A CAUSAL RELATIONSHIP BETWEEN INFLATION AND
PRODUCTIVITY: AN EMPIRICAL
APPROACH FOR ROMANIA

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Abstract

This paper attempts to analyze the relationship between the productivity and
the inflation for a transition country of European Union as Romania. For this
purpose we use quarterly data from 1990:IV to 2003:I and the causality analysis,
which is based on an error correction model. The results of the empirical analysis
showed that there is a causal relationship between inflation and productivity in
Romanian economy.

key words: productivity, inflation, Granger causality, cointegration, error correction
models, Romanian economy.

JEL Classification A10, C22

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The starting point for the transition process in Romania was more difficult than in other countries in Central and Eastern Europe. Pre-transition policies emphasized self-dependence, putting excessive focus on heavy industry and large infrastructure projects. This strategy led to the depletion of domestic energy sources and induced costly dependence on imports of energy and raw materials. During 1980s there was no growth in exports in order to repay the debt imports from the West. The technological lag increased significantly as a result. Towards the end of the 1980s the Romanian economy was on the verge of collapse and, unlike other transition economies, no attempts to reform had yet been tried.

Given this difficult legacy, the dominant political forces in place since the early 1990s advocated a gradualist approach, seeking to minimize the social costs associated with the transformation to market. The 1993 OECD Assessment of the Romanian economy pointed out clearly the risks associated with the delaying structural reforms. A key point in the Assessment was that, without deep restructuring of the economy, macroeconomic stabilization could not be sustained. Therefore, since 1993 the boost in exports and the apparent success in reducing inflation under the stabilisation policy of Romanian economy were noted.

The Seville European Council (1996) encouraged Romania to pursue its efforts for accession in European Union and also reiterated its commitment to provide full support to this candidate country.

Romania is expected to join the European Union on the basis of the same economic and political criteria that had been set by the Copenhagen and Madrid
European Councils (1993, 1995) as well. As confirmed by the Laeken European Council (2001) the accession process is now irreversible.¹

The European Commission recommended, on the basis of Copenhagen criteria, that Romania shouldn’t be included in the first group of countries with whom negotiations should be opened. Finally, Romania was invited at the Helsinki summit meeting in December 1999 to start negotiations for membership. The substantive negotiations started in March 2000.²

Romania on the basis of last Regular Report of European Union fulfills the political criteria as defined by Copenhagen European Council (1993). However, Romania still needs to improve legislative and decision making processes, while judiciary reforms should be made political priority. The government’s policy supports the institutions of human rights and protection of local minorities. Important steps were taken to implement the National Strategy for improving the Condition of Roma. Romania has continued to make progress towards being a functioning economy with competitive market. Sustained and full implementation of planned measures together with the completion of the reform agenda should allow Romania to be able to cope with competitive pressure and market forces within the Union in the medium term.³

The historic decision adopted by EU at Helsinki meeting in December 1999 to include Romania in the group of candidate countries, signifies that Romania has moved to a new stage of its European integration process.4

Economic integration is to be facilitated by bringing new opportunities for trade, and as the economic environment becomes more attractive, by increasing foreign direct investment inflows. To this end, “Europe Agreement” provides the chance to Romania to have easier access in the economies of the European Union’s member states.

European Commission has specified the following prerequisites before Romania can pave a solid way to EU accession. Firstly, macroeconomic stability, without which there cannot be sustainable growth, is essential and secondly, inflation reduction in the level of 2% on the basis of the “Europe Agreement”. Trade liberalization and exports growth in agricultural and industrial products consist the main target for economy restructuring. The abolition of tariff barriers allows the foreign direct investments growth to the domestic market.

