MACRO-ECONOMIC VARIABLES ANALYSIS
IN UKRAINE: AN EMPIRICAL APPROACH
WITH COINTEGRATION METHOD

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Abstract

This paper investigates the relationship among exports, economic growth, investments and employment for a former country of Soviet Union such as Ukraine. The purpose of this paper is to examine the long-run relationship between these variables using quarterly data for the period 1991:I-2000:IV and applying the cointegration analysis as suggested by Johansen and Juselious. Then a multivariate autoregressive vector model (VAR) is used to estimate the short-run and the long-run relationships of variables of this model. The results of this paper suggested that exports growth in combination with the increase of investments and employment have a positive effect on Ukraine’s economic growth.
1. Introduction

Ukraine will complete the thirteenth anniversary of its independence on 24 August 2004. Early forecasts of its disintegration because of the regional, ethnic, and language conflicts proved to be futile. Indeed, the relations among Ukrainians and other ethnic minorities are very close. The country’s economy was stabilized to a significant degree by the financial fund of the International Monetary Fund and by the application of government policy, which has adopted a new program of economic reforms.

Ukraine has signed treaties of friendship with all of its neighbours, including its former imperial master, the Russian Federation, and settled all outstanding boundary disputes with them. Emerging from the remnants of a large Eurasian Empire, Ukraine signalled a “European choice” in its foreign policy early on and has played an active role in NATO’s Partnership for Peace (PfP) and in peacekeeping operations in South-Eastern Europe. Ukraine seeks integration into Europe and cooperation with Russia.¹

The ultimate goal of the common cooperation between EU and Ukraine is related to the respect of democratic principles, the protection of human rights and the transition process to a market economy. For this reason, the Partnership and Cooperation Agreement (PCA) and the EU’s Common Strategy (CS) should be applied between Ukraine and EU by determining the political and strategic importance of their relations. The PCA is an important instrument in harmonizing Ukraine’s legal framework with the single European market and the World Trade

¹ Murpphy, R, et al (1999) Collected Papers: UKRAINE IN EUROPE, Centre for Strategic and International studies occasional reports in European studies, http://www.csis.org/europe/pubs/UkraineInEurope.pdf
Organization (WTO) system. The PCA also provides trade liberalization, allows free turnover of goods, services, labour and capital, strengthens the economic development and leads to the investments growth.

The European Union’s Common Strategy adopted in 1999 as a new instrument, under the Common Foreign and Security Policy. It aims to develop a strategy partnership between the EU and Ukraine on the basis of the PCA, since it acknowledges its convergence to EU. This common strategy sets three principal objectives:

- economic and democratic transition process in Ukraine
- meeting of common challenges on the European continent such as stability and safety in Europe, environment, energy and nuclear disarmament
- strengthening of the cooperation between Ukraine and EU in the context of enlargement integration into the European and world economy

Ukraine, the second largest country in Europe in terms of surface area, will become an even more crucial neighbor and partner for the EU after enlargement. As Ukraine’s immediate neighbor, the European Union has demonstrated a particular interest to this stable independent state in political and economic level.

Ukraine continues its democratic development and accelerates the transition process to a free market economy. Also, it is an attraction pole for the development of commercial relations with EU and its member states, for the growth of exporting trade and the free turnover of goods and the installation of multinational enterprises, which affect the economic and political status of the country.

The available energy resources and the anxiety for existence of nuclear weapons led to the growth of an international competitive market, where different political and economic interests will dominate. The illegal immigration, the
disarmament of nuclear weapons and the fight against organized crime and terrorism are the most crucial issues in the transition process to EU.

The reduction of inflation and the adoption of a new stable currency, the hryvnya, which introduced in 1996, conducd to the economic development of the country. The Ukrainian government had to start from scratch to build a system of public administration and to reform the judiciary sector on the basis of accession process to European Union.2

Investment is projected to be an important factor of sustainable long-term growth in the next 5 years. In real terms, gross investment grew at 14.4% in 2000 and 17.2% in 2001. Total investment remained heavily concentrated in the traditional industrial areas of the country. Two thirds of the investment realized in 2001 was financed exclusively by enterprises funds. The second most important source of the investment financing was constituted by bank credits, the share of which has grown considerably over the last three years and reached 14% of the total in 2002.

