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Estimation of the investment function for the Republic of Macedonia

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Abstract

Investment is one of the crucial macroeconomic variables - it adds to the capital stock and thus determines the long term production capacity in the economy. Investment, also, is one of the channels through which macroeconomic policies, monetary and fiscal policy, can affect the real economy. This paper presents an estimate of the investment function for the Republic of Macedonia, based on the Johansen cointegration technique. The results obtained show that, according to the Keynesian accelerator theory, investments are driven by changes in the aggregate demand. In addition, as the neoclassical model predicts, the cost of employing additional unit of capital exhibits significant influence on the investment decisions' of the firms, but only in the short run. The obtained results are broadly in line with the ones found in different studies and with the one used in previous work on this topic for Macedonia.

September, 2008

* E-mails: PetkovskaB@nbrm.gov.mk. I am grateful to Sultanija Bojceva-Terzijan, Branimir Jovanovic and Aneta Krstevska for their useful comments and recommendations. The views expressed in this paper are those of the author and do not necessarily represent those of NBRM.

1. Introduction

Investment is an important macroeconomic variable. Defined as increase in the actual level of capital in the economy, investment determines the long run production capacity and contributes to the economic growth. Investment expenditures increase the demand for capital goods and consequently, shift the level of employment and income in the capital goods producing industries. The literature points out that investment, as the most volatile component of the gross domestic product (GDP), accounts for much of the fluctuations of GDP across the business cycle, even though it does not has the highest share in the GDP (Dornbusch and Fischer, 1994).

Investment spending is one of the channels through which macroeconomic policies, monetary and fiscal policy, can influence the real economy. Firms' investment decisions depend on the cost of buying an additional unit of capital i.e. the user cost of capital, which in turn depends on the lending interest rate and on taxes. Through the interest rate transmission channel the monetary authorities can affect investment and from here, the aggregate demand. The user cost of capital is also dependent upon changes in the tax system i.e. the higher is the corporate income tax, the higher the cost of capital. Thus, fiscal policy can encourage investment spending by decreasing the corporate income tax.

The primary objective of this research is to improve the investment function for Macedonia, initially estimated in the macroeconometric model MAKMODEL. The MAKMODEL's investment function is of a neoclassical type and is estimated for the 1994-1999 period. The short estimation period is one of the main problems with the MAKMODEL's investment function. Therefore the re-estimation will serve as a robustness and stability test of the Macedonian investment function.

As investment leads GDP through the business cycle and as investment spending influences the production capacity of the economy, the aggregate employment, the income and the balance of payment, it is of great importance to identify the determinants of investment. In fact, the identification of the determinants of investment means identification of the sources of the long term economic growth. This will help policy makers to reduce the fluctuation in the aggregate demand. This research, through the re-estimation of the investment function, tends to answer some of these questions besides the initial objective.

The paper is structured in the following way. First, we present the theory of investment. Next, we give a short historical overview of the evolution of the gross fixed capital formation in Macedonia and we show the other series used in the analysis. Third, we estimate the investment function following some of the theories explained in the first part and we discuss the results. At the end, we conclude the study with the main findings and with some recommendations for future research in this field.

2. Investment function – theoretical aspects

The theory of investment is in fact theory of the demand for capital. In other words, through the law of capital accumulation (equation one), economy's total capital stock is equal to the sum of the stock of capital from previous year and the investment in capital goods in the current period minus the depreciated capital. From here the stock of capital in the economy is equal to the sum of all past investment, given that the law of capital accumulation is valid for all past periods i.e. $K_{t-1}, K_{t-2}\ K_{t-3}$ etc.

$$K_t = (1-\delta) * K_{t-1} + I_t \qquad (1)$$

In equation one K_t is the capital stock in period t, δ is the rate of depreciation and I_t is the investment in period t. From here the investment is equal to the first difference of the capital stock adjusted for the rate of capital depreciation (equation two).

$$I_t = K_t - (1-\delta) * K_{t-1} \qquad (2)$$

There is a vast literature on investment theories. The accelerator, or the Keynesian theory of investment, the neoclassical theory of investment and the Tobin's q theory are usually classified as traditional theories of investment. All these theories assume that investment in every current period adds to the stock of capital and, that in this way investment help the adjustment of the capital stock to some long term, equilibrium or desired level of capital in the economy. Today there are various theories that augment these traditional approaches. These modern models of investment control for the time of adjustment of the actual to the desired capital stock, for the financial constraints or for the uncertainty (Caballero, 1999; Driver et al., 1999). Having in mind that the ultimate goal of this research is the improvement of the MAKMODEL's investment function, testing these theories is beyond the scope of this research.

The accelerator model (Clark, 1917) assumes that there is a constant and stable relationship between the stock of capital and the output[1]. Additionally, investment in every period adjusts the actual to the desired stock of capital i.e. the adjustment is instantaneous. The accelerator theory is in fact a Keynesian theory since it embodies the basic Keynesian principle that it is the aggregate demand that influence the real economy, the output in the Clark's model being proxy for the aggregate demand. Since the adjustment is instantaneous

[1] The capital to output ratio in the developed countries varies from 2.6 to 3.9 (Livermore, 2004; Vikram et al., 1993).

and since there is a constant capital to output ratio, investment is uniquely determined by changes in the aggregate demand. Put differently, when the demand in the economy is increasing, firms, in order to maximize their profit, will invest more since this will create larger supply and higher output in the economy. Prices, wages, taxes and interest rates have absolutely no effect on firms' investment decisions. Empirical work confirmed that this theory can be easily proven i.e. the positive and statistically significant relationship between the investment and the output is usually found. However, it is the most criticized theory because of the assumption of constant capital to output ratio, as well as because it ignores the importance of the cost of capital in the firms' decision making.

The flexible accelerator theory and ***the neoclassical theory*** emerged as a logical answer to these critiques. The flexible accelerator theory (Clark, 1944) assumes that certain time, longer than one period is needed for the adjustment of the actual to the desired capital stock. Given that there is no instantaneous adjustment and that the capital to output ratio is not constant, investment in the current period is equal to the difference between the desired capital stock and the value of the capital in the previous period.

