Testing of the Formal Statistical Validity of a Tax Model of the Investment Demand in the Republic of Macedonia

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This article is aimed for presentation of the formal testing steps of the statistical validity of a multiple regression model that explains the formation of the investment demand in the Republic of Macedonia. This specifically developed model is based upon the concept of the "cost of capital", which is known as one of the most traditional approaches that can effectively explain the formation of the capital demand in a certain country, especially with interaction of changes in the tax code. Therefore, it is considered as an appropriate model for the purpose to unveil whether the country's tax rates play or not a significant role for creation of the domestic demand for investment. Precisely, the statistical analysis of the presented model confirms its formal validity, since all the formal assumptions regarding the residuals of the multiple regression are generally satisfied. This also ensures relevance and formal justification of the chosen model, for its further exploitation for empirical research, while the results of this research will be published in a separate article.

Keywords

Tax model, investment demand, statistical validity, residual assumptions, cost of capital, Republic of Macedonia.

1. Introduction

The economic theory suggests that there are, in general, two fundamental types of models used to explain investment behavior and the response on changes in tax policy. The roots of the first one lie in Jorgenson's neoclassical theory of investment [1], which is otherwise known as the user cost theory (or the cost of capital theory). his theory predicts that under the condition of a perfect capital market, a profit maximizing firm will continue to invest in capital up to the point where the marginal product from the employed last unit of capital is equal to the users cost of capital. So, the elements that reduce the cost of capital should in theory stimulate investment and thus capital formation. For example, if the government lowers the tax rates, increases the tax depreciation rates, introduces new tax credit or another tax deduction, or simply if the market conditions lower the interest rate. Right after the popularization of the theory, economists have intended to incorporate the impact of different liquidity (cash-flow) constraints on investment with introduction of appropriate variables to the original equation. It was an attempt to overcame the limitation of the user cost theory imposed by the assumption of perfect capital markets, according to which firms can borrow and lend freely in order to reach their optimal capital stock. Practical evidence provided by Schaller [2], prove that in reality, asymmetric information and market inefficiencies could indeed create financial constraints problems, „forcing“ the firms to rely more on internal sources of capital, and as a consequence, interrupt the process of capital optimization. The second approach is the q-theory of investment which was originally developed by Tobin [3]. Differently from the user cost theory, the q-theory suggests that investment should depend on the market value of capital, based on the future streams of profits, relative to its replacement cost. In the focus of this theory is the so-called Tobins's marginal q, or the „shadow“ to replacement value ratio, which should serve in theory, as an informational indicator for the investment firm. Here, serious disadvantage is the inability for empirical observation of the outlined indicator, upon which the investment decision is made. We must notice that many different variations of the user cost model have emerged soon after the Jorgenson's user cost theory. For example, the theory of the effective marginal tax rates (EMTR), which is primarily used to measure and compare the effective marginal tax burden on real investment in fixed capital assets. It was developed by King & Fullerton [4], based on the papers of Jorgenson [5], Hall & Jorgenson [6], and King [7], [8], and essentially, represents a natural extension of the cost of capital approach. According to them, the EMTR captures the share of return on a marginal unit of investment which is cut by taxation, and actually, serves as a relevant indicator for the extent of the available tax incentives built in the system. Since the majority of articles rely on the „overexploited“ methodology originated from the Neoclassical Theory of Investment, here, we attempt to follow a different pattern and engage the methodology of METR. Precisely, the cost of capital variables used in our model are based and derived according to the methodological approach of METR developed from Michael Devereux and Rachel Griffith [9].