This upward trend of investment follows from the introduction of market principals in agricultural sector and the reduction of barters in economic transactions. In line with recent levels, about 11% of investment was financed by the state budget. In 2002 an improvement of investment climate in the country was noted and the most important factors led to this result attributed to the stability of the exchange rate of the hryvnia and the rapid growth of the long-run bank credits.

However, the investment environment in Ukraine would become more attractive if the government should:

- continue the privatization of public enterprises in transparent and competitive way

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2 Country Strategy Paper 2002-2006, National Indicative Programme 2002-2006 Ukraine
http://europa.eu.int/comm/external_relations/ukraine/csp02_06en.pdf
strengthen the capital adequacy and Central Bank supervision of the banking system. Strong and healthy commercial banks will permit to narrow interest spreads and fees, and thus promotes further investment and growth.

- promote greater transparency in public decision-making process.

- implement the tax reforms simplifying the tax system and reducing rates. The efforts of Ukranian government to speed up the tax reforms consists of an important step for the improvement of investment environment. The introduction of the new Tax Code could ensure economic equilibrium in order to preserve macroeconomic stability, which is sensitive to domestic and external shocks. The gross fixed capital formation grew up by 17.2% because of the bank credits growth by 46% in 2001.³

According to the State Committee of Statistics of Ukraine the growth rate of merchandise exports was 11.6%, while exports increased by 13% respectively. In January 2002 economic growth and industrial production decelerated to 3.2% and 1.7% respectively. Exports constitute about 57% of GDP in 2001 and consisted the main source of foreign exchange in Ukraine. The most urgent step for Ukraine is to become a member of World Trade Organization (WTO).

The ultimate goal of the National Bank is to maintain the inflation rate in low levels. Indeed, the consumer price index came down from 25.8% in 2000 to 6.1% in 2001, while in January 2002 was 5.6%. The public deficit was estimated by 0.5% of GDP. The goal of a zero budget deficit was almost achieved. Despite the shortage of capital inflows, the current public surplus is efficient to cover the public debt of the country.⁴

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³ Figliuoli, L., and Kryshko, M., (2002), Challenges and policy reforms for improved investment environment in Ukraine, Investment Climate in Ukraine, OECD - Ukraine forum on investment and enterprise development, http://www.oecd.org/pdf/M000277000/M00027582.pdf

⁴ Giucci, R., and Movchan, V., (2002), challenges and policy reforms for improved investment environment in Ukraine: Ukraine's Macroeconomic Situation and Outlook, OECD - Ukraine forum on investment and enterprise development, http://www.oecd.org/pdf/M00026000/M00026727.pdf
The high level of unemployment and the low standard of living are the main characteristics of Ukrainian economy during the last years. The problem of unemployment came up as a result of economic crises, which aroused after the breakdown of Soviet Union. If in 1992 the number of the registered unemployed was 70 thousand, in 1997 it became 5 times more.

The level of employment in Ukraine is one of the lowest among other European countries. The average annual rate of the employed for the period 1990-1999 in industrial sector was 56,4%, in agriculture sector was 98% and in manufacturing was 41,7%. The level of employment is related to the level of education, while it is followed by the dramatic decline in production and in the level of real wages. In 1999 the employment rate of total population was 54,7% and the unemployment rate was 12% respectively. In the labor market, which is characterized by the correlation between supply and demand and the prevailing financial system, young specialists with the higher educational level and professional skills should be employed.5

2. Theoretical and empirical approaches

There is a wide body of literature analyzing the theoretical relation between exports and economic growth. According to this literature there are two other intermediate variables, which affect this relation. Clearly, since exports are a component of GDP, export growth contributes directly to GDP growth. However, there are important indirect factors, which affect this relationship between exports and economic growth. Exports relax binding foreign exchange constraints and allow

5 Gerasymenko, S., and Gerasymenko, O., (2001), Statistic estimation of the youth labour market in transition, http://www.aueb.gr/espe2001/pdf/Gerasymenko%20S.,%20Gerasymenko%20O..PDF
increases in imported capital goods (McKinnon 1964, Chenery and Strout 1966, Voivodas 1973, Afxentiou and Serletis 1992, Federici and Marconi 2002). Also, exports allow poor countries with narrow domestic market to benefit from economies of scale (Helpman and Krugman 1985).

Furthermore, exports conduce to improved efficiency in resources allocation and lead to better utilization of capital (Balassa 1978, Bhagwati and Srinivasan 1979, Krueger 1980). Moreover, exports facilitate the diffusion of technology knowledge through learning-by-doing (Grossman and Helpman 1991).