The neoclassical theory (Jorgenson, 1963) highlights the importance of the user cost of capital in the investment decision process. This theory is founded on the optimizing behaviour of the agents i.e. it has micro foundations. Firms decide for future investment conditional on their goal i.e. profit maximization and constrained by the available factors of production i.e. the production function they follow in the production process. The desired level of capital, according to the neoclassical theory, is the level of capital achieved when the marginal product of capital equals the user cost of capital, which in turn, depends on the interest rates, the rate of depreciation and taxes. However, an empirical support of this theory is rarely found; even in the empirical studies for developed countries the user cost of capital is not always statistically significant.

Tobin's q theory of investment defines the investment as a function of the market value of the firms and of the replacement value of the firms' assets. The firms' market value to replacement cost ratio is known as the Tobin's q coefficient. Theory predicts that higher than one 'q' coefficient will increase investment, whereas smaller than one coefficient will reduce the investment.

3. Empirical work

In this part we estimate the investment function for the Republic of Macedonia following the accelerator and the neoclassical model. Tobin's q theory was not tested mainly because of data unavailability. Before we proceed with the empirical analysis we discuss shortly the evolution of investments (gross fixed capital formation) in Macedonia and present the other variables used in the analysis.

3.1. Gross fixed capital formation in Macedonia

Demand for investment goods in Macedonia, proxied through the gross fixed capital formation, accounts for around 16% of GDP in the period from 1997 to 2006. Investment share in GDP is rather modest; however, as theory predicts and as confirmed by the empirical research investment is one of the most important determinants of the GDP, and given its volatility, one of the best indicators for the cyclical movement of GDP.

Figure 1
Gross fixed capital formation and GDP (annual growth rates)

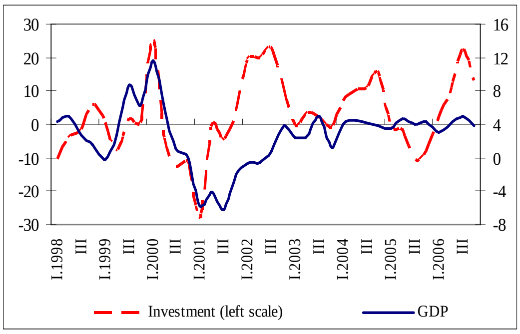
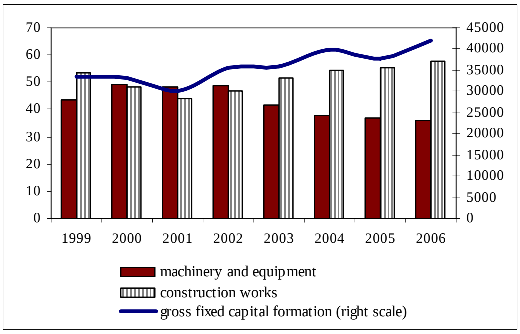


Figure 2
Gross fixed capital formation (millions of denars) and the share of the machinery and equipment and construction works (in %)



Source: State Statistical Office of R.M. and own calculations

As shown on Figure 1, the growth rates of gross fixed capital formation and GDP are in accordance with the theoretical predictions. Investment and GDP behave in the same manner, excluding the beginning and probably the end of the sample period. However, investment growth rate is much volatile as compared to the GDP growth rate; the standard deviation of the investment growth rate is around 12 percentage points, whereas the standard deviation of GDP growth is around 4 percentage points. Figure 2 points out investments in machinery and equipment (around 43% of the gross fixed capital formation) and investments in construction work (around 51% of the gross fixed capital formation) as the main components of the gross fixed capital formation in Macedonia in the 1999-2006 period. In addition, one can notice a decreasing share of the investments in machinery and equipment starting from 2002 and an increasing share of the investments in construction work starting from 2001 (see Figure 2). Another important feature of investment activity in Macedonia is that agents finance their investment mainly from their own financial assets. Only 16% of the gross fixed capital formation in the 1999-2006 period was financed through borrowing.

Generally, with the exception of 2001 when there is a fall in investment spending caused by the war conflict, investment flows have an upward trend. Investment flows were highest in 2004 and 2006 mainly due to the increased investment in construction, agriculture and trade[2]. Moreover, the growth of investment in capital goods in these periods coincides with the movements in the foreign direct investment flows (FDI). In 2004 the flow of FDI has increased for around 57%, whereas the inflow of capital in the form of FDI in 2006 is three times larger than the one in 2005. However, when compared to other transitional economies Macedonia has the lowest level of gross fixed capital formation, expressed as a percent of GDP (Table 1). The low demand for investment goods, through the law of capital accumulation, implies that the stock of capital in the economy is also low and this emerges as an important constraint for the future economic growth.

Table 1
Gross fixed capital formation, % of GDP[3]

	Bulgaria	Czech Republic	Estonia	Latvia	Lithuania	Hungary	Poland	Romania	Slovenia	Slovakia	Macedonia
1997	9.4	28.9	24.7	16.9	20.0	20.4	21.7	-	23.4	32.8	17.3
1998	12.2	28.9	28.9	26.1	22.5	22.1	23.6	-	24.5	34.4	16.3
1999	14.4	27.6	24.4	23.5	21.5	22.4	24.1	18.3	27.1	29.0	15.4
2000	15.7	28.0	26.0	24.2	18.8	23.0	23.7	18.9	26.2	25.8	14.5
2001	18.6	29.1	26.5	25.0	20.0	23.2	21.2	19.7	25.8	28.2	13.9
2002	19.3	30.0	30.4	26.5	20.7	24.5	19.6	20.3	25.1	27.0	16.3
2003	21.0	29.1	33.8	27.8	21.4	24.0	18.8	20.9	26.2	25.1	16.0
2004	22.3	29.0	32.6	31.7	23.1	24.7	19.0	21.4	27.0	25.0	17.0
2005	25.9	27.7	32.6	35.4	23.7	25.0	19.5	23.2	26.5	27.5	15.5
2006	28.0	27.6	35.8	36.7	25.8	23.4	21.1	25.6	27.2	27.4	16.6
average for the period	18.7	28.6	29.6	27.4	21.7	23.3	21.2	21.0	25.9	28.2	15.9

Source: Eurostat, State Statistical Office of R.M. and own calculations.

Historically, the low level of investment in Macedonia is due to the unfavorable financial state of the enterprises, high real interest rates and, when compared to other transitional economies, insufficient FDI inflows (see Table 2). After fifteen years of transition, in 2005 and 2006 Macedonia is still, among the countries with the smallest FDI inflows.