2. The Model

Based on the concept of the cost of capital from the methodological frame of METR, developed by Devereux and Griffith [10], [11], [12], the tax component was effectively separately from the non-tax (economic) component of the cost of capital, in order to quantify the individual contribution of the available tax determinants on investment policy. So, the model we propose will take the form of a linear multiple regression as it follows:

$$[1] \qquad ln(K_t) = \alpha + \alpha_1 ln(Y_t) + \alpha_2 ln(NTC\tilde{p}_t) + \alpha_3 ln(TC\tilde{p}_t) + \alpha_4 Tinf_t + \alpha_5 Tcr_t + \varepsilon_t$$

As it can be seen, for each period t, we observe the capital stock *K* (investment demand or capital formation) as a linear function of the national output *Y* (GDP), the "non-tax" component of the cost of capital *NTCp~* (mainly defined from the basic economic parameters) and the "tax" component of the cost of capital *TCp~* (generally composed of the various tax parameters). Particularly, a special attention is granted to the effect of corporate (business) taxes as they present the form of tax with the greatest influence on private investment.
Also, the model incorporates two more variables: where *Tinf* represents the inflation time specific dummy variable, while *Tcr* the financial crisis time specific dummy variable respectively. These exogenous variables are added to the system to capture the effect from the external shocks, such as the inflation and the crises on the flows of capital stock. Their justification is due to the fact that before two decades the country was hit by a massive inflation and also was not overpassed by the latest international financial crisis. In this model, $Tinf_t$ is defined 1 if the average inflation rate of the particular year exceeds 8% (1993, 1994, 1995 and 2008), otherwise 0, and Tcr_t has value of 1 only for the period when the financial crisis was most influential in the country (2008, 2009, 2010), otherwise 0.

3. Time Series Data

For the purpose to construct the required data for the time series analysis, a substantial amount of information was acquired. In this particular case, the data set consists of the Macedonian nominal GDP, gross fixed capital formation (expressed at nominal values), real net capital stock, and the cost of capital. The official macro-data was collected on a yearly basis, generally from the State Statistical Office, the Ministry of Finance and the Central Bank of the Republic of Macedonia. Additional calculations were conducted as well, in order to measure the true factual value of the cost of capital. The observed time horizon is from 1993 to 2014, which means from the point when the first tax code was introduced after the independence, trough the period of transition (1993-1999), the conflict year (2001), the period of macroeconomic stability and growth (2002-2007), the period of the financial crisis (2008-2010), and finishes at the point of year 2014.

4. The Formal Statistical Test

To confirm if the multiple linear regression model is statistically valid, several assumptions regarding the residuals had to be satisfied and therefore, formally tested. These required residual assumptions are as follows: 1) The residuals should have a mean of approximately zero; 2) The residuals must have similar variances throughout all residual values; 3) They must be normally-distributed and there must be enough data points to conduct normality testing of residuals; 4) The residuals may not be highly correlated with any of the independent (X) variables; and 5) The residuals must be independent and not autocorrelated with each other. Additionally, the joint significance of the included dummy variables has been tested, the stationarity and the exogenously of data.

Assumption no. 1 (zero mean value of time series residuals). Concerning the first assumption, it is easy to formally determine the mean value of the residuals, which is very near zero, exactly as it is presented in xls.sheet1. The dialogue box of standardized residuals doesn't show any presence of outliers among residual values also. A standard rule of thumb is that a data point is considered to be an outlier if its residual value is more than three standard deviations from the mean of the residuals [13]. Measurements reveal that the largest distance in our case is 2,094 standard deviations in absolute value from the residual mean.