Romania has concluded free-trade agreements with the European Union, EFTA, CEFTA, Moldova, and Turkey. The basic principles of the agreement between Romania and European Union are:

- trade liberalization
- elimination of quantitative restrictions on imports
- elimination of quantitative restrictions on exports

Romania’s commercial relations with the EU became predominant beginning in 1995. The share of exports to EU countries in the total Romanian exports increased from 33.9% in 1990 to 65.5% in 1999. The same trend was

4 In Easter and Central Europe, Slovenia, the Czech Republic, Hungary, Poland and Estonia were chosen as the
registered for Romanian imports from EU countries, whose share in total Romanian imports was 55.1% in 1999 compared with 21.8% in 1990. Among the candidate countries in 1999 (including Turkey, Cyprus and Malta), Romania was both the sixth largest destination for exports and the sixth largest source of imports in Europe.

The status of Romania as an EU candidate country should enhance its attractiveness to foreign investors. Gross Domestic Product was 7.3% in 1997 and next year declined to 6.6%\(^5\). The Copenhagen European Council (2002) set 2007 as final date of accession to EU for Romania as full member.

While output continued to grow in 1996 fiscal policy was derailed under the impact of a largely unrestructured economy. The official budget deficit was increased by quasi-fiscal items, such as the National Bank of Romania (NBR) refinancing of credits to the agricultural sector. This slippage resulted from pre-election policies in support of output and demand and a pervasive lack of financial discipline in large state-owned companies. With rapid growth of the money base, inflation accelerated readily in such a point that World Bank halted their financial support.

2. Theoretical and empirical approaches

Inflation is always a monetary phenomenon, and productivity is a purely real occurrence. But upon reflection, we may reasonably think that inflation or at the least things associated with it must matter for firms ability to improve their

productivity. In considering a link between inflation and productivity there are two possible causal directions: productivity affects inflation or inflation affects productivity. The first generally has higher productivity allowing cost reductions that flow through to product prices and thereby reduce inflation. Higher productivity growth thus represents a positive supply shock that lowers inflationary pressures. The second effect posits that inflation affects productivity growth. From first principles, prices matter because they are a highly efficient means of transmitting the myriad of individual demand and supply decisions that occur throughout the economy (Bulman and Simon 2003). In an inflationary environment, the price mechanism loses its efficiency. It seems plausible then, that when prices are changing frequently, firms may find it more difficult to distinguish an increase in the relative scarcity of their inputs from an across the board increase in prices. Similarly, the reduced certainty brought about by inflation increases the risk of entrepreneurial errors and would potentially induce lower levels of investment. This would all lower the overall productivity of the firm.

Early research into the inflation-productivity nexus was stimulated by the experience of high inflation of the 1970s and the subsequent fall in productivity growth. Most of the literature has debated the statistical question of whether the data support any relationship, and if so, the causal direction. Minimal work explores the theoretical side, or how inflation may be transmitted into slower productivity growth and vice versa. The view was a little circumspect about the nature of any relationship between productivity growth and inflation. Nonetheless, both Keynesian and neoclassical theory suggest a negative relationship (Lucas 1973). It is recognized that inflation has adverse effects on macroeconomic variables such as output and productivity growth (Bitros and Panas 2001, Dritsakis 2003).
Gillman, Harris and Matyas (2004) use a monetary model of endogenous growth and based on a panel of OECD and APAC countries using annual data for the period 1961-1997, they found that there is a negative effect of inflation and productivity for these countries.

US data over the period 1948 – 1981 demonstrate a similar correlation, with causation running one-way from higher inflation to slower productivity growth (Clark 1982, Buck and Fitzroy 1988, Saunders and Biswas 1990). Methodologically, these studies apply Granger-type causality test to OLS (Clark 1982, Ram 1984) or Full Information Maximum Likelihood (Jarret and Selody 1982) estimations.

Gillman, and Nakov (2003) investigate the causal relationship between inflation and growth in two accession countries of EU, Hungary and Poland. Using exogenous variables such as money supply they concluded that there is a causal relationship with direction from money to inflation and from inflation to growth for both accession countries.

Jarrett and Selody (1982) proposed two rationales for this occurrence: that the tax system’s lack of neutrality during periods of inflation increases the private sector’s tax burden, and that inflation’s increasing variance with higher levels of inflation would cause sub-optimal resource allocations and increase the probability of entrepreneurial error, hence reducing investment. Using 1963-1979 Canadian data, Jarrett and Selody found a bi-directional relationship, with the rise in inflation explaining nearly the entire slowdown in productivity growth.

