$ of $EC_{t-1}$ are used to test for Granger causality. The numbers in parentheses are the lag lengths determined by using the Akaike criterion.

As discussed earlier in section 2, there are two channels of causality Granger (1988). These are called channel 1 and channel 2. If lagged values of a variable (except the lagged value of the dependent variable) on the right hand side in equation 3 are jointly significant then this is channel 1. On the other hand, if the lagged value of the error correction term is significant, then this is channel 2. The results are summarized in table III.

Take in Table III
For convenience in discussing the results, let us call the relationships a “strong causal relation” if it is through both channel 1 and channel 2 and simply a “causal relation” if it is through either channel 1 or channel 2.

From the results of table III we can infer that coefficient $\delta$ is statistically significant only in case we use as an endogenous variable real wages, the unemployment rate and gross domestic product. In this case we have channel 2 which means that the consumer price index, labour productivity, unemployment rate and gross domestic product affect real wages, consumer price index, labour productivity, real wages and gross domestic product have an effect on unemployment rate as well as consumer price index, labour productivity, unemployment rate and real wages affect gross domestic product. Furthermore, the coefficients of lagged variables are statistically significant in the case where all the variables that are examined in the model are used as endogenous variable (channel 1).

The results of table IV present causality test through these channels:

**Take in Table IV**

From the results of Table IV we can infer that there is a “strong Granger causal” relation between real wages and unemployment rate, as well as between consumer price index and real wages, between consumer price index and unemployment rate, between labour productivity and real wages, between labour productivity and unemployment rate and finally between labour productivity and gross domestic product. The relation between unemployment rate and real wages, between unemployment rate and gross domestic product as well as between gross domestic product and real wages, and also gross domestic product and unemployment rate is “strong Granger causal” relation. Finally, the relation between wages and consumer
price index, between wages and gross domestic product, consumer price index and gross domestic product, between unemployment rate and consumer price index, between unemployment rate and labour productivity and also between gross domestic product and consumer price index is simply a “causal relation” as well.

Concluding remarks

In this paper an effort was made in order to examine the role of labour productivity, real wages, consumer price index, unemployment rate and gross domestic product in one of the member states of the European Union, Greece, through the analysis of multivariate causality based on an error correction model. For the empirical testing of the above variables, we used the Johansen cointegration test and then continued with Granger causality tests based on a vector error correction model. The results of the cointegration analysis denote the presence of three cointegration relationships among variables from which only one is used as an error correction in VAR model according to the signs and also according to the economic theory that the components of vector cointegration have. This indicates the presence of a common inclination or of long-run relations among these variables.

The results of causality analysis show that labour productivity cause real wages, unemployment rate and gross domestic product and this causality is characterized as ‘strong causal’ relationship and the same happens with real wages and unemployment rate, whereas with real wages that cause consumer price index and gross domestic product the causality is characterized as ‘simple causal’ relationship.

Since the hypotheses set at the beginning of this paper have been answered, as a final concluding remark we can infer that the impact of labour productivity and that of real
wages is very prominent in the general macroeconomic environment and also in the Greek economy.

Notes

1. The specification of a multivariate equation in a causality analysis is a major departure from the bivariate equations that have been widely used in the literature to examine the causal relationships. The bivariate studies have been considered to suffer from specification error.
2. Cooley and LeRoy (1985) have criticized the VAR, being a system of unrestricted reduced form equations. See also Runkle (1987) for the controversy surrounding this methodology. However all agree that there are important uses of the VAR model.
References