[2] The significant growth of the gross fixed capital formation in 2002 is due to the low base from the previous year when the investment activity and GDP fell for about 8.6% and 5%, respectively.
[3] The gross fixed capital formation and GDP data for Macedonia is real, expressed in 1997 prices; the gross fixed capital formation and GDP data for foreign countries are real, expressed in 2000 prices.

Table 2
Foreign direct investment, % of GDP[4]

	2005	2006
Bulgaria	8.5	15.9
Croatia	4	8.3
Romania	6.7	9.4
Albania	3	3.1
Bosnia and Herzegovina	6.5	6.4
Macedonia	**1.7**	**5.8**
Montenegro	22.8	24.3
Serbia	6.1	15.3

Source: Transition Report, May 2007

The other series used in the analysis are GDP, commercial banks' lending interest rate and the inflation. GDP and the gross fixed capital formation are real level variables, expressed in 1997 prices[5]. For the lending interest rate we used the representative credit interest rate data. It is a constructed variable in a sense that until 2005 we used the short term interest rate on denar credits, whereas for the period from 2005 we used the total (short and long term) interest rate on denar credits. The choice of short term interest rate until 2005 and the total interest rate starting from 2005 was due to the unavailability of long enough series for the long term credit interest rate.

Figure 3
GDP (millions Denars, in 1997 prices)

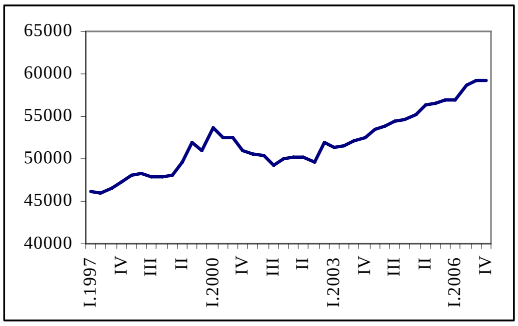


Figure 4
Consumer Price Inflation (annual rate, %)

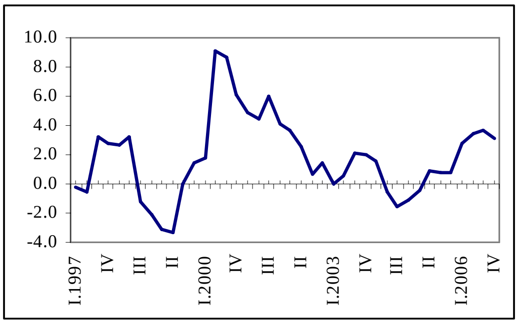
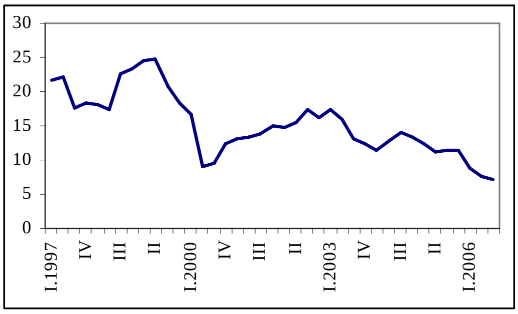


Figure 5
Real lending interest rate (%)



[4] The FDI data is net inflow from the balance of payment. The data for 2006 is estimated.

[5] GDP and inflation data are from the State Statistical Office of the Republic of Macedonia. The lending interest rate series is from the National Bank of the Republic of Macedonia.

3.2. Accelerator model

The accelerator model predicts that investments are solely determined by changes in aggregate demand. Firms increase their investment activity (I_t) in order to increase production as a response to increased aggregate demand (ΔY_t). As already mentioned this model is founded on the assumption of constant capital to output ratio. Since no official capital stock data is available for Macedonia, the only way this assumption can be checked is by constructing capital stock series. The capital stock was constructed following the Perpetual Inventory Method (PIM). This approach is usual in the absence of official data as it is the case for many transitional and developing economies (Pula, 2003; Room, 2001).

Construction of the stock of capital

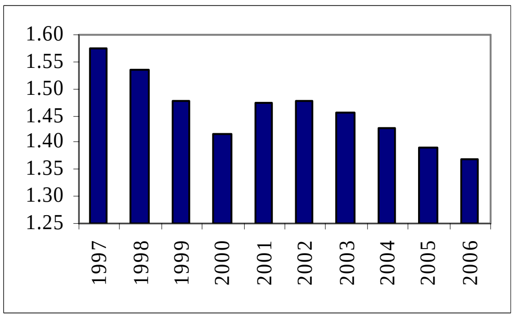
PIM approach defines the capital stock as a sum of all investment flows, expressed in real terms. However, as the investment data in Macedonia and in other transitional economies is too short we augmented the original PIM method. In other words we used an initial value for the level of capital in the economy and then added the investment flows (Room, 2001). As an initial level we used the value of the tangible and non-tangible assets of the enterprises for 2001[6]. The GDP deflator for 2001, 1997 based, was used to get real data for the initial capital level in 2001. In this way we achieved consistency between the data on gross fixed capital formation, GDP and the constructed capital stock series, since they are all expressed in 1997 prices. For the depreciation rate it is assumed that around 10% of the physical capital is wasted every year i.e. constant rate of depreciation[7]. For all periods after 2001 capital stock is calculated as:

$$K_{t+1} = (1-\delta)\cdot K_t + I_{t+1} \tag{3}$$

For all periods before 2001 we apply the following formula:

$$K_t = \frac{K_{t+1} - I_{t+1}}{(1-\delta)} \tag{4}$$

Figure 6
Capital to output ratio
(%)



Capital to output ratio in Macedonia, as shown on Figure 6, is not constant in contrast to the main assumption of the accelerator theory. Moreover, this ratio has a downward trend from 2002 which, having in mind the official data on gross fixed capital formation, leads to a conclusion that the stock of capital in

[6] The data on the enterprises' annual accounts is from the Central Register of the Republic of Macedonia.
[7] The 10% rate of depreciation is assumed in accordance with the amortization data from the State Statistical Office.