Another group of papers took up the debate in the mid 1990s. These had the advantage of being able to observe the productivity growth inflation relationship
after the 1980s’ disinflation, and also draw on the experience of a wider range of G7 economies.

Smyth (1995a, 1995b) using annual data for the period 1951-1991 for Germany and 1955-1990 for USA respectively, suggested that there is not any causal relationship between productivity and inflation for both examined countries. Chowdhury and Mallik (1998) resulted in the same conclusion in their research for Australia and New Zealand, and also Cameron, Hum and Simpson (1996) in their research for USA, United Kingdom, Kanada, West Germany.

A further group of papers is skeptical of any inflation productivity growth relationship. These papers take two tacks. One approach is to argue that the results show that the business cycle drives simultaneous variations in both productivity growth and inflation, not a long run relationship (Sbordone and Kuttner 1994, Freeman and Yerger 1997, 2000). The stylized facts have productivity growth peaking ahead of the business cycle, with inflation then accelerating. In response, the monetary authorities increase interest rates, thus slowing output growth hence productivity growth through the effects of labour hoarding. Inflation’s slow-down lags that of the real economy. Thus, an appropriate model of the productivity growth inflation relationship must absorb the business cycle through variables such as real interest rates, the output gap, or variations in GDP growth.

The other critique argues the statistical point that productivity growth and inflation have different orders of integration (Sbordone and Kuttner 1994, Cameron, Hum and Simpson 1996, Tsionas 2001, 2003). These studies claim inflation is non-stationary while productivity growth is stationary, and therefore there cannot be a long run relationship. Almost all the paper run Granger causality tests, or a close relative, VAR models. There does appear to be a relationship between productivity
growth and inflation, and where it is determinable, the causality appears to flow from inflation to productivity growth.

This paper tries to investigate the direction of causality between inflation and productivity in Romania. It seems that this country has the most problems from all the other countries in transition, and that’s the reason why we chose it. In the empirical analysis we used quarterly data for the period 1990:IV to 2003:I for the variables used. The remainder of the paper proceeds as follows: Section 1 is referred to the economic evolution of Romania during its transition period until to the decision of European Union in order to be a candidate accession country. Section 2 employs with the theoretical and empirical approaches. The variables data with the methodology of VAR model are presented in section 3 of this paper. Section 4 applies the Dickey-Fuller and Phillips Perron tests and investigates the stationarity of the used data. The analysis of cointegration between the used variables is implied in section 5. Section 6 reports the estimations of error correction models, and deploys the Granger causality tests. Final, section 7 presents the conclusions of this study.

3. Data and Methodological Issues

In order to test the causal relationship between the price level and the productivity of Romania, we use the following VAR model:

\[ U = (CPI, PROD) \]  

(1)

where:
CPI is the price level

PROD is the productivity

The data which are used in this investigation are quarterly, covering the period from 1990:IV to 2003:I and are derived from the databases of OECD (Main Economic Indicators), International Monetary Fund (IMF), and Datastream regarding 1995 as a base year.

All data are expressed by logarithms in order to include the proliferative effect of time series and are symbolized with the letter L preceding each variable name while Δ denotes the first differences of these variables.

If these variables share a common stochastic trend and their first or second differences are stationary, then they can be cointegrated. Economic theory scarcely provides some guidance for which variables appear to have a stochastic trend and when these trends are common among the examined variables as well.

Initially, a bivariate VAR model of prices and productivity is estimated. Then, a four variable VAR model is introduced in order to account for potential influences of cyclical factors and changes in monetary policy on the price level-productivity relationship, two variables the real gross domestic product and the interest rate were added.