Assumption no. 2 (residuals must be homoscedastic). The variance of the residuals is the degree of spread among the residual values. The property of having similar variance across all sample values or across different sample groups is known as *homoscedasticity*. The property of having different variance across all sample values or across different sample groups is known as *heteroscedasticity.* Linear regression models require that all residuals are homoscedastic. To test for the homogeneity of variance two tests were conducted: the Levene's test and the Breusch-Pagan test [14]. The first one, which is a form of a single factor ANOVA on the absolute values of the sample group residuals, tests the Null hypothesis: $\sigma_1^2 = \sigma_2^2 = \ldots = \sigma_k^2$, against the alternative: $\sigma_1^2 \neq \sigma_2^2 \neq \ldots \neq \sigma_k^2$. If the test confirms that group variances are equal, then the average size of the residual should be the same across all groups. The test which is presented in xls.sheet2 generates *p*-value of 0,7004, thus failing to reject the null hypothesis of no significant difference between the group means, and satisfying therefore, the assumption for homogeneity of variances. A Breusch-Pagan test, which is a form of an auxiliary regression with the squared residuals as dependent variable, strongly rejects the hypothesis of random effects and heteroscedasticity in errors as well. The lagrange multiplier LM yields value of 4,3179 (R^2xN), which is below the chi-square (p-1) critical value of 11,0705 and the *p*-value of 0,5046 additionally supports the Null hypothesis of homoscedastic errors as shown in xls.sheet3.

Assumption no. 3 (normal distribution of time series residuals). Another important assumption of linear regression is that the residuals are *normally-distributed*. Indication if the distribution of residuals is normal or not could be initially provided by a visual examination of the residual's histogram and their normal probability plot. But formally and more accurately, normality testing could be performed statistically, as well. There are many available methods to test the required property of normal distribution of residual values such as the Anderson-Darling or Shapiro-Wilk test [15]. Specifically, in xls.sheet4, we applied the later Shapiro-Wilk test for the purpose of our research. Since test statistic W (0,96469) is larger than W Critical 0,911, the Null Hypothesis cannot be rejected, reflecting the conclusion that there is not enough evidence to state that the data are not normally-distributed with a confidence level of 95 percent. It should be noticed here also, that normality tests should be much more powerful and the results stronger, if the number of data points would be as greater as possible. We think that the number of observations in our time series data of 22, which are annually assembled, is sufficient enough to avoid violations and thus satisfy the normality assumption. Preparing the data on quarterly basis was impossible for a few reasons: first, we detected a substantial lack of quarterly information for much of the input parameters within the domestic statistical and registration system; and second, this would have demanded an enormous efforts and costs and eventually, it could have limited the research from a practical and economical point of view.

Assumption no. 4 (residuals must not be correlated with the independent variable). To examine if the residuals have *significant correlation with any other variables*, a correlation matrix is simultaneously generated, as presented in xls.sheet5. The correlation matrix shows all of the correlations across each of the variables to be low, primarily indicating on the absence of any relationship between the variables and the residual values.

Assumption no. 5 (residuals must not be autocorrelated). Another very important issue of the regression model is the *degree of autocorrelation* that exists within the residuals. If the errors of a model manifest a high degree of correlation with each other, they would not be considered as independent and the regression would not be considered as valid. Autocorrelation is commonly evident with time-series data, when data values are influenced by the time interval among them. The last remark brings the importance for us to examine and test the level of autocorrelation among residuals with the application of the Durbin-Watson statistics in the model. The Durbin-Watson test statistic d uses the residuals from the least squares procedure and it is aproximatelly equal to $2(1 – p)$. The distribution of the DW test statistic is difficult and Excel cannot compute the p-value associated with d, but tables are available for performing the hypothesis test, now called the Durbin-Watson bounds test. [16]. Here, the decision rule would be as it follows: if $d >$ upper bound, fail to reject the null hypothesis of no serial correlation; if $d <$ lower bound, reject the null hypothesis and conclude that positive autocorrelation is present; if lower bound $< d <$ upper bound, the test is inconclusive. As it is seen from xls.sheet1, the result of the perfomed d statistics in our case is 1,7658. From the available Durbin-Watson tables, with 22 observations, 5 independent variables and probability of 5%, the lower bound and the upper bound *d's* are 0,666 and 1,691 respectivly. Since $d >$ the upper bound, we cannot reject the null hypothesis that $p = 0$, and don't find any evidence of autocorrelation.