Table I. Tests of unit roots hypothesis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Augmented Dickey-Fuller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\tau_{M}$</td>
</tr>
<tr>
<td>LRW</td>
<td>-0.87191</td>
</tr>
<tr>
<td>LCPI</td>
<td>-0.32773</td>
</tr>
<tr>
<td>LLP</td>
<td>-1.7637</td>
</tr>
<tr>
<td>LUR</td>
<td>-1.2580</td>
</tr>
<tr>
<td>LGDP</td>
<td>-0.27394</td>
</tr>
<tr>
<td>$\Delta$LRW</td>
<td>-2.6713*</td>
</tr>
<tr>
<td>$\Delta$LCPI</td>
<td>-3.5531**</td>
</tr>
<tr>
<td>$\Delta$LLP</td>
<td>-4.1745***</td>
</tr>
<tr>
<td>$\Delta$LUR</td>
<td>-8.9237***</td>
</tr>
<tr>
<td>$\Delta$LGDP</td>
<td>-6.7626***</td>
</tr>
</tbody>
</table>

Notes: $\tau_{M}$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is not included in equation 2 and $\tau_{t}$ is the t-statistic for testing the significance of $\delta_2$ when a time trend is included in equation 2. The calculated statistics are those reported in Dickey-Fuller (1981). The critical values at 1%, 5% and 10% are –3.61, -2.94 and –2.60 for $\tau_{M}$ and –4.21, -3.53 and –3.19 for $\tau_{t}$ respectively.

The lag-length structure of $a_t$ of the dependent variable $x_t$ is determined using the recursive procedure in the light of a Langrange 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.

***, **, * Indicate significance at the 1, 5 and 10 percentage levels.

Table II. Cointegration tests based on the Johansen and Johansen and Juselious approach (LRW, LCPI, LLP, LUR, LGDP VAR lag = 5)

<table>
<thead>
<tr>
<th>H0: $r$</th>
<th>Trace test</th>
<th>5% critical value</th>
<th>10% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r = 0$</td>
<td>61.0702</td>
<td>34.4000</td>
<td>31.7300</td>
</tr>
<tr>
<td>$r \leq 1$</td>
<td>35.2367</td>
<td>28.2700</td>
<td>25.8000</td>
</tr>
<tr>
<td>$r \leq 2$</td>
<td>23.5339</td>
<td>22.0400</td>
<td>19.8600</td>
</tr>
<tr>
<td>$r \leq 3$</td>
<td>9.0053</td>
<td>15.8700</td>
<td>13.8100</td>
</tr>
<tr>
<td>$r \leq 4$</td>
<td>5.2760</td>
<td>9.1600</td>
<td>7.5300</td>
</tr>
</tbody>
</table>

Notes:
- Critical values are taken from Osterwald – Lenum (1992).
- $r$ denotes the number of cointegrated vectors.
- Schwarz Criteria (SC) was used to select the number of lags required in the cointegration test. The computed Ljung – Box Q – statistics indicate that the residuals are white noise.

Table III – Causality test results based on vector error – correction modeling

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>F – significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F_{EC_t-1}$</td>
</tr>
<tr>
<td>$ALWR$</td>
<td>0.107(2) 0.000(2)***</td>
</tr>
<tr>
<td>$ALCPI$</td>
<td>0.025(1)** 0.063(2)*</td>
</tr>
<tr>
<td>$ALLP$</td>
<td>0.245(2) 0.145(3)</td>
</tr>
<tr>
<td>$ALUR$</td>
<td>0.011(3)** 0.044(3)**</td>
</tr>
<tr>
<td>$ALGDP$</td>
<td>0.147(2) 0.287(1)</td>
</tr>
</tbody>
</table>

Notes: *, **, and *** indicate 10%, 5%, and 1% levels of significance. Number in parentheses is lag length.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Channels</th>
<th>Causal</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR → CPI</td>
<td>1</td>
<td>Causal relation</td>
</tr>
<tr>
<td>WR → LP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WR → UR</td>
<td>1, 2</td>
<td>Strong causal relation</td>
</tr>
<tr>
<td>WR → GDP</td>
<td>2</td>
<td>Causal relation</td>
</tr>
<tr>
<td>CPI → WR</td>
<td>1, 2</td>
<td>Strong causal relation</td>
</tr>
<tr>
<td>CPI → LP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI → UR</td>
<td>1, 2</td>
<td>Strong causal relation</td>
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