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ARDL investment model of Tunisia

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Abstract. *The paper investigates the determinants of investments in Tunisia using annual data over the period of 1961-2011. The importance of this study comes from the necessity to determine important factors influencing domestic investments in Tunisia. An Autoregressive Distributed Lag (ARDL) modeling is employed to investigate the impact of the gross domestic product, monetary base and trade openness on domestic investments. Our results reveal that there is an equilibrium relationship between investments and monetary base, the influence of the others is insignificant or rather ambiguous.*

Keywords: cointegration; domestic investments; ARDL; bounds test; Tunisia.

JEL Codes: E22, E52.
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1. Introduction

Capital formation is a crucial factor in economic development. Countries having accumulated high levels of investments long-term and systematically belong today to the most developed countries. The effects of the investments on economic growth are two-fold. First, demand for investment goods forms a part of aggregate demand in the economy. Thus, any investment incentives stimulate both the domestic demand and economic growth, respectively. Second, the capital formation increases the productive capacity of the economy and improves its technical level to be able to produce more outputs.

The main purpose of the study is to investigate the short and long run effects of various macroeconomics variables on domestic investments in Tunisia, which is currently facing all the problems typical for the post-revolutionary period as well as problems caused by effects of massive recession of the European countries.

The rest of the paper is organized as follows: section 2 reviews Tunisian economic background. This is followed by the relevant theoretical considerations in section 3. Section 4 contains data description, section 5 provides us with details of econometric methodology and section 6 gives the empirical results. Finally, the last section presents the conclusion remarks.

2. Background of Tunisian economy

Tunisia's strategic location made it for a long time as a very specific country for investment, production and trade. It represents a meeting point between Europe, on the one hand, and the Middle East and Africa, on the other hand. The democratic changes achieved after the Tunisian 2010/11 revolution revealed new potential and opportunities for the future development. On the other side, the Tunisian economy has already been characterized by free market economy features and openness to the international competition for an unusually long period. The government's control role in the economy began to weaken after political tensions in the second half of the eighties and was accompanied by the privatization and simplification of the tax structure. In this time, Tunisia has adopted a series of structural economic reforms designed to give dynamics to the market mechanisms and encourage private initiative through price liberalization, foreign trade and approving the conversion of the domestic currency (Tunisian Dinar). This period was accompanied by above-average economy growth rates and slowing the inflation. The main role in the growth played the tourism and trade sectors. The free market principles introduction issued in signing the membership agreement with the World Trade

Organization in 1995 and a free trade zone agreement with the European Union in 1998.

In addition, the progressive social policy associated with the free market principles have stimulated raise of the standard of living. Real growth, which averaged 5 percent for much of the 2000s, declined to 4.4 percent in 2008 and 0.7 percent in 2009 due to the global recession and weakening demand in Europe. On the other hand, further approximation of the economic policy to the free market standards after the 2010/11 revolution represents a new potential for further economic development.

Tunisia currently faces new challenges, such as economization of the public sector, privatization, foreign direct investment attraction, reduction of the trade deficit and reduction of the social inequalities. Its GDP in 2010 was US$ 43.863 billion, growing 3.79 percent and is expected to increase by 3.83 percent to US$ 45.543 billion in 2011. The 2015 forecasts predict Tunisia GDP will grow to US$ 57.201 billion, increasing at a rate of about 6 percent per year from 2012 onwards.

Latest statistics for Tunisia in 2010 indicate 10.8 percent of the labor force is employed in agriculture, 28.3 percent in industry and 61 percent in services. Tunisia population in 2010 was 10.544 million and is expected to grow to 11.108 million by 2015. As in 2010, Tunisia unemployment rate was 13.2 percent; however it is expected to decline to 12.9 percent by 2015.

3. Theoretical issues

Theoretical investment modeling in conditions of the Arabic countries is restricted to the concepts avoiding use of the interest rates. In addition, the disposable dataset using macroeconomic aggregates instead of firms-level data also restricts our theoretical background. That is why we neglected some specific approaches (e.g. the liquidity theory may serve as representative example) and decided to find the roots for our explanation in terms of the traditional macroeconomic theories.

The idea of our modeling is the following. First, we suppose that there is a relation between money supply and investments. From the theoretical point of view, the aggregate demand containing its investments part is generally derived from demand for money. According to Friedman (1956), when money supply increases, economy agents will have no incentives to hold supplementary money and start their spending to achieve new real assets-money equilibrium. Consequently, the aggregate demand containing also private investments rises. On the other hand, there exists also a contradictory money neutrality hypothesis supported mainly by neoclassical school.