4.1. Joint Significance of the Dummy Variables

The regression performs much better with addition of the time specific dummies. For the purpose to test the joint significance of dummy variables within the multiple regression model, we performed an F-test. It is useful to determine whether two or more explanatory variables are jointly important to the model, comparing the sum of the squared errors from the original, full unrestricted model from equation 1, to the sum of squared errors from a shortened, restricted model upon which the null hypothesis has been set [17]. In our case, as we can see from below, the reduced model is formed without presence of the two time specific dummy variables, which means that the number of restrictions J is 2:

$$[2] \qquad ln(K_t) = \alpha_0 + \alpha_1 ln(Y_t) + \alpha_2 ln(NTCp_t^{\sim}) + \alpha_3 ln(TCp_t^{\sim}) + \varepsilon_t$$

The performing result from the F-statistics, presented in xls.sheet6, shows that F > F critical value (13,8269 > 3,6337) and P-value < α (0,0003 < 0,05), thus rejecting the null hypothesis at 5% level and confirming the joint significance of the time dummies.

4.2. Stationarity of Data (A Unit Root Test)

The arguments presented in the text above, prove that the required residual assumptions in the multiple linear regression model are formally met. But, in time series analysis, it is also necessary to check for stationarity of the available data. Time series data is stationary when the means, variances, and covariances are constant and don't depend on the period in which they are measured. [18]. As we can see there are 2 macroeconomic variables included in the model, the capital stock K_t and the output Y_t, which could manifest non-stationary properties. GDP and capital accumulation for a single country are a long-term dynamic processes with changeable trends that could cause their mean to vary from time to time, just like in many other macroeconomic variables. The problem with non-stationarity is that it can produce a spurious regression in which the variables are not actually related. Running a spurious regression could result with statistically significant, but not reliable OLS estimates. The reason for that behavior in spurious regression might be a random coincidence in time series data, or a presence of unidentified "lurking" variable.
To check for the stationarity of variables, we must conduct a *unit root test*, particularly the *Augmented Dickey-Fuller (ADF) test*. Actually, the ADF test is based on the autoregressive model (univariate time series analysis), where the differenced values of each of the continuous independent variables are regressed on their lagged and lagged differenced values. For example, for parameter Y_t the general autoregressive model with *p* lag lengths - $AR_{(p)}$ for the purpose of the ADF test could be described as:

$$[3] \qquad \Delta Y_t = \alpha + \phi Y_{t-1} + \gamma_1 \Delta Y_{t-1} + \gamma_2 \Delta Y_{t-2} + ... + \gamma_{p-1} \Delta Y_{t-p+1} + \delta t + \varepsilon_t$$

where ΔY_t represent the serie of the differenced values of parameter Y_t, α is the intercept, Y_{t-1} are the first lenght or *t-1* lagged values of parameter Y_t and ϕ is the coefficeint estimate, ΔY_{t-1} is the first lenght or *t-1* lag of the parameters differenced values and γ_1 is the coefficient estimate etc., *t* is the deterministic trend and δ is the relevent coefficient, while ε_t is the residual term.
The focus of the ADF test is on the first lag parameter. The procedue involves testing weather the coefficient on Y_{t-1} *(ϕ)* is zero with aplication of the t-test. We must notice here that the critical values of the t-statistic does not have the usual Student t-distribution, and must be taken from the specific Dickey-Fuller statistical tables, where they differ depending on the sample size and the type of model (without constant, with constant and without trend, and with constant and trend). It is recomended to start the ADF test for each variable in Excel with estimation of the $AR_{(p)}$ model with deterministic trend and use the *sequental testing strategy* to select the apropriate lag lenght and make decision weather the deterministic trend should be included in the model or not. The econometric technique known as the information criterion[1] as well as some software packages could provide the results more automatically, and unfortunatelly, that's not the case for Excel. But the sequental strategy is an alternative procedure for the common purpose, which starts with a choice of the maximum lag lenght p_{max} and then sequentally drops lags if the relevant coefficients are insignifficant [19]. The procedure which is obviouselly *ad hoc,* is repeated until a signifficant coefficient for the last lag lenght is found, with indication that this is the relevent lag length. After, we check from the *p*-value if the