Macedonia is not only low but also it has a rather slow growth rate. On the other hand, one should not overstate this result, since the capital stock data is constructed for a very small sample period and it is not an official, publicly available data. Additional problem in the analysis is that the accelerator model, as well as the neoclassical model tested bellow, refers to the investment of the firms. Gross fixed capital formation, which is used as proxy for the investment demand, is a composite of the households', firms' and public investments. Nevertheless, data on firms' investment is available starting form 2002 and in nominal terms. Given that firms' investment constitute more than 50% of the gross fixed capital formation in the 2002-2006 period we believe that gross fixed capital formation is good proxy for firms' investment activity. Therefore, we continue with the empirical test of the accelerator model as first formal step towards identification of the factors that determine investment movement and future economic growth.

The data used to test this theory is GDP, as an indicator for aggregate demand and gross fixed capital formation, as an indicator for the firms' investment. Both series are in real terms and expressed in 1997 prices. The investment data from the State Statistical Office is available only with annual frequency. To get quarterly data we used the Chow-Lin interpolation method and as a series-interpolator we used the series on investment goods' import[8]. The equilibrium relationship between the variables was estimated using the Johansen cointegration approach.

Before the cointegration test was conducted all series were tested for unit root using the Augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP). We expected that all series are integrated of order one, given the graphical representation of the series in the previous part and this is formally justified with the unit root test shown in Appendix 1. Next step in the cointegration analysis is determination of the underlying VAR model. VAR (1) is chosen given that the inclusion of one lag is enough to free the residuals form serial correlation[9]. The cointegration test, shown in Table 3, confirmed the existence of one cointegrating vector i.e. a long term relationship between the investment and the aggregate demand. Namely, the null of one cointegrating vector can not be rejected according to both test statistics, Trace and Maximum Eigenvalue, at the conventional levels of statistical significance[10].

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[8] We used this series because of at least two reasons. First, this series was used in the MAKMODEL's investment function. Second, the correlation coefficient between the gross fixed capital formation and the imports of investment goods is 0.99.

[9] The usual practice when working with quarterly data is to start with VAR(4) model. However, when the sample period is small like in our case working with VAR(4) will mean lost of observation points and consequently, lost of degrees of freedom.

[10] The cointegration test is in fact a joint test of determining the number of cointegrating vectors and specifying the elements in the cointegrating vector, such as intercept and trend. We followed the Pantula principle as the testing procedure i.e. we chose the first option in which the null hypothesis is not rejected. In our case, the first no rejection was in the third option with one cointegrating vector i.e. the option with unrestricted intercept and no trends in the VAR.

Table 3
Cointegration test
(unrestricted intercept and no trends in the VAR)

Test	H_0	H_1	Test-statistics	95% critical values	90% critical values
Trace	r = 0	r >= 1	34.586	17.86	15.75
	r <= 1	r =2	0.573	8.07	6.50
Maximal	r = 0	r = 1	34.013	14.88	12.98
Eigenvalue	r <= 1	r =2	0.573	8.07	6.50

The estimated accelerator model with the long run coefficients and the short run dynamic is shown in Table 4. As the theory predicts GDP i.e. the aggregate demand has a positive and statistically significant influence on the demand for investment goods. More importantly, one percent increase in the aggregate demand leads to one percent increase in the investment, on average, ceteris paribus. The size of this coefficient is in accordance with the one found in other empirical studies. The short run dynamic, as given by the coefficient on the adjustment mechanism is also significant and has the correct sign.

Table 4
Cointegration vector and the short run dynamics[11]

long term relationship	coefficients	standard errors	short run dynamics	coefficients	standard errors
Ln(investment)	1	-	error correction mechanism	-0.844	(0.131)*
Ln(GDP)	-0.962	(0.139)*	intercept	-1.136	(0.188)*
			Seasonal dummy 1	-0.138	(0.025)*
			Seasonal dummy 2	0.018	(0.025)
			Seasonal dummy 3	-0.030	(0.245)
			Dummy variable	-0.188	(0.030)*

* coefficient is statistically significant on 5% level of significance

This model is mainly criticized because it assumes that investment depends solely on changes in aggregate demand. Expectation of the agents, the cost of investing and the macroeconomic environment and policies has absolutely no effect on the investment decisions. In order to account for some of these factors, namely the cost of capital and from here, the influence of the monetary policy on the investment decisions of the firms, in turn we test the neoclassical model.

[11] The complete specification is given in Appendix 2.

3.3. Neoclassical model of investment

The neoclassical theory emphasizes the importance of the user cost of capital in the firms' investment decisions. The user cost of capital is the cost of buying one more unit of capital in the production process and it depends on the real lending rate, depreciation rate and on taxes. If we assume that firms are financing their purchase of capital by borrowing, then every rise in the lending interest rates leads to an increase in the user cost of capital. This link between the interest rate and the investment, through the cost of capital should be especially emphasized because this is the channel through which the macroeconomic policies can influence the real economy. First, the lending interest rate is part of the interest rate transmission channel of the monetary policy i.e. the central bank can influence the inflation if the lending rates are reacting to changes in the central bank's interest rate. If there is a significant relationship between the interest rate of the central bank and the lending interest rates of the commercial banks, then every rise in the central bank's interest rate will lead to higher cost of capital which will ultimately, reduce investment. Second, increased government spending leads to higher income and higher interest rates (through the IS curve) and from here, to increased cost of capital (crowding out effect).

Besides the interest rate, the cost of capital depends upon the rate of depreciation of the capital; higher rate of depreciation means that larger amount of money is needed to replace the wasted capital and hence, means higher cost of capital. In addition to interest and depreciation, the user cost of capital is affected by taxes i.e. by the corporate income tax and the so-called investment tax credits. The higher is the corporate income tax, the higher the cost of capital. The investment tax credits refer to the allowed deduction from taxes if firms invest certain part of their profits. Therefore, investment tax credits decrease the cost of capital. Since the influence of the tax system of the economy on the user cost of capital is mixed the usual practice, if one wants to test for this effect, is to calculate some kind of an effective indicator.

We tried to construct the user cost of capital for Macedonia. However, in the analysis that follows we used the real lending rate as a proxy for the cost of capital. This choice was motivated of at least three arguments. *First*, there is no available data for the rate of depreciation. *Second*, it is very difficult to calculate the effective tax indicator in any transitional country. For example, in the case of Macedonia the annual accounts of enterprises contain a composite data for the costs due to taxes, social and pension contribution and this data is with annual frequency for the 2001-2006 period. We believe that every additional interpolation and assumption will worsen the estimation, instead of improving it. *Third*, the use of the interest rate as a proxy for the user cost of capital is often met in practice (Valadkhani, 2004; Barry et al., 2000; Livermore, 2004).