Early empirical tests of the export-led growth hypothesis adopted an augmented production-function approach, in which exports are included in addition to the traditional inputs of capital and labour (Balassa 1978, Feder 1982, Anwer and Sampath 2000). In these studies researchers resulted in the conclusion that there is a contemporary correlation between exports and economic growth (Michaely 1977, Balassa 1978, Tyler 1981, Feder 1982, Ram 1987, Sun and Parikh 1999, Dritsakis 2004a).

Exports affect positively the components of economic growth such as investments and labor (Pereira and Xu 2000, Abdulai and Jaquet 2002, Dritsakis 2003). Furthermore, exports expansion increases productivity by offering greater economies of scale (Helpman and Krugman 1985, Lee and Huang 2002, Dritsakis 2004b), brings about higher quality products because of the exporter’s exposure to international consumption patterns (Krueger 1985). Also exports expansion leads a firm to overinvest in new technology as a strategy for release to a larger scale of output, increasing the rate of capital formation and technological change (Rodrik 1988, Sinha and Sinha 2002). An export-oriented approach in labour surplus economy permits the rapid growth of employment and real wages (Krueger 1985).
The methodology proposed by Granger (1969) and Sims (1972) for causality test on the relationship between exports and economic growth is based on the estimation of bi-variate relationships between the two variables. These tests are designed to capture exclusively the short run dynamics between the two variables. The recent development of cointegration analysis allowed researchers to test for the existence of this long-run equilibrium relationship between exports and output.

In this paper a multivariate vector autoregressive model (VAR) has been used, in which in addition to exports and economic growth, investment and employment are included. The focus on this multivariate dynamic model permit us to investigate the effects of exports on these two extra variables and to identify the factors through which economic development affects exports growth.

The multivariate VAR approach presupposes the possible existence of short-term relations between exports and the other variables, but it allow us to study the long-run effects of exports on the other variables as well.

Since the previous literature has largely ignored the dynamic interactions between exports and these two extra variables, investment and employment, it could be noted that the incorporation of such dynamic interaction is a very important element of this approach. Consequently, exports can affect economic growth directly or indirectly through their effects on investment and employment and in turn, economic growth should affect exports.

In empirical analysis of this paper we used quarterly data for the period 1991:Ι-2001:IV for all variables. The remainder of the paper proceeds as follows: Section 2 presents the theoretical and empirical approaches, while Section 3 analyses the data specification model and the multivariate VAR model that is used. Section 4 applies the Dickey-Fuller tests and investigates the stationarity of the used data. The
cointegration analysis between the used variables is implied in Section 5. Section 6 describes the error correction model. Finally, section 7 provides the conclusions of this paper.

3. Data - Specification model

A VAR approach is adopted in this study to estimate the effects of export growth on the growth of domestic variables. The use of this methodology allows us to identify long-term cumulative effects by taking into account the dynamic feedback between exports and the domestic variables (Pereira and Hu 2000).

In time-series analysis appropriate differencing is important because most estimation algorithms fail when the time series are nonstationary. In addition, there may be efficient gains from differencing. For small samples, the distributions of the estimates can be improved by estimating the VAR model in differences (Hamilton 1994). Since there are only 44 observations for each time series in our sample, we use the first differences of each series in our estimation. In addition to the above econometric considerations, the use of first differences facilitates our interpretations of the results, since the first differences of the logarithms of the original variables represents the growth rate of the original variables.

For cointegration analysis between exports, investments, economic development and employment, we use the following multivariable VAR model:

\[ EXP = f(GDP, INV, EMP) \]  

where:

EXP are the exports
GDP is the economic development
INV is the investment
EMP is the employment

The economic development variable is measured by the real GDP (nominal GDP adjusted by GDP deflator). The investment variable (INV) is measured by the gross fixed capital adjusted by the GDP deflator. The exports variable is measured by the real export revenue and is obtained by adjusting the nominal export value by an export price index from the International Financial Statistics (IFS). The employment variable EMP is estimated by the number of employed people. The data that used in this analysis are quarterly, cover the period 1991:I -2001:IV regarding 1996 as a base year and derived from the database of OECD (Business Sector Data Base).