[1] Some of the most popular are the Akaike Information Criterion (AIC) and the Bayesian or Schwarz Information Criterion (BIC or SIC)

coefficient of the detrministic trend is smaller than the level of signifficance. If it is true than the trend is relevant and should stay within the model, if not, it should be droped. A common rule of thumb for determination of the maximum lag lenght is provided by Schwert [20], where T is the number of periods in the time series or simply, the number of observations:

$$[4] \qquad p_{\max} = \left[12 \cdot \left(\frac{T}{100} \right)^{1/4} \right]$$

After we chose the maximum lag lenght that seemed resonable for us, we applied the sequental testing technique for all of the present variables in the model, except the dummies, since they are not continuous variables. The sequental approach reveiled that the output and the non-tax component must be tested with trend and one lag, the dependent variable with trend and two lags and the tax-component with one lag but without trend. This is preety logical becouse it‘s quite usual for macroaggregates (GDP and capital stock) to be trend determined, the non-tax component is basicaly formed by the interest rate and the inflation which could also manifest trending behaviour, while the tax-component where the discreate decisions of authorities are crutial, would not bring any trending expectations at all. So, the forms of the ADF test for each of the variables would look like the following:

$$[5] \qquad \Delta ln(K_t) = \alpha + \phi ln(K_{t-1}) + \gamma_1 \Delta ln(K_{t-1}) + \delta t + \varepsilon_t$$

$$[6] \qquad \Delta ln(Y_t) = \alpha + \phi ln(Y_{t-1}) + \delta t + \varepsilon_t$$

$$[7] \qquad \Delta ln(NTCp_t^{\sim}) = \alpha + \phi ln(NTCp_{t-1}^{\sim}) + \delta t + \varepsilon_t$$

$$[8] \qquad \Delta ln(TCp_t^{\sim}) = \alpha + \phi ln(TCp_{t-1}^{\sim}) + \varepsilon_t$$

At the bottom line of this section we reffer to the results from the Augmanted Dickey-Fuller test (see xls.sheet7, xls.sheet8, xls.sheet9, and xls.sheet10). The t-stat for $ln(K_{t-1})$ coefficient is -4,10207, -18,1982 for $ln(Y_{t-1})$ and -11,5083 for the coefficient of $ln(NTCp_{t-1}^{\sim})$. Since these values are more negative than -3,60 (which is the 5% Dickey-Fuller critical value for T=25 and AR model with deterministic trend), the unit root hypothesis is thus rejected. The same holds for the tax component $ln(TCp_{t-1}^{\sim})$ as well. Its t-stat -4,55837 is smaller than -2,99, the 5% Dickey-Fuller critical value for T=25 and AR model without deterministic trend. Becouse the examined variables do not have the unit root problem, we may conclude that they are all stationary.

4.3. Endogeneity of Data (Instrumental Variables Testing)

Finally, we examined the possibility that the included regressors in the model could be endogenous[2] i.e. correlated with the error term. The problem of endogeneity is a relevant issue associated with the regression analysis, because it could threaten the internal validity of a given regression model due to a number of circumstances such as: functional form misspecifications, measurement error, sample selection problem, omitted variables or simply, occurrence of a random, simultaneous causality. To eliminate the risk if any of the variables are endogenous, it is recommended to use the instrumental variables estimation approach [21]. By definition, an instrumental variable for a potentially endogenous variable *X* is an alternative variable *Z*, that is uncorrelated with the disturbance error in the structural model *e*,

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[2] In jargon, it is said that an endogenous variable is a one that is build, incorporated in the system.