There are different approaches in the literature regarding the estimation of the neoclassical investment function. Generally, the main question is the choice of the dependent variable i.e. whether to use the gross fixed capital formation or the capital stock as dependent variable. If we follow the investment theory, investment is zero in the moment when the marginal product, which in turn depends on capital and output, is equal to the user cost of capital. Hence, there exists a long run relationship between the stock of capital, the output and the real user cost of capital and this relationship can be tested through cointegration analysis (du Toit and Moolman, 2004; Benk et. al., 2006; Bank of England, 1999). On the other hand, there are number of studies which estimate a long run relationship between investment, output and the user cost of capital (Pelgrin et al., 2002; Valadkhani, 2004). In fact this approach is valid under the assumption of constant rate of growth of capital. The biggest advantage of this model is that one can avoid the use of the capital stock data which is usually constructed or has a bad quality.

For the Macedonian case we follow the second approach. First, because there is publicly available data on capital stock. Second, the assumption of constant (or almost constant) growth rate of capital can be true given that we estimate the investment function for a period of ten years[12]. The neoclassical model with the constant growth rate of capital assumption is presented bellow.

[12] The average growth rate of capital stock in the analyzed period is 1%. The lowest growth rate of capital, with the exception of the 2001 period, is 0.3%, whereas the highest is 2.2%.

The neoclassical model of investment

A representative firm is producing in a perfectly competitive market i.e. the firm cannot influence the market price. The firm's ultimate goal is to maximize the profit, which is equal to the output minus the costs of production (the cost for employing labour and capital).

$$\pi_t = p_t Y_t - \left[w_t L_t + r_t K_t \right] \tag{5}$$

π_t is the profit of the firm, p_t is the price of the output, Y_t is the output, w_t is the cost for labour (the wage), L_t is the labour input, r_t is the user cost of capital and K_t is the capital input.

The firm uses two factors of production, labour and capital and produces according to a Cobb-Douglas production function with constant returns to scale:

$$Y_t = A \cdot K_t^{\alpha} \cdot L_t^{1-\alpha}, \tag{6}$$

α is the contribution of the capital input in the total output.

Firm's profit is maximized when the marginal product of capital is equal to the user cost of capital. The marginal product of capital (MP_K) is a partial derivative of the production function with respect to capital.

$$MP_K = \frac{\alpha Y_t}{K_t} \tag{7}$$

The firm will increase its investment until the marginal product i.e. the marginal benefit of employing another unit of the capital, is greater than the user cost of capital i.e. the cost needed to employ an additional unit. In the long run the marginal product of capital is equal to the cost of capital. Solving this relation for the desired level of capital, K^*, we obtain the long relationship:

$$\frac{\alpha Y}{K} = r \qquad \Rightarrow \qquad K^* = \frac{\alpha Y}{r} \tag{8}$$

If the growth rate of capital is constant (equation 9), then following the law of capital accumulation (equation 1) we get:

$$K_{t-1} = \frac{K_t}{(1+g)} \tag{9}$$

$$I_t = K_t - (1-\delta) \cdot \frac{K_t}{(1+g)} \quad \Rightarrow \quad I_t = \frac{(g+\delta)}{(1+g)} K_t \tag{10}$$

The long run relationship in this case is equal to:

$$I = \frac{(g+\delta)}{(1+g)} \cdot \alpha \frac{Y}{r}, \text{ or in logarithmic form} \tag{11}$$

$$\log I = con + \log Y + \log r, \text{ where} \tag{12}$$

$$con = \log(g+\delta) + \log(\alpha) - \log(1+g)$$

3.3.1. Estimation of the neoclassical investment function

The neoclassical investment function with constant growth rate of capital is estimated with the real lending interest rate as proxy for the user cost of capital and in logarithmic form.

$$\ln I = con + \ln Y + \ln irate \quad (13)$$

We include the following variables in the model: GDP, as an indicator for the aggregate output, and gross fixed capital formation, as an indicator for the firms' investment, both of them expressed in 1997 prices. The real lending rate represents the real user cost of capital[13]. Additionally, we include the inflation (π) as an indicator of the macroeconomic stability in the economy. The cointegration test, the estimated long run relationship and the short run dynamics, with the error correction mechanism are given in Table 5 and Table 6.

Table 5
Cointegration test

Test	H_0	H_1	Test-statistics	95% critical value	90% critical value
Trace	r = 0	r >= 1	38.885	38.930	35.880
	r <= 1	r =2	6.073	23.320	20.750
	r <= 2	r =3	1.257	11.470	9.530
Maximal Eigenvalue	r = 0	r = 1	32.812	24.590	22.150
	r <= 1	r =2	4.816	18.060	15.980
	r <= 2	r =3	1.257	11.470	9.530

Table 6
Cointegration vector and short run dynamics[14]

long term relationship	coefficients	standard errors	short run dynamics	coefficients	standard errors
Ln(investment)	1	-	error correction mechanism	-0.726	(0.134)*
Ln(GDP)	-0.728	(0.304)*	Δ Ln(investment)	-0.006	(0.129)
Ln(Interest rate)	0.032	(0.064)	Δ Ln(GDP)	-0.866	(0.295)*
Ln(Inflation)	0.008	(0.006)	Δ Ln(Interest rate)	-0.480	(0.201)*
			Δ Ln(Inflation)	0.0005	(0.003)

* coefficient is statistically significant on 5% level of significance

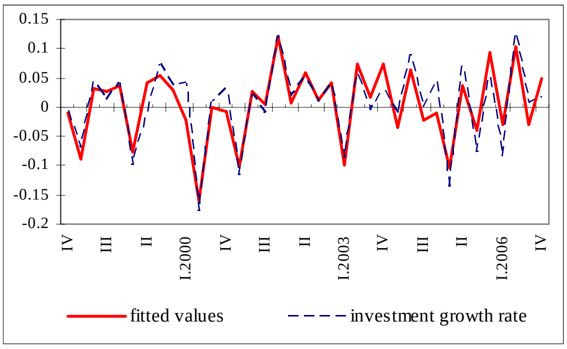
Johansen cointegration test confirmed that there is a long run relationship between the variables. As in the accelerator model, there exists a stable, positive and statistically significant relationship between the output and the investment, even though when compared to the accelerator model the estimated coefficient is slightly smaller. The other two variables,

[13] The unit root tests are given in Appendix 1.
[14] In the fully specified model, presented in Appendix 3, we included seasonal dummies, namely because of the seasonal pattern of GDP, and dummy variable for the period from the second quarter of 2000 to the third quarter of 2001.

the real lending rate and the inflation are not statistically significant on the conventional levels of significance. Regarding the coefficient on inflation we argue that there is a possibility that the investment decisions in Macedonia are conducted without taking into account the rate of inflation given the long period of low and stable inflation. It is possible that, when inflation is stable and low, the demand for investment good depends on other factors, one of which can be the expected future economic growth.