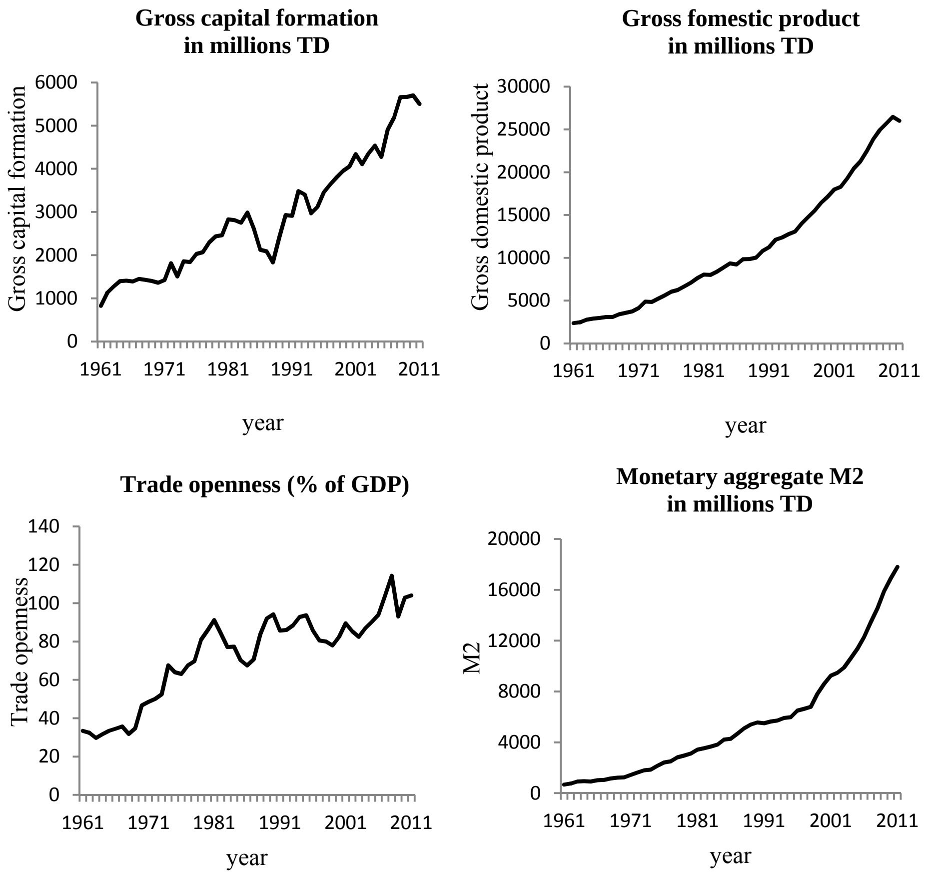
In order to explain the relation between real GDP and investment, we can appeal to the Accelerator Hypothesis (the simplest accelerator model invented by J. M. Clark in 1917), according to which the level of net investment depends on the change in expected output. The theory states that any temporary change in output could lead to the change in investment spending (Gordon, 2009). Another form of this theory is Flexible Accelerator theory – dynamic multiplier model of business (Goodwin, 1951), which considers adaptive expectations. Flexible accelerator models are nowadays under active development (see e.g. Zambelli, 2012).

Moreover, there are three main transmission mechanism channels, besides those on interest rates and debt instruments, through which the monetary policy can affect the economy (e.g. in our case investment): stock market prices, real estate prices and exchange rates (Mishkin, 2009). First of all we can mention stock market effects on investment (Tobin's q-theory; Tobin, 1969). Mishkin (2009) stated that expansionary monetary policy (increasing money supply) leads to increase of the stock prices, decrease of the cost of capital that consequently causes rising of the investments and output in the whole economy. Secondly, bank balance sheets can affect investments through real estate prices effect flowing from monetary expansion. Expansionary monetary policy causes real estate prices increase. For banks, the value of real estate is collateral in order to minimize credit risk from the provided loan. If real estate prices rise, potential banks' loan losses will decrease and the bank capital will increase. Therefore banks will be ready to provide more loans and investments will rise. The impact of real estate prices on investment was analyzed for example by Chaney et al. (2010).