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. 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 for 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 unit root test is used for the estimation of individual time series, with intention to provide evidence for when the variables are integrated. The unit root test is followed by the multivariate cointegration analysis.
4. Unit root test

The cointegration test among the variables that are used in the above model requires previously the test for the existence of unit root for each variable and specifically, for economic development, exports, investment and employment, using the augmented Dickey-Fuller (ADF) (1979) test on the following regression:

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

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 these tests 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, under the indication “Lag”. As far as the autocorrelation disturbance term test is concerned, the Lagrange Multiplier LM(4) test has been used. The MFIT 4.0 (1997) econometric package that was used for the estimation of ADF test, provides us the simulated critical values.
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). Moreover, for all variables the LM(4) test first differences shows that there is no correlation in the disturbance terms.

5. Cointegration and Johansen test

If the time series (variables) are non-stationary in their levels, they can be integrated with integration of 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. Granger (1986) argued that ‘A test for cointegration can thus be thought of as a pre-test to avoid ‘spurious regression’ situations’.

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.

The order of $r$ is determined by using the likelihood ratio (LR) trace test statistic suggested by Johansen (1988).

$$\lambda_{\text{trace}(q,n)} = -T \sum_{i=q+1}^{k} \ln(1 - \hat{\lambda}_i)$$

(3)

for $r = 0, 1, 2, \ldots, k-1$,

$T$ = the number of observation used for estimation

$\hat{\lambda}_i$ = is the ith largest estimated eigenvalue.

Critical values for the trace statistic defined by equation (3) are 39.81 and 36.69 for $H_0: r = 0$ and 24.05 and 21.46 for $H_0: r \leq 1$ at the significance level 5% and 10% respectively as reported by Osterwald-Lenum (1992).

The maximum eigenvalue LR test statistic as suggested by Johansen is:

$$\lambda_{\text{max}(q, q+1)} = -T \ln(1 - \hat{\lambda}_{q+1})$$

(4)

The trace statistic either rejects the null hypothesis of no cointegration among the variables ($r=0$) or does not reject the null hypothesis that there is one cointegrating relation between the variables ($r\leq1$).
The results that appear in Table 2 suggest that the number of statistically significant cointegration vectors is equal to 1 and are the following:

\[
LEXP = 0.76854 \times LGDP + 1.7021 \times LINV + 0.93492 \times LEMP
\]

\[
(4.173) \quad (2.949) \quad (2.145)
\]

The coefficients estimations in equilibrium relationships, which are basically the long-term estimated elasticities relatively to exports growth, suggest that investments are elastic while economic development and employment are inelastic.

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

6. 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 arised from the long-run cointegration relationship and has the following form:

\[
\Delta LGDP_t = \text{lagged}(\Delta LGDP_t, \Delta LEXP_t, \Delta LINV_t, \Delta LEMP_t) + \lambda u_{t-1} + V_t \quad (4)
\]

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

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

\(-1<\lambda<0\) short-run parameter
One difficulty confronting a researcher in estimating a VAR model is the appropriate specification of the model. In particular, the researcher has to decide what deterministic components should be included as well as the number of time lags that should be used. Since arbitrarily chosen specifications of a VAR model are likely to produce unreliable results, we use a data based model selection criterion to specify the VAR model for Ukraine’s economy. Among various model selection criteria the one proposed by Schwartz (1978), known as Schwartz Bayesian information criterion (SBC), is shown to outperform other alternatives (Mills and Prasad 1992). Therefore, our specification of the VAR model are based on Schwartz Bayesian information criterion. Schwartz’s criterion selected a first order VAR specification with constant and time trend as well.

The final form of the Error-Correction Model was selected according to the approach suggested by Hendry, (Maddala 1992). The initial order of time lag for the model is 2 years, 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 (LM) for the possible existence of autocorrelation and heteroscedasticity, the Bera-Jarque (C) normality test and the Ramsey’s Reset test for the functional form of the model. 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 (51%). The

\[ V_t \] white noise disturbance term
Error Correction Term is not statistically significant although it has a negative sign, which confirms that there is a problem in the long-run equilibrium relation between the independent and dependent variables in 5% level of significance, but its relatively value 0.13167 (-1.0742) shows a satisfactory rate of convergence to the equilibrium state per period.

From the results of Table 3 we can see that a short-run increase of economic development per 1% induces an increase of exports growth per 0.32%, an increase of investments per 1% induces an increase of exports growth per 0.55%, while an increase of employed per 1% induces an increase of exports growth per 0.42%.