The lending rate is statistically significant in the short run and statistically insignificant in the long run. There are two possible explanations for this result. First, according to the theory investment depends upon the user cost of capital which is composite of more factors. In our case we used only the interest rate and we ignored the influence of the taxes and the rate of depreciation. Second, the period under examination is characterized with very high real interest rates, especially in the first half. In such circumstances, arguably, firms didn't finance their investments through borrowing; they used other alternative sources. In fact, according to the official data only 16% of the investment is financed through borrowing in the 1999-2006 period[15]. This situation is changing in the last few years when there is a downward trend in the interest rates. This, accompanied with softer constraints on borrowing, increases the importance of the interest rate for the investment decisions. Additionally, we estimated the investment function for the 1997-2006 period, whereas the intensification of the banking lending activity to the private sector starts from the 2003. These arguments can justify the insignificant long run coefficient. The significant coefficient in the short run means that the interest rate is an important variable for the short term agents' decisions.

Figure 7
Fitted values of the growth rate of investment (%)



The fit of the equation i.e. the changes between the growth rate of investment and its fitted values as shown in Figure 7, and the diagnostic tests presented in Table 7 suggest that the neoclassical model is well specified.

[15] The data is from the State Statistical Office.

Table 7
Diagnostic tests

null hypothesis	degrees of freedom	Test-statistics	p-values
The residuals are serially uncorrelated	χ^2 (4)	5.103	0.277
The model is well specified	χ^2 (1)	2.120	0.145
The residuals are normally distributed	χ^2 (2)	0.285	0.867
Homoscedasticity	χ^2 (1)	0.973	0.324

3.4 Comparison of the results

Having in mind the primary objective of the research - improvement of the MAKMODEL's investment function, in this part of the research we compare the results from the estimated models, the accelerator and the neoclassical model, with the MACMODEL's investment function.

In MAKMODEL the GDP coefficient is calibrated, not estimated. Also, it is calibrated as one meaning that one percent increase in GDP leads to a one percent increase in investment, on average, ceteris paribus. Models estimated in this research suggest that one percent increase in GDP will cause a rise in investment of one percent, in the accelerator model and a rise of 0.7 percents, in the neoclassical model. Moreover both of the estimated coefficients are statistically significant at a 5% level of statistical significance. Compared to other countries, the estimated GDP coefficients for Macedonia are slightly different. Namely, this coefficient is estimated as 0.94 for Albania (Dushku et al., 2006), between 0.93 and 1.23 for the OECD countries (Pelgrin et al., 2002), 1.43 for Iran (Valadkhani, 2004) and 0.99 for Namibia (Eita and Du Toit., 2007). This difference between the estimated coefficients is logical given that there are country specific characteristics and that each specification of the investment function is different to reflect these characteristics.

Table 8
MAKMODEL, the accelerator model and the neoclassical model[16]

	GDP	interest rate	changes in the interest rate (-1)	error correction mechanism
The accelerator model	0.962*			- 0.844*
The neoclassical model	0.728*	- 0.032	- 0.480*	- 0.726*
MACMODEL	1		- 0.002*	- 0.88*

* coefficient is statistically significant on 5% level of significance

[16] The GDP coefficient in the MACMODEL is calibrated.

The cost of capital, as proxied by the real lending rate is not included in the long run equilibrium relationship in the MAKMODEL, whereas in the short run it is statistically significant and has the correct negative sign, but the size of the coefficient is rather small. Put differently, a one percent increase in the rate of growth of the interest will lead to 0.002 percents decrease in the growth of investment. In our neoclassical model we obtained an insignificant coefficient in the long run, but with the correct negative sign. As argued above, this result can be due to missing variables in the specification of the cost of capital, on one hand and to the fact that the interest rate is becoming important determinant in the economic environment only in recent years, on the other hand. In the short run we obtained a statistically significant coefficient suggesting that a one percent increase in the rate of growth of the interest will reduce the growth in investment for 0.4%. This result emphasizes the real lending interest rate as one possible factor through which the monetary authorities can influence the real economy.

4. Concluding remarks and recommendations for future research

This research showed that the output is an important determinant of investment spending and from here, of the long run level of capital in the economy. In both estimated models we obtained a statistically significant, positive and around one coefficient of GDP; in the MAKMODEL this coefficient was calibrated to one. On the other hand, the real lending rate is important for the demand of investment goods, but only in the short run. However, this result is justified on the basis of the characteristics of the Macedonian economy and the use of the interest rate instead of the cost of capital in the investment function.

Nevertheless, we do not aim to over state this results. First, the sample period of ten years is too short for cointegration analysis; for comparisons the investment function for Iran is estimated for a period of forty years. Second, the official data on investment is with annual frequency; the quarterly data is obtained by interpolation.

Additionally, one should have in mind that the theories of investment are theories of enterprises' investment. In this research we used the gross fixed capital formation which besides the investment of the enterprises includes the households' and public investment. It would be more appropriate to estimate both models only with the investment of the enterprises as dependent variable and to model the households' and the public investments as exogenous variables (Benk et. al, 2006).

The neoclassical model can be augmented by adding certain financial variables in the model. The goodness of fit of around 80% in both, the accelerator and in the neoclassical model, suggests that there are some explanatory variables missing from the investment function. For example, one can include financial market indicators, such as the stock of private credits, in order to capture the degree of financial intermediation or the ratio of stock market capitalization to GDP, to capture the ease with which funds can be raised in the equity market (Pelgrin et. al., 2002). However, at the moment we believe that this variables do not influence investment decisions in Macedonia given that financial markets are still underdeveloped. We leave this recommendation for some future extension of this research.