The review of above mentioned mechanisms and dataset limitations leads us to test a compound model covering more of the above mentioned theories. We use the gross domestic product, monetary base, trade openness as the explanatory variables of the domestic investments. Here, in line with above mentioned investment theories, we hypothesize that the investments are positively related to the levels of the real GDP and monetary base. The trade openness is suggested to be another important positive determinant of investments in developing countries as it represents accessibility to modern technologies for domestic country.

4. Data

Our study uses an annual time series data covering the period from 1961 to 2011. The data were retrieved from the World Bank database and are given in constant prices of local currency unit (in millions of Tunisian Dinar – TD). The considered variables are: INV – gross capital formation, GDP – gross domestic product, MB – monetary aggregate M2. Trade openness TROPENS is measured as a percentage share of the Export + Import on the GDP. The dummy variable (DUM; 1 in 1985-1988, 0-otherwise) was included to consider the political and economy crisis period 1984-1988. The time series evolution is given in Figure 1. For the computational purpose, the logs of the time series were used.



Note: data are in constant prices, TD = Tunisian dinar (local currency unit),
Source: output from R, data based on World Bank database (WDI).

Figure 1. *Investments and their determinants in the Tunisian economy*

5. Methodology

Nonstationarity, a property common to the many macroeconomic and financial time series, can incorporate the spurious correlation error into the econometric methodology. For this reason, the differencing and logarithmic transformation is needed to stabilize the time series, which are used for further processing. The non-stationary data are utilized only to model the long-run equilibrium defined as a stationary linear combination of the respective time series. Then, each deviation from the equilibrium is assumed to be corrected in the next period (Engle, Granger, 1987).

So far many econometric methods have been proposed for investigation of the long-run equilibrium cointegration approach with many time series variables. The seminal works of Engle and Granger (1987), Phillips and Hansen (1990), and Johansen (1988) are most recognized examples of the boosting research of the late 20-nth century. For the purpose of our study we chose the Autoregressive Distributed Lag (ARDL) modelling approach developed by Pesaran and Pesaran (1997), Pesaran and Smith (1998), and Pesaran et al. (2001). The ARDL is becoming popular because of several advantages in comparison with other single equation cointegration procedures. It results from the ability to estimate the long and short-run parameters of the model simultaneously for the avoidance of the problems posed by non-stationary time series data. In addition, this approach does not require a prior determination of the order of the integration amongst the variables, unlike other approaches which require that the variables pose the same order of integration. Furthermore, the ARDL procedure is statistically much more significant approach to determine the cointegration relationship in small samples, which allows different optimal lags of variables.

Following the empirical literature, the standard log-linear functional specification of the long-run relationship for domestic investment equation nesting theoretical approaches introduced in the previous section may be expressed as:

$$INV_t=F(GDP_t,MB_t,TROPENS_t,u_t)\ , \qquad (1)$$

where u denotes an error term t is a time index.

To investigate the presence of the long-run relationship, a bounds test based on the Wald or F-statistics was proposed by Pesaran (2001). The asymptotic distribution of the F statistics is non-standard under the null hypothesis of no cointegration relationship between the examined variables, irrespective of whether the explanatory variables are purely I(0) or I(1). The cointegration relationship for the domestic investment equation is estimated using the bounds test, which is based on the following Unrestricted Error Correction Model (UECM):

$$\Delta lnINV_t = b_o + \sum_{i=0}^{p} b_1 \Delta lnGDP_{t-i} + \sum_{i=0}^{p} b_2 \Delta lnMB_{t-i} +$$
$$+ \sum_{i=0}^{p} b_3 \Delta lnTROPENS_{t-i} + \sum_{i=1}^{p} b_4 \Delta lnINV_{t-i} +$$
$$+ b_5 lnGDP_{t-1} + b_6 lnMB_{t-1} + b_7 lnTROPENS_{t-1} +$$
$$+ b_8 lnINV_{t-1} + b_9 DUM_{t-1} + u_t \qquad (2)$$

where ΔlnINV, ΔlnGDP, ΔlnTROPENS, and ΔlnMB are the first differences of the logarithms of the respective variables.