and at the same time is correlated with the potentially endogenous variable *X.* With this approach, the instrumental variable breaks the endogenous variable *X* into 2 segments: a segment that is correlated with the error term, and a segment that is not. This segregation initiated by the instrumental variable, enables to detect the movements of *X* that are not correlated with *e,* and use them to estimate the true variable's coefficient α[3]. The available econometrical technique for the purpose is called TSLS (Two Stage Least Squared) instrumental variable regression, which in the case of multiple regression, when there are multiple potentially endogenous regressors, takes the general (structural) form of [22]:

$$[9] \qquad Y_t = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + ... + \alpha_k X_{kt} + \alpha_{k+1} W_{1t} + \alpha_{k+2} W_{2t} + ... + \alpha_{k+r} W_{rt} + \varepsilon_t$$

where, Y_t is the dependent variable, $X_{1t}, X_{2t}, ... X_{kt}$ are the endogenous regressors that might be potentially corelated with e_t, $W_{1t}, W_{2t}, ... W_{rt}$ are the included exogenous variables not correlated with e_t, α_0 is the intercept, $\alpha_1, \alpha_2, ... \alpha_k$, are the regression coefficients of the endogenous variables, and $\alpha_{k+1}, \alpha_{k+2}, ... \alpha_{k+r}$, are the regression coefficients of the exogenous variables..

The first stage of TSLS procedure requires running a separate regressions for every endogenous variable with its available instrumental variables and the other exogenous variables from the structural model. Thus with *k* endogenous regressors, we have k first stage regressions. For example, if $Z_{1t}, Z_{2t}, ... Z_{mt}$ are the possible instrumental variables that define X_{1t}, than the first stage regression for X_{1t} would be:

$$[10] \qquad X_{1t} = \alpha_0 + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + ... + \alpha_m Z_{mt} + \alpha_{k+1} W_{1t} + \alpha_{k+2} W_{2t} + ... + \alpha_{k+r} W_{rt} + \nu_{mt}$$

If $Z_{1t}, Z_{2t}, ... Z_{st}$ are the possible instrumental variables that define X_{2t}, than the first stage equation for X_{2t} is:

$$[11] \qquad X_{2t} = \alpha_0 + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + ... + \alpha_s Z_{st} + \alpha_{k+1} W_{1t} + \alpha_{k+2} W_{2t} + ... + \alpha_{k+r} W_{rt} + \nu_{st}$$

And if $Z_{1t}, Z_{2t}, ... Z_{pt}$ are the variables possibly correlated with X_{kt}, the first stage regression for X_{kt} will take the form:

$$[12] \qquad X_{kt} = \alpha_0 + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + ... + \alpha_s Z_{pt} + \alpha_{k+1} W_{1t} + \alpha_{k+2} W_{2t} + ... + \alpha_{k+r} W_{rt} + \nu_{pt}$$

In the second stage of the TSLS procedure, we use the predicted values of the regressions from the first stage $\underline{X_{1t}}, \underline{X_{2t}}, \dots \underline{X_{kt}}$, to replace the endogenous variables from the structural form:

$$[13] \qquad Y_t = \alpha_0 + \alpha_1 \underline{X_{1t}} + \alpha_2 \underline{X_{2t}} + ... + \alpha_k \underline{X_{kt}} + \alpha_{k+1} W_{1t} + \alpha_{k+2} W_{2t} + ... + \alpha_{k+r} W_{rt} + \varepsilon_{IVt}$$

Running the regression from above yields consistent and reliable coefficient estimates, but wrong standard errors, which need to be corrected adequately.