References

Bank of England (1999), “Economic Models at the Bank of England”, London: Bank of England.

Batista C. and Zalduendo J. (2004), "Can the IMF’s Medium-Term Growth Projections be Improved?", IMF Working Paper 04/203

Barry F., Bradley J., Kejak M. and Vavra D. (2000), "The Czech Economic Transition: Exploring Options Using a Macrosectoral Model", CERGE EI Working Paper, October

Benk S., Jakab Z. M., Kovács M. A., Párkányi B., Reppa Z. and Vadas G. (2006), "The Hungarian Quarterly Projection Model (NEM)", Magyar Nemzeti Bank Occasional Papers 60.

Berndt R. E. (1991), *Econometrics: classic and contemporary*, Addison-Wesley Publishing Company

Chow C. G. (2006), "New capital estimates for China: Comments", *China Economic Review*, 17, p.186–192.

Clark, J. M. (1917), "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles", *Journal of political economy*, 25:1, p. 217-235.

Dornbusch R. and Fischer S. (1994), “Macroeconomics”, McGraw-Hill.

Doyle P., Kuijs L. and Jiang G. (2001), "Real Convergence to EU Income Levels: Central Europe from 1990 to the Long Term", IMF Working Paper 01/146

Du Toit C. and Moolman E. (2004), "A neoclassical investment function of the South African economy", *Economic Modelling*, 21, p. 647–660.

Dushku E., Binaj G.and Kota V. (2006), "A Macro Econometric Model Approach for Albania", Bank of Albania, Research Department.

Eita J. H. and Du Toit C. (2007), "Explaining Investment Behaviour of the Namibian Economy", The Economic Society of South Africa, 2007, conference paper

Faroque A. and Minor R. (2002), "What determines business fixed investment? Evidence from the Canadian economy", *Applied Economics Letters*, 9, p.497-500.

Fic T., Kolasa M., Kot A., Karol Murawski K., Rubaszek M. and Tarnicka M. (2005), "ECMOD Model of the Polish Economy", National Bank of Poland Working Paper No. 36.

Felipe J. (2005), "Aggregate Investment in the People's Republic of China: A Comment", Centre for Applied Macroeconomic Analysis Working Paper No. 17.

Gomme P. and Rupert P. (2007), "Theory, measurement and calibration of macroeconomic models", *Journal of Monetary Policy*, Vol.54, p.460–497.

IMF (2006), “Former Yugoslav Republic of Macedonia: Selected Issues”, IMF Country Report No. 06/345.

Jorgenson, D. W. (1963), "Capital Theory and Investment Behaviour", *American Economic Review*, 53:2, 247-259.

Jorgenson, D. W. (1971), "Econometric Studies of Investment Behaviour: A Survey", *Journal of Economic Literature*, 9:4, 1111-1147.

Livermore S. (2004), "An Econometric Model of the Slovak Republic", Financial Policy Institute, Ministry of Finance of the Slovak Republic.

Pelgrin, F., S. Schich and A. de Serres (2002), "Increases in Business Investment Rates in OECD Countries in the 1990s: How Much Can be Explained by Fundamentals?", OECD Economics Department Working Papers, No. 327, OECD Publishing.

Pula, Gabor (2003), “Capital stock estimation in Hungary: a brief description of methodology and results”, MNB working paper 2003/7, Hungarian central bank

Room, Marit (2001), “Potential Output Estimates for Central and East European Countries Using Production Function Method”, Working Papers of Eesti Pank No 2

Singh R. (2006), "An Investment Equation for Fiji", University of the South Pacific - School of Economics Working Paper No. 1.

Shapiro M. D. (1986), "Investment, Output and the Cost of Capital", *Brookings Papers on Economic Activity*, 111-164.

Tobin J. (1969), "A General Equilibrium Approach to Monetary Theory", *Journal of Money, Credit and Banking*, 39:5, 845-855.

Turner D., Richardson P. and Rauffet S. (1996), "Modelling the supply side of the seven major OECD countries", OECD Economics Department Working Papers, No. 167, OECD Publishing.

Valadkhani A. (2004), "What determines private investment in Iran?", *International Journal of Social Economics*, Vol. 31 No. 5/6, 2004, p. 457-468.

Vikram N. and Dhareshwar A. (1993), "A New Database on Physical Capital Stock: Sources, Methodology and Results", *Rivista de Analisis Economico* 8 (1) p. 37-59

APPENDICIES

Appendix 1 - Unit root tests

Data	Model	Lags in the ADF test	ADF	PP
Ln(GDP)	Intercept	0	-0.453	-0.409 (0,898)
	Trend and intercept	0	-1.771	-1.912 (0,629)
	No trend and intercept	0	2.255**	2.492 (0,996)
Ln(Gross fixed capital formation)	Intercept	1	-1.269	-2.352 (0,162)
	Trend and intercept	0	-3.781**	-3.777 (0,029)**
	No trend and intercept	1	0.592	0.987 (0,912)
Ln(Real lending rate)	Intercept	0	-1.020	-1.190 (0,669)
	Trend and intercept	1	-2.686	-2.375 (0,386)
	No trend and intercept	0	-1.261	-1.208 (0,204)
Ln(CPI index)	Intercept	0	-0.859	-0.611 (0,857)
	Trend and intercept	0	-2.361	-2.457 (0,346)
	No trend and intercept	0	1.505	3.092 (0,999)
Δ Ln(GDP)	Intercept	0	-7.208***	-7.138 (0,000)***
	Trend and intercept	0	-7.116***	-7.054 (0,000)***
	No trend and intercept	1	-3.101***	-6.356 (0,000)***
Δ Ln(Gross fixed capital formation)	Intercept	0	-9.534***	-14.824 (0,000)***
	Trend and intercept	0	-9.582***	-28.606 (0,000)***
	No trend and intercept	0	-9.597***	-11.486 (0,000)***
Δ Ln(Real lending rate)	Intercept	0	-5.286***	-5.298 (0,000)***
	Trend and intercept	0	-5.222***	-5.222 (0,001)***
	No trend and intercept	0	-5.191***	-5.201 (0,000)***
Δ Ln(CPI index)	Intercept	0	-6.042***	-6.457 (0,000)***
	Trend and intercept	0	-5.960***	-6.360 (0,000)***
	No trend and intercept	0	-5.700***	-5.704 (0,000)***

Notes:

1. */**/*** significance at 10%, 5%, and 1% level of significance.
2. In both tests the null hypothesis is that the series has a unit root.
3. The critical values for the Augmented Dickey Fuller test (ADF) with no lags and an intercept are -3.610/ -2.939/ -2.608, with no lags and an intercept and a trend are -4.212/ -3.530/ -3.196 and with no lags and no trend and intercept are -2.626/ -1.949/ -1.612.
4. The critical values for the Augmented Dickey Fuller test (ADF) with one lag and an intercept are -3.616/ -2.941/ -1.611, with no lags and an intercept and a trend are -4.219/ -3.533/ -3.198 and with no lags and no trend and intercept are -2.627/ -1.949/ -1.611.
5. The p-values in the Phillips Perron test (PP) are given in the brackets.