In order to test the existence of the statistical relationship among the examined variables, we pursue the following steps:

The first step is to verify the order of integration of the variables, since the causality tests are valid if the variables have the same order of integration. For the integration of these variables we used ADF test (Dickey- Fuller 1979, 1981) and PP test (Phillips – Perron 1988).
The second step involves testing for the existence of cointegration between the price level and the productivity level by using the Engle – Granger (1987) method, the error correction model and the Johansen maximum likelihood approach (Johansen 1988, Johansen and Juselius 1990, 1992).

The Engle-Granger method is based on residuals cointegration test. The error correction model is employed to test directly for cointegration between the two variables by examining the significance of the lagged level of the dependent variable. Two additional variables are introduced in order to account for changes in real output and monetary policy. In this multivariate framework the cointegration test is applied by using Johansen and Juselious approach, which is based on the error correction representation of the VAR(p) model in conjunction with Gaussian errors model. This method tests for all numbers of cointegrated vectors between the variables. It uses all variables as endogenous ones, thus avoiding an arbitrary choice of the dependent variable. Finally, it provides a unified framework for the estimation and the cointegrated relations test within the framework of the vector error correction model.

Evidence of cointegration rules out the possibility of the estimated relationship being spurious. As long as the four variables have a common trend, causality in the Granger sense, and not in the structural sense, should exist in at least one direction. Although cointegration implies the presence of Granger causality, it does not necessarily identifies the direction of causality between variables. This Granger causality can be captured through the vector error correction model derived from the long-run cointegrating vectors (Granger 1986, 1988).

Thus, the third step involves utilization of the vector error correction model for testing the causality among the model variables. Engle-Granger (1987) claim that in the presence of cointegration, there always exists a corresponding error correction
representation, which implies that changes in the dependent variable are a function of the level of imbalance in the cointegrated relationship captured by the error correction term (ECT). Thus, through the error correction term (ECM), model VECM establishes an additional way to examine the Granger causality. The non-significance of ECT is referred to as a long-run non-causality. The absence of short-run causality is established by the non-significance of the sum of the lags of each explanatory variable. Finally, the non-significance of all the explanatory variables including the ECT term in the VECM indicates the absence of Granger causality.

4. Data stationary tests

To examine the stationarity of the mentioned variables of the above model (1), we have used the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests (1979, 1981), but also Phillips-Perron (1988) (PP) test. The results of these tests appear in Table 1. The minimum values of the Akaike (AIC) (1973) and Schwartz (SC) (1978) statistics indicated that the ‘best’ ADF equations were those including an intercept and trend and the corresponding numbers of lagged terms. As far as the autocorrelation disturbance term test is concerned, the Lagrange Multiplier LM(4) test has been used.

INSERT TABLE 1

The results of Table 1 suggest that the null hypothesis of a unit root in the time series cannot be rejected in variable levels at a 1%, 5% and 10% levels of significance. Therefore, no time series appear to be stationary in variable levels.
When the time series are transformed into first differences they become stationary and consequently the related variables can be characterized integrated of order one, i.e. they are I (1). Moreover, for all variables the LM(4) test first differences shows that there is no serial correlation in the disturbance terms.

5. Cointegration test

In this section, by applying the Engle-Granger (1987) method and estimating the error correction model, it has been examined if there is any cointegration relationship between the productivity and the price level in the examined country since these two variables are integrated of order one.

The results of cointegration analysis using the Engle-Granger method and an error-correction model are presented in Table 2 testing for the significance of the coefficient of lagged level of the dependent variable. The results suggest that the hypothesis of no cointegration for the two variables, namely the price level and the productivity, is rejected.

INSERT TABLE 2

Then in order to investigate the effects on the real production and also on the monetary policy, two more variables are added to the VAR model, namely the gross domestic product and the interest rate. The results of cointegration analysis of the four variables using the Johansen maximum likelihood approach are presented in table 3.
This approach tests for the number of cointegrated vectors among the examined variables. Further, this approach uses all the variables as endogenous ones, thus avoiding the arbitrary choice of the dependent variable. Finally, it provides a unified framework for the estimation and the test of cointegrated relationships within the framework of the vector error correction model.