The null hypothesis is tested by considering the unrestricted ECM for domestic investment equation in (2) excluding the lagged variables lnINV, lnGDP, lnTROPENS, lnMB and DUM; more formally, we perform a joint significance test, where the null and alternative hypotheses are:

H_o: $b_5 = b_6 = b_7 = b_8 = b_9 = 0$

H_1: $b_5 \neq b_6 \neq b_7 \neq b_8 \neq b_9 \neq 0$

Narayan (2004) tabulated two sets of critical values – the upper bound critical values refers to the I(1) series and the lower bound critical values to the I(0) series. For some significance level, if the F-statistics falls outside the critical bound, a conclusive inference can be made without considering the order of integration of the explanatory variables. For example, if the F-statistic is higher than the critical bound the null hypothesis of no cointegration is rejected. In the case when the F-statistic falls between the upper and lower bounds, a conclusive inference cannot be made. Here, the order of integration for the explanatory variables must be known before any conclusion drawing conclusions.

The long-term ARDL(q1,q2,q3,q4) equilibrium relation is given as

$$lnINV_t = \alpha_o + \sum_{i=1}^{q1} a_1 lnINV_{t-i} + \sum_{i=0}^{q2} a_2 lnGDP_{t-i} + \sum_{i=0}^{q3} a_3 lnMB_{t-i} +$$
$$+ \sum_{i=0}^{q4} a_4 lnTROPENS_{t-i} + d\,DUM_t + \varepsilon_t, \qquad (3)$$

where ε_t is defined as the gap (term error is used more frequently) between the $\ln(INV_t)$ and its equilibrium level, which is to be filled in the next period. Then, the resulting model is in the form

$$\Delta\ln INV_t = c_o + \sum_{i=1}^{q} c_1 \ln\Delta INV_{t-i} + \sum_{i=0}^{q} c_2 \Delta\ln GDP_{t-i} + \sum_{i=0}^{q} c_3 \Delta\ln MB_{t-i} +$$

$$+ \sum_{i=0}^{q} c_4 \Delta\ln TROPENS_{t-i} + c_5 \varepsilon_{t-1} + u_t \ , \qquad (4)$$

Here, the estimated coefficient is expected to be negative and is interpreted as a speed of adjustment for the explained variable towards the equilibrium. To ascertain the goodness of fit of the ARDL model, the diagnostic and stability tests are conducted. The diagnostic test examines the serial correlation, functional form, normality and heteroscedasticity associated with the model. The stability tests of the regression coefficients were also performed.

6. Empirical results

Using the Dolado, Sosvila-Rivero, Jenkinson (1990) methodology, we found out that there is no deterministic trend in the investigated time series. Then, instead of the traditional ADF test, we examined the presence of the unit roots by the modified Dickey – Fuller Generalized Least Square (DF-GLS test) because of his higher power and better seize properties compared to the standard Augmented Dicky-Fuller (ADF) unit root tests. We applied DF-GLS tests for both the levels and their first differences (Table 1). As the results were not clear enough (see case of lnINV), and there persists suspicion of lnINV to be integrated of order 2 (not applicable in the ARDL approach), we estimated the first order autocorrelation of its second differences to be – 0.58, which signals the time series over differencing. That is why we concluded the DF-GLS test unfavourable results on the differenced INV time series to be just realization of the statistical Type II. error and lnINV time series was further considered being integrated of order 1 .

Table 1

Modified Dicky-Fuller (DF-GLS) unit roots tests

Variables	Tau stat., levels, (lag)		Tau stat., differences, (lag)	
LINV	1.01	(4)	-1.18	(2)
LGDP	-0.30	(4)	-6.99 *	(1)
LMB	0.29	(5)	-2.01 *	(2)
LOPENNS	-0.13	(1)	-6.00 *	(1)

Note: * indicates significance at 5% level

Source: output from R.

The ARDL procedure starts with determining of an appropriate lag order (p) in equation (1). For this purpose, we used the Akaike Information Criterion (AIC) indicating that p = 1 is the most appropriate lag length for the investment equation. In the following step we tested for the presence of long run relationships in the investment model (1). The results of the bound test indicate that the calculated F statistics 4.241 surpassed the upper bound critical value 3.264 (Narayan, 2004 tables, Case II. model, p. 28) and the null hypothesis of no cointegration is rejected. It means there is a long-term equilibrium among the considered variables, in the examined period. Then, the long-run equation (2) was estimated using the optimal ARDL(q1,q2,q3,q4) order according to the Akaike Information Criterion. The initial maximal lag in the equation (2) has been set equal 2, which is the maximal order recommended by Pesaran and Shin (1999) for annual data. The estimated long term elasticities are given in Table 2.