The problem that arises here, is that we actually don't know if the included variables in the model are endogenous or not. What we are sure is that only the time specific dummy variables could be qualified as exogenous, since they were additionally added to the model to capture the effect on capital accumulation from the exogenous shocks such as the inflation and the financial crises. In order to find whether the rest of independent variables are endogenous, and thus to confirm the need for IV estimation, we need to apply the Wu-Hausman test. The basic idea is to see if the estimates from OLS and IV are different. If we conclude so (in this case reject the Null hypothesis), than the variables from the model are correlated with *e,* OLS estimates are biased and we should rely on the IV procedure. If the test confirms otherwise,

[3] We have to note that if only one regressor is endogenous, all the other coefficient estimates are biased.

then under the classical assumptions OLS is blue and more efficient than the IV procedure. The Hausman test procedure is similar to the IV procedure [23]. Initially, for each X we must conduct the first stage regression as described in the expressions 10, 11 and 12, obtain the residuals v_t, and then, include them in the original (structural) form equation 9. If an F-test of the hypothesis that the added coefficients on v_{mt}, v_{st}, … v_{pt} are jointly equal to zero, rejects H_0, then at least one independent variable is endogenous and we must proceed with the IV procedure. If the F-test fails to reject H_0, the exogeneity of the variables is confirmed and the OLS procedure gets the green light. In this article we've conducted the Hausman test as already described on the 3 possible suspicious variables from the model: the output Y_t, the tax component of the cost of capital $TCp_t^{\sim}$, and the non-tax component of the cost of capital $NTCp_t^{\sim}$.

In practice, it is very difficult to find a valid instrument which is not included in the model, not correlated with the disturbances of the model, but yet highly correlated with the endogenous variable. But since the data set is consisted of aggregated time series, we could use the variables lagged values as an instruments. Intuitively, a $_{t-1}$ lagged value of a parameter should be correlated with its $_t$ value, and at the same time independent from the system's error, so by definition, it fits the IV criterion. Another good example for suitable IV is the previous realization of the same variable. The availability of information about previous realizations of the variables of interest opens interesting possibilities for possible instruments, since the previous realizations are given before the current values are realized. For example, in the equation of the permanent income, we could use its previous form-the disposable income as IV, for the overall *TCp*, we could use for IV the assets group *TCp* (TCp_{bu}, TCp_{eq} or TCp_{int}) etc. Guided by this logical end economical reasoning from one side, and following the rule of exact identification of the parameter (*m=k)* from the other side, we have managed to identify only one potential IV for the output variable Y_t and the non-tax variable $NTCp_t^{\sim}$, and two potential variables for the tax component variable $TCp_t^{\sim}$. That would be Y_{t-1}, and $NTCp_{t-1}^{\sim}$, for the first two variables and $TCp_{t-1}^{\sim}$ and $TCp_{but}^{\sim}$ for the third variable respectively. It follows from this that the first stage regressions will be identified as:

$$[14] \qquad ln(Y_t) = \alpha_0 + \alpha_1 ln(Y_{t-1}) + \alpha_2 Tinf_t + \alpha_3 Tcr_t + v_{mt}$$

$$[15] \qquad ln(NTCp_t^{\sim}) = \alpha_0 + \alpha_1 ln(NTCp_{t-1}^{\sim}) + \alpha_2 Tinf_t + \alpha_3 Tcr_t + v_{st}$$

$$[16] \qquad ln(TCp_t^{\sim}) = \alpha_0 + \alpha_1 ln(TCp_{t-1}^{\sim}) + \alpha_2 TCpbu_t^{\sim} + \alpha_3 Tinf_t + \alpha_4 Tcr_t + v_{pt}$$

The strenght of the instruments was tested during the first stage also. Appling a weak isntrument could yield a biased IV estimator as well [24]. A common rule of thumb is that a F-test statistic over 10 should be apropriate as an indication of a strong instrumental variable. The F-stats is 46,756 in the case of TCp_t, 32,506 in the case of Y_t and 11,462 for $NTCp_t$, formally satisfying the orientational rule of thumb (see xls.sheet11, 12, 13). Ensuring that the selected IV generally reveil strong connections with the independend variables, in the second stage we employed the residuals from the first stage for the Hausman test according to the following (unrestricted) model:

$$[17] \qquad \begin{aligned} ln(K_t) = \alpha_0 + \alpha_1 ln(Y_t) + \alpha_2 ln(NTCp_t^{\sim}) + \alpha_3 ln(TCp_t^{\sim}) + \alpha_4 Tinf_t + \alpha_5 Tcr_t \\ + \delta_1 v_{mt} + \delta_2 v_{st} + \delta_3 v_{pt} + \varepsilon_t \end{aligned}$$