**INSERT TABLE 3**

Given the fact that in order to apply the Johansen approach 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 $\rho=2$ is the appropriate specification for the above relationship. In addition, each equation of the VAR system passes a series of diagnostic tests including serial correlation, ARCH(4), normality and heteroskedasticity tests.

Table 4 reports the specification tests for the VAR (4) system. The tests do not reveal any misspecification except the rejection of normality for price level and interest rate. From the above results we can infer that there is a long run relationship among the price level, the productivity, the real production, the interest rate for Romania for the examined period. Therefore, the above relationships can be used as an error correction mechanism in the VAR model.

**INSERT TABLE 4**

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

\[ \Delta LCPI_t = \text{lagged}(\Delta LCPI_t, \Delta LPROD_t, \Delta LGDP_t, \Delta LINTER_t) + \lambda u_{t-1} + V_t \quad (5) \]

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

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

and represent the deviation from the equilibrium in the time period \( t \).

\(-1<\lambda<0\) is the short-run parameter which expresses the response of the dependent variable in every period which starts from the equilibrium state.

\( V_t \) is a 4X1 vector of white noise errors.

Granger (1988) suggested that there are two channels of causality, the first one is obtained through the lagged variables (\( \Delta LPROD, \Delta LGDP, \Delta LINTER_t \)), when the coefficients of all these variables are statistically significant (F-distribution) and the second channel is raised in case the (\( \lambda \)) coefficient of the variable \( u_{t-1} \) is statistically significant (t-distribution). If \( \lambda \) is statistically significant in equation (5) productivity, real gross domestic product and interest rate effect on the price level.

INSERT TABLE 5
The error correction model (equation 5) is used to investigate the causal relationships among the model variables. This analysis provides the short run dynamic adaptation to the long run equilibrium. The levels of significance of F-distribution test for the Granger causality, while with t-distribution the $u_{t-1}$ coefficient is examined as well. The numbers in parentheses are the lag lengths determined by using the Akaike criterion. As discussed earlier, there are two channels of Granger causality (1988), which are called channel 1 and channel 2. If the coefficients of the lagged values of the variables (apart from the coefficients of the lagged values of the dependent variable) on the right hand side in equation 5 are jointly significant, then this is called channel 1. On the other hand, if the coefficient of the lagged value of the error correction term is statistically significant, then this is called channel 2. For convenience, 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.

INSERT TABLE 6

From the results of table 6 we can infer that there is a unidirectional Granger causality between the price level and the productivity with direction from the price level to the productivity. This result is in accordance with the papers of Clark (1982), Ram (1984), and Buck and Fitzroy (1988) and Saunders and Biswas (1990) as well. The price level and the productivity cause the gross domestic product for the examined period, while there is a bi-directional causal relationship between the gross domestic product and the interest rate. Finally, we can see that there is a dynamic
causal relationship between the real gross domestic product and the productivity, and also between the interest rate and the productivity.

7. Conclusions

The purpose of this paper was to examine the subject of Granger causality between the price level and the productivity in a transition country to European Union such as Romania using quarterly data for the period 1990:IV – 2003:I through the multivariate causality analysis, which is based on an error correction model. For this reason, the latest time series methods have been used such as unit root tests, the bivariate and the multivariate cointegration tests and vector error correction models. Especially, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests have been used for the existence of unit root test. On this basis, the bivariate cointegration analysis has been used, as suggested by Engle-Granger, and the estimation of error correction model, while the Johansen and Juselious estimation method has been applied for the multivariate cointegration.