7. Conclusions

This paper employs with the relationship among exports growth, economic development, investment, and employment for a former country of Soviet Union, using quarterly data for the period 1991:I-2001IV. The empirical analysis suggested that the variables that determine exports growth in Ukraine present a unit root. On this basis the cointegration analysis has been used as suggested by Johansen and Juselious to arise a long-run equilibrium relationship among the examined variables. The results of this analysis show that there is a positive relationship among exports growth, investment, employment and economic development. Then an error correction model’s methodology was used to estimate the short-run and long-run relationships. The selected vectors gave us the error correction terms, which proved to be statistically insignificant in 5% level of significance during their introduction in short-run dynamic equations.
The results of positive long-run effects of economic development investments and employment on exports growth are consistent with the arguments for positive external effects of these variables in literature (as reported to section 2). Greater export opportunities should promote investment not only in the export sector but also in other sectors related to exports. Furthermore, exports growth in developing countries such as Ukraine, typically suggests a shift of domestic production towards more labor-intensive commodities with comparative advantages in the world market. The results of Table 3 suggested that investments growth is the most important factor for Ukrainian exports as a result of Levine and Renelt’s (1992) study.

Finally, the effects of economic development on exports growth through the employment and investment proved to be positive for Ukraine. This fact emphasizes the role of indirect intermediate variables through economic development affects exports growth in this country.
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Table 1 – DF/ADF unit root tests

| Variables (X_t) | Lag | Test statistic (DF/ADF)* | LM(4)** | Lag | Test statistic (DF/ADF)* | LM(4)** |
|----------------|-----|--------------------------|---------|-----|--------------------------|---------|
| LEXP           | 2   | -3.4205                  | 2.3171  | 0.269 | 2                        | -3.6947 | 0.2203 | 0.629 |
| LGDP           | 4   | -2.8349                  | 0.0992  | 0.758 | 4                        | -3.9926 | 3.2497 | 0.121 |
| LINV           | 4   | -3.2302                  | 0.3102  | 0.624 | 4                        | -4.1154 | 0.3281 | 0.642 |
| LEMP           | 0   | -2.9344                  | 0.2900  | 0.674 | 4                        | -5.7612 | 1.4091 | 0.267 |

*Critical value: -3.5279
**The numbers in brackets show the levels of significance (for serial correlation test)

Table 2 - Johansen and Juselius Cointegration Tests

| Variables | LEXP, LGDP, LINV, LEMP |
|-----------|------------------------|
| Maximum lag in VAR = 3 |

| Eigenvalues | Critical Values         |
|-------------|-------------------------|
| Null        | Alternative | Eigenvalue | 95%     | 90%     |
| r = 0       | r = 1       | 32.0895    | 23.9200 | 21.5800 |
| r = 1       | r = 2       | 11.8686    | 17.6800 | 15.5700 |

| Trace Statistic | Critical Values | |
|-----------------|-----------------| |
| Null            | Alternative     | Eigenvalue | 95%     | 90%     |
| r = 0           | r > 0           | 46.4426    | 39.8100 | 36.6900 |
| r ≤ 1           | r > 1           | 14.3531    | 24.0500 | 21.4600 |
Table 3 - Error Correction Model

\[
\Delta \text{LEXP}_t = 0.037499 + 0.70939 \Delta \text{LEXP}_{t-1} + 0.32217 \Delta \text{LGDP}_{t-1} + 0.29027 \Delta \text{LGDP}_{t-2} \\
+ 0.55090 \Delta \text{LINV}_{t-1} + 0.42047 \Delta \text{LEMP}_{t-2} - 0.13167 u_{t-1} \\
\]

\[
\begin{align*}
(1.7978) & \quad (2.8109) & \quad (2.9465) & \quad (1.8480) \\
[0.082] & \quad [0.008] & \quad [0.006] & \quad [0.074] \\
\end{align*}
\]

\[
R^2 = 0.51 \quad F(6,34) = 5.6005 \quad DW = 1.7259
\]

\[
\begin{align*}
\text{A:} & \quad X^2[1] = 2.1597 \quad & \quad \text{B:} & \quad X^2[1] = 0.48957 \\
 & \quad [0.706] & \quad & \quad [0.484] \\
\text{C:} & \quad X^2[2] = 1.7676 \quad & \quad \text{D:} & \quad X^2[1] = 2.3628 \\
 & \quad [0.413] & \quad & \quad [0.124] \\
\end{align*}
\]

Notes:

\(\Delta\): 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.

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

[ ] = We denote prob. Levels.