Table 2

Investment long term equilibrium

Regressor	Coefficient	STD
LGDP	1.442 ***	0.309
LGDP(-1)	- 2.073 ***	0.438
LGDP(-2)	0.598 *	0.332
Σ	- 0.033	
LMB	- 0.175	0.303
LMB(-1)	0.790 **	0.303
LMB(-2)	- 0.400 *	0.214
Σ	0.215	
DUM	- 0.183 ***	0.032
LINV(-1)	0.647 ***	0.084
C	1.284 **	0.528

Note: *, ** and *** indicates significance at 10, 5 and 1% level.
Source: output from R.

As shown in Table 2, the presence of significant lags of the respective variables evokes several questions. It shows that the long run equilibrium is underpinning a more complicated dynamic structure and the possible persisting autocorrelation in the error term ε_t would become critical for correct interpretation of the speed of adjustment towards equilibrium coefficient c_5. Fortunately, the respective autocorrelation coefficient (0.03) proved to be not statistically significant and autoregressive polynomial distributed structure given in Table 2 seems to explain the long term equilibrium dynamics well. However, the interpretation of the estimated particular elasticities having opposite signs in different lags is not straightforward. That is why we introduced the sums of the respective elasticities, which are listed in Table 2. They should be interpreted as an average elasticity. Then, the comprehensive long-term influence of the GDP on Investments seems to be statistically insignificant, while in the case of the monetary base, its increase by 1% would invoke Investments increase by 0.215%. This fact favours the explanation of the long term trends in light of the liquidity theory if compared to the accelerator like approaches.

Having quantified the error term ε_t, we follow by the estimation of the final model (4). The optimal lag was selected according to the Akaike Information Criteria. The estimated results are given in Table 3.

Table 3

Error correction estimates of investment model

Dependent variable is Δln*INV*		
Regressor	Coefficient	STD
Δln_*INV(-1)*	0.440 **	0.193
Δln_*GDP*	1.394 ***	0.412
Δln_*GDP(-1)*	-2.031 ***	0.567
Δln_*MB*	-0.262	0.316
Δln_*MB(-1)*	0.905 ***	0.287
Δln_*TROPENS*	0.039	0.134
Δln_*TROPENS(-1)*	0.054	0.134
ε(-1)	-0.948 ***	0.308
const	0.006	0.030

Note: R-squared = 0.58; F(8,39) = 6.739***; DW = 1.94; Ramsey RESET test {residual squares}: F(1,38) = 0.057; Breusch – Pagan heteroscedasticity: Chi-square(8) = 9.900; Normality test: Chi-square(2) = 3.494; Chow test for structural break at observation 1986: F(9,30)= 0.518; Ljung Box test of autocorrelation: F(4,35) = 1.653; CUSUM test for parameter stability: Harvey-Collier t(38) = 0.189.
Source: output from R.

Diagnostic tests for serial correlation, functional form, parameter stability, normality and heteroscedasticity were conducted and the results are shown in Table 3. These tests show us that short run model passes through all diagnostic tests. The results also indicate that there is no suspicion of multicolinearity among variables as functional form of the model is well specified and there is no evidence for heteroscedasticity as well.

The error correction coefficient is negative and statistically significant, which confirms the long-run relationship between the variables. Its value -0.948 indicates a rapid adjustment process, with almost the whole disequilibrium of the previous year's shock adjusting back to the long-run equilibrium in the current year.

The estimation results from the model reveal that GDP has significant implications for investments; this finding is consistent with the neo-classical investment theory which stipulates that greater output enhances investment. On the other hand, this working hypothesis is rather contested by the negative influence of the lagged values of the GDP on the investments. The monetary base as well trade openness seem not to be statistically significant in the current period, however, the significantly large coefficient by the lagged monetary base variable may indicate lagging conforming of the investments to the monetary base shocks.

7. Conclusion

This paper offers econometric investigation of the impact of the investments determinants in Tunisia over the period of 1961-2011. The long run estimate of the investment function for Tunisia has been derived using the highly efficient ARDL bounds approach. The results of the study indicate that the monetary base largely explains the pattern of investments in Tunisia, while the influence of the GDP is long-term insignificant and short-term unambiguous. There is evidence that the investments and monetary base are bound together in the long run. On the other hand, the statistically significant influence of the monetary base shocks leads the investments by one period in the short run. Trade openness of the country proved to be statistically insignificant. Given the importance of investments for the economic development, the monetary base must be taken into account for its potential impact on the investment decisions.

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