Although Romania has high relatively inflation rates for the studied period, the results of empirical analysis suggested that there is a long run relationship between the productivity and the price level in both techniques of cointegration analysis which have been used, as well as in the multivariate cointegration analysis adding two more variables, which consist changes in real production such as gross domestic product and also in monetary policy such as the interest rate. Then an error correction model’s methodology has been used to estimate the short run and long run relationships. The selected vectors gave us the error correction terms,
which proved to be statistically significant in 5% and 10% levels of significance respectively for the variables of the productivity and the real gross domestic product. The results of causality analyses suggest that the Granger price level causes productivity. This result is consistent with the studies of Clark (1982), Ram (1984), Buck and Fitzroy (1988) and Saunders and Biswas (1990). Also, the price level and productivity cause the gross domestic product, while there is a bilateral causal relationship between gross domestic product and interest rate. Finally, there is a dynamic causal relationship between the gross domestic product and the productivity, but also between the interest rate and the productivity for the examined period.
References


Table 1 - Tests of unit roots hypothesis

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\tau_\mu$</th>
<th>$\tau_\tau$</th>
<th>k</th>
<th>LM(4)</th>
<th>$\tau_\mu$</th>
<th>$\tau_\tau$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCPI</td>
<td>-2.3757</td>
<td>-2.1457</td>
<td>1</td>
<td>2.1567 [0.632]</td>
<td>-2.1917</td>
<td>-1.5427</td>
</tr>
<tr>
<td>LPROD</td>
<td>-1.7366</td>
<td>-1.6321</td>
<td>4</td>
<td>4.9745 [0.275]</td>
<td>-1.6723</td>
<td>-0.8427</td>
</tr>
<tr>
<td>LGDP</td>
<td>-1.4278</td>
<td>-1.2673</td>
<td>2</td>
<td>4.8945 [0.266]</td>
<td>-0.9452</td>
<td>-0.8453</td>
</tr>
<tr>
<td>LINTER</td>
<td>-0.9452</td>
<td>-0.9028</td>
<td>2</td>
<td>3.9034 [0.427]</td>
<td>-1.8943</td>
<td>-1.7612</td>
</tr>
<tr>
<td>$\Delta$LCPI</td>
<td>-3.0958**</td>
<td>-3.6746**</td>
<td>1</td>
<td>3.9786 [0.402]</td>
<td>-5.8945**</td>
<td>-5.6271**</td>
</tr>
<tr>
<td>$\Delta$LPROD</td>
<td>-7.934***</td>
<td>-7.634***</td>
<td>3</td>
<td>1.7852 [0.743]</td>
<td>-7.3422***</td>
<td>-7.0167***</td>
</tr>
<tr>
<td>$\Delta$LGDP</td>
<td>-5.453***</td>
<td>-5.296***</td>
<td>1</td>
<td>3.6745 [0.454]</td>
<td>-8.1242***</td>
<td>-7.8934***</td>
</tr>
<tr>
<td>$\Delta$LINTER</td>
<td>-4.067***</td>
<td>-3.956***</td>
<td>3</td>
<td>4.1349 [0.277]</td>
<td>-13.287***</td>
<td>-12.167***</td>
</tr>
</tbody>
</table>

Notes: The relevant tests are derived from the OLS estimation of the following autoregression for the variable involved:

$$\Delta X_t = \delta_0 + \delta_1 X_{t-1} + \delta_2 t + \sum_{i=1}^{k} \Phi_i \Delta X_{t-i} + u_t$$ (2)

$\tau_\mu$ is the t-statistic for testing the significance of $\delta_1$ when a time trend is not included in equation 2 and $\tau_\tau$ is the t-statistic for testing the significance of $\delta_1$ when a time trend is included in equation 2. The calculated statistics are those reported in D-F (1981). The critical values at 1%, 5% and 10% for N=50 are -3.58, -2.93 and -2.60 for $\tau_\mu$ and -4.15, -3.50 and -3.18 for $\tau_\tau$ respectively.

The lag length structure of $\Phi_i$ of the dependent variable $X_i$ 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 of t-statistic of the coefficient associated with the last lag in the estimated autoregression.

Numbers inside the brackets indicate significant levels.