The result from the conducted F-test for the joint signifficance of the added residuals v_{mt}, v_{st}, and v_{pt} in the restricted (structural) model of interest [1], with number of observations N=22, number of parameters K=9 and number of restrictions J=3, shows F-stat of 1,921 and *p*-value of 0,176. Since F-stat < F-critical value (1,921 < 3,410) and *p*-value > α (0,176 > 0,05), the decision rule would be not to reject the Null hypothesis and conclude that the suspicious

variables are not endogenous (see xls.sheet14). Remarking the last conclusion, we cancel the IV and proceed with the standard OLS procedure.
In this section of endogeneity issues, we must refer to another question of relevance and that is the validity of the selected IV and the possibility that they could be also correlated with the error term. For an instrument variable to be considered as valid, it must satisfy 2 conditions. First, it's the conditionality of instrument relevance $cov(Z, X) \neq 0$, which is sort of formally satisfied by testing of the strength of the instrument. And second, it's the conditionality of the instrument exogeneity $cov(Z, \varepsilon) = 0$, a condition that can't be tested directly, because as we know, the error is unobservable and as a consequence, unbiased estimator for ε does not exist. But for this purpose we can exploit the Sargan test for over identifying restrictions [25]. The Sargan test is unemployable if the number of the endogenous regressors is identical with the number of the instrumental variables $(k = m)$. Only when there is more instrumental variables than endogenous explanatory variables $(m > k)$, which is exactly as in our case, we have the condition of overidentifying restrictions, and we could effectively test the validity of the applied instruments via the Sargan test.
The procedure of the test is as follows: First, we provide the IV residuals ε_{IVt} from the second stage of the IV procedure, according to equation 13. Second, in another regression we use the obtained residuals as a dependent variable and all the instrumental and exogenous variables as independent variables. The later regression in our case is presented below in equation 18:

$$[18] \quad \varepsilon_{IVt} = \alpha_0 + \alpha_1 ln(Y_{t-1}) + \alpha_2 ln(NTCp_{t-1}^{\sim}) + \alpha_3 ln(TCp_{t-1}^{\sim}) + \alpha_4 TCpbu_t^{\sim} + \alpha_5 Tinf_t + \alpha_6 Tcr_t + \varepsilon_t$$

Sargan test statistic is NxR^2 and the critical values have chi-square distribution, so they could be provided from $\chi 2(m-k)$. Running the test yields test statistics of 1,635 and the critical value for one degree of freedom and probability of 5% is 3,841. Since the S-stat value is less than the chi-square critical value (1,635 < 3,841), we affirmatively confirm that the instruments are valid (see xls.sheet15).

5. Conclusion

In this article we performed all the relevant statistical tests in order to confirm the statistical validity of a multiple regression model describing the formation of the aggregate demand for investment in the Republic of Macedonia. The model is based upon the traditional concept of the Jorgenson's "cost of capital" approach, which was recently modified and adopted by Devereux & Griffith. Indeed, the statistical analysis of the presented model confirms its formal validity, since all the formal assumptions regarding the residuals of the multiple regression are generally satisfied. Specifically, the time series residuals manifested zero mean value and normal distribution, it was proved that they were not autocorrelated nor heteroscedastic, while the residuals by themselves were not also correlated with the independent variable from the main equation. A unit root test determined that the data set was stationary, on the other hand, the instrument variables test confirmed that all the elements in the systematic equation were endogenous. The joint significance of the only two exogenous dummy variables was also detected appropriately. All these facts contribute to the econometric relevance of the chosen model, for its further exploitation for empirical research. The authors intend to publish the results from this research in a separate article.

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