Appendix 2 - The accelerator model

Cointegraction vector and the short run dynamics

```
              ML estimates subject to exactly identifying restriction(s)
          Estimates of Restricted Cointegrating Relations (SE's in Brackets)
                             Converged after 2 iterations
         Cointegration with unrestricted intercepts and no trends in the VAR
*******************************************************************************
39 observations from 1997Q2 to 2006Q4. Order of VAR = 1, chosen r =1.
List of variables included in the cointegrating vector:
LINV           LGDP
List of I(0) variables included in the VAR:
S1             S2              S3              DUM2000
*******************************************************************************
List of imposed restriction(s) on cointegrating vectors:
a1=-1
*******************************************************************************
Vector  1
LINV              1.0000
                  (*NONE*)

LGDP               -.96166
                  ( .13879)

*******************************************************************************
LL subject to exactly identifying restrictions= 163.9194
*******************************************************************************
         ECM for variable LINV estimated by OLS based on cointegrating VAR(1)
*******************************************************************************
 Dependent variable is dLINV
 39 observations used for estimation from 1997Q2 to 2006Q4
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 Intercept                 -1.1357              .18751            -6.0566[.000]
 ecm1(-1)                  -.84429              .13063             6.4630[.000]
 S1                        -.13813             .024906            -5.5462[.000]
 S2                        .018305             .024966             .73320[.469]
 S3                       -.030227             .024470            -1.2353[.225]
 DUM2000                   -.18832             .030029            -6.2712[.000]
*******************************************************************************
 R-Squared                       .74062   R-Bar-Squared                   .70132
 S.E. of Regression             .053963   F-stat.    F(  5,  33)   18.8449[.000]
 Mean of Dependent Variable  .0062126   S.D. of Dependent Variable     .098739
 Residual Sum of Squares        .096096   Equation Log-likelihood        61.7778
 Akaike Info. Criterion         55.7778   Schwarz Bayesian Criterion     50.7871
 DW-statistic                    2.2436   System Log-likelihood         163.9194
*******************************************************************************
                               Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   4)=   6.5334[.163]*F(   4,  29)=   1.4590[.240]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   5.2229[.022]*F(   1,  32)=   4.9481[.033]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=   1.7699[.413]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .45686[.499]*F(   1,  37)=   .43857[.512]*
*******************************************************************************
```

Appendix 3 - The neoclassical model

Cointegraction vector and the short run dynamics

```
          ML estimates subject to exactly identifying restriction(s)
      Estimates of Restricted Cointegrating Relations (SE's in Brackets)
                     Converged after 2 iterations
     Cointegration with unrestricted intercepts and no trends in the VAR
*******************************************************************************
 37 observations from 1997Q4 to 2006Q4. Order of VAR = 2, chosen r =1.
 List of variables included in the cointegrating vector:
 LINV            LGDP            LIRATE          INF1
 List of I(1) exogenous variables included in the VAR:
 INF1
 List of I(0) variables included in the VAR:
 S1              S2              S3              DUM2000
*******************************************************************************
 List of imposed restriction(s) on cointegrating vectors:
 a1=1
*******************************************************************************
                  Vector  1
 LINV                 1.0000
                  (   *NONE*)

 LGDP                -.72826
                  (   .30400)

 LIRATE              .032255
                  (  .064644)

 INF1               .0081576
                  ( .0061507)

*******************************************************************************
 LL subject to exactly identifying restrictions= 257.5570
*******************************************************************************


         ECM for variable LINV estimated by OLS based on cointegrating VAR(2)
*******************************************************************************
 Dependent variable is dLINV
 37 observations used for estimation from 1997Q4 to 2006Q4
*******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 Intercept                  .92708              .15983            5.8005[.000]
 dLINV1                  -.0059947              .12891          -.046503[.963]
 dLGDP1                    -.86591              .29542           -2.9311[.007]
 dLIRATE1                  -.47974              .20097           -2.3871[.024]
 dINF11                   .4515E-3            .0032845            .13747[.892]
 ecm1(-1)                  -.72595              .13418           -5.4102[.000]
 S1                       -.080147             .022792           -3.5165[.002]
 S2                       -.098980             .037420           -2.6451[.013]
 S3                       .0078237             .020230            .38674[.702]
 DUM2000                   -.14534             .020762           -7.0002[.000]
*******************************************************************************
 R-Squared                     .82191   R-Bar-Squared                   .76255
 S.E. of Regression           .033808   F-stat.    F(  9,  27)   13.8453[.000]
 Mean of Dependent Variable  .0045174   S.D. of Dependent Variable     .069379
 Residual Sum of Squares      .030861   Equation Log-likelihood        78.6493
 Akaike Info. Criterion       68.6493   Schwarz Bayesian Criterion     60.5947
 DW-statistic                  2.0033   System Log-likelihood         257.5570
*******************************************************************************
                             Diagnostic Tests
*******************************************************************************
*    Test Statistics  *        LM Version        *         F Version          *
*******************************************************************************
*                     *                          *                            *
* A:Serial Correlation*CHSQ(   4)=   5.1033[.277]*F(   4,  23)=   .91998[.469]*
*                     *                          *                            *
* B:Functional Form   *CHSQ(   1)=   2.1202[.145]*F(   1,  26)=   1.5804[.220]*
*                     *                          *                            *
* C:Normality         *CHSQ(   2)=   .28542[.867]*       Not applicable       *
*                     *                          *                            *
* D:Heteroscedasticity*CHSQ(   1)=   .97280[.324]*F(   1,  35)=   .94507[.338]*
```