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

Table 2 – Bivariate cointegration tests

<table>
<thead>
<tr>
<th>Method</th>
<th>Dependent variable</th>
<th>Dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Productivity</td>
<td>price level</td>
</tr>
<tr>
<td></td>
<td>k</td>
<td>t-test</td>
</tr>
<tr>
<td>Engle-Granger</td>
<td>3</td>
<td>-3.4245</td>
</tr>
<tr>
<td>Error Correction Estimates</td>
<td>2</td>
<td>-4.0561</td>
</tr>
</tbody>
</table>

Notes: The augmented D-F test is based on the equation (2) with constant and without trend, where $u_t$ is the estimated residual from the long-run model $LCPI_t = \alpha_0 + \alpha_L LPROD_t + u_t$ (3) The lag length k is chosen so the estimated residuals of equation (2) will be without autocorrelation. The critical values for the rejection of null hypothesis of no cointegration between the two variables at 1%, 5% and 10% are – 3.90, -3.33 and –3.04, respectively.

The single equation error correction model is estimated for $LCPI$ and $LPROD$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 X_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \sum_{j=1}^{k} \gamma_j \Delta X_{t-j} + u_t$$ (4)

The reported values are t tests for the estimated coefficient $\alpha_1$. The critical values for $\alpha_1$ at 1%, 5% and 10% for N=50 are –4.32, -3.67 and –3.28, respectively.
### Table 3 - Johansen and Juselius Cointegration Tests

**Variables:** LCPI, LPROD, LGDP, LINTER(VAR=4)

<table>
<thead>
<tr>
<th>Maximum Eigenvalues</th>
<th>Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null</td>
<td>Alternative</td>
</tr>
<tr>
<td>r = 0</td>
<td>r = 1</td>
</tr>
<tr>
<td>r &lt; 1</td>
<td>r = 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trace Statistic</th>
<th>Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null</td>
<td>Alternative</td>
</tr>
<tr>
<td>r = 0</td>
<td>r &gt; 1</td>
</tr>
<tr>
<td>r &lt; 1</td>
<td>r = 2</td>
</tr>
</tbody>
</table>

### Table 4 - Equation specification tests

<table>
<thead>
<tr>
<th>Tests</th>
<th>LCPI</th>
<th>LPROD</th>
<th>LGDP</th>
<th>LINTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Correlation</td>
<td>1.23</td>
<td>0.82</td>
<td>0.44</td>
<td>0.19</td>
</tr>
<tr>
<td>ARCH(4)</td>
<td>0.78</td>
<td>0.26</td>
<td>1.27</td>
<td>0.34</td>
</tr>
<tr>
<td>Normality</td>
<td>7.56</td>
<td>1.08</td>
<td>2.15</td>
<td>10.67</td>
</tr>
<tr>
<td>Heteroskedasticity</td>
<td>2.14</td>
<td>1.45</td>
<td>0.96</td>
<td>0.72</td>
</tr>
</tbody>
</table>

**Notes:** Test for normality follow X² distribution, all the others follow F-distribution.

### Table 5 – Causality test results based on vector error – correction modeling

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>F – significance level</th>
<th>t – statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>∆LCPI</td>
<td>∆LPROD</td>
</tr>
<tr>
<td>∆LCPI</td>
<td>0.419(2)</td>
<td>0.414(1)</td>
</tr>
<tr>
<td>∆LPROD</td>
<td>0.247(2)</td>
<td>0.128(2)</td>
</tr>
<tr>
<td>∆LGDP</td>
<td>0.528(1)</td>
<td>0.723(1)</td>
</tr>
<tr>
<td>∆LINTER</td>
<td>0.147(2)</td>
<td>0.315(1)</td>
</tr>
</tbody>
</table>

**Notes:** *, **, and *** indicate 10%, 5%, and 1% levels of significance. Number in parentheses are lag lengths.

### Table 6 – Summary of causal relations

<table>
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<tr>
<th>CPI→PROD</th>
<th>CPI→GDP</th>
<th>CPI→INTER</th>
<th>PROD→CPI</th>
<th>PROD→GDP</th>
<th>PROD→INTER</th>
<th>GDP→CPI</th>
<th>GDP→PROD</th>
<th>GDP→INTER</th>
<th>INTER→CPI</th>
<th>INTER→PROD</th>
<th>INTER→GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
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<td>2</td>
</tr>
</tbody>
</table>

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