Advanced Econometrics - Project

Empirical analysis of Italian financial accounts

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1 Abstract

This empirical work on Italian financial account try to estimate the Gross Domestic Product in 2011. The econometric analysis is conducted on Bank of Italy data. The authors of this paper try to find an appropriate model for the estimate, firstly they conducted the ADF and other statistical test to decide which model apply, an ARDL model. However, the model is inadequate for the purpose of the analysis, and a spurious regression is discovered instead.

2 Introduction

2.1 Background

The Gross Development Product (GDP) is one of the most important indicator of a country because it tells its history of growth and development. GDP is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period, it is usually computed on annual periods. Studying GDP and his principal components, such as consumption, investment, public expenditure, imports and exports, is important to discover what are the strengths and weaknesses of a country. Investigate about the components of GDP tells us more about the development of a country.
For example, the authors of this project chose Italy as the country to analyze. It is known that from 1961 to 2011 the country went through several financial and economic crises: the financial crisis in 2011, the crisis of national debt in 2008, the crisis of European Monetary System (EMS) in 1998, and the crisis of energy in 1979. In the 1960s Italy had a growth trend due to central bank's fiscal policy while in the late 1960s the system pension reform, the birth if national sanitary system, and welfare policy for public employees were implemented in the system. Bank of Italy could controlled the balance of payments imbalances controlling the governments bonds. In 1973 IVA, the tax on value added, was introduced in the economical system and the next year was inserted the taxation model based on personal income tax, contributing on tax with holding agent and fiscal drug. In this period structural changes were realised in the balance due to high public expenditure. Also a proportional system was the birth of politics of consensus which was more important for the government, instead of the growth of the country. In the 1980s Italy didn't depreciate the lira enough, and the ratio of public debt-GDP continued to grow. In the 1990s Italian economy started to slow down, in the 1997 it exited from the EMS, and the deficit started to fall, thanks to the Stability and Growth Path.

2.2 Scope and expectations

The aim of this project is to analyse the Italian financial accounts from 1961 to 2011 and search for important conclusions that must be useful for further economic policy, or to investigate the data to note

how much the different items may influence the budget. Our discover should be important to perform an efficient economic policy.
This empirical work would like to determine the most important components of the GDP of 2011 studying the time series mentioned before. It will follow an ARDL approach, based on dynamic approach of ADL models, conducted on similar analysis by Bisio L. and Moauro F. (2018).
This analysis is crucial for the growth of the country because it permits to focus the attention on the correct sectors of economy, and it permits also to understand if the Italian economy was in surplus or deficit in 2011. Moreover, discovering the value of finance balance allow to analyse the institutional sectors of the economy. This work will follow the main stream approach of economic theory.
Performing our analysis, we expected an overall growth trend, exception for 2007-2008 crisis.

3 Literature Review

Many other researchers focused their attention on this problem. For example, Romero-Avila and Strauch (2008) noted that "if the policy variable follow a specific time series pattern economic growth should exhibit the same behaviour under exogenous growth theory". The long-term analysis provided different output, but the results of fiscal policy on trend growth by employing a distributed lag approach. According Magazzino (2014), the variance of public expenditure is essentially due to its own shocks, in the short as well as in the very long period, with a slow and marginal increase of public revenues innovations. This phenomenon may explain the relationship between revenue and public expenditure in Italy. This kind of empirical work (Moauro and Piergiovanni, 2005) may be influenced by highly volatile subjected to the revision and to some extent unreliable for inferring long-run trends.
Magazzino (2018) argued that increases in government expenditure, beyond the optimal value, may represent an obstacle to the economic growth. The approach here proposed advocates the search of equilibrium, which should not necessarily be that in correspondence of which the GDP is maximized. A high rate of growth which is accompanied by an unequal distribution of resources could, in fact, conflict with the objective of maximizing general welfare, not reflecting the actual individual preferences. On the contrary, with very high shares of public expenditure, citizens would have little incentive to invest and produce, since the levels of fiscal burden would be exorbitant, but also in this case the growth would suffer. These argumentation should contribute to explain the trend of GDP according our model. Also, it is important to know that for the growth of Italy during the observed period preserved a strong government, the plan of availability of medium term, the development of solid institutional abilities of the offices and the other agencies cooperate with the government for the elaboration of recovery plan, and a sound fiscal framework that extends through all levels of government.
Our model focus attention on analysing the situation in 2011 and the most desirable result was a positive trend of GDP, but also we have to consider important phenomenon as the financial crisis in 2008,

the decrease of investment in research and development, and the change of Bretton-Woods deals have influenced the trend of Italian economy. The distribution of categories of economic agents (households, enterprises and public sector) depends on many factor as the income distribution and the kind of public finance adopted by each country (low or high taxation). We have to consider that the finance balance structure, which is the base of brokerage requirements, will be different from country to country because it is a consequence of model of development adopted, the distribution of value added of each country.
To evaluate each economy we can consider the rate between the degree of financial intensity relative to the real economy in order to understand the rate of the financial development of each country. Specifically, the aim of this model is understanding the 2011's GDP and investigate the Italian financial development based on time series from 1960 to 2011.

4 Data

4.1 Data cleaning

We selected the data from the official site of bank of Italy (`https://www.bancaditalia.it/pubblicazioni/quaderni-storia/2011-0018/index.html?com.dotmarketing.htmlpage.language=1`) and downloaded them edited for the 150th anniversary of Unification of Italy.
There were other excel sheets in the download with different types of tables and data, but the one selected was the first one in which it is possible to see, in millions (of euro) at current prices, the current boundaries from 1861 to 2011.
The original dataset contained 150 rows for 23 columns; each column contains a different variable, and in many cases we have disaggregated variable, so only the **sum of disaggregated variables** are selected for the analysis. Also, not all years were selected for the analysis, but only the last fifty years from 1960 to 2011, because they are more significant for the economy of the country. These factor were fundamental for the dimensional reduction of our dataset. Eventually, the cleaned dataset has 51 rows and 12 columns that indicate the variables and the corresponding year.
The process of clearing data was done in Excel, because the dataset was well organised and cleaned. Not many transformations were necessary, indeed copy and paste the values selected.
At the end of this procedure the attention was focus on the variable of our model.

4.2 Data description

The **dependent variable** is the GDP at market prices (**market_prices_gpd**).
The **independent variables** are:

- **va_tot**: value added of agriculture;

- **net_indir_tax**: net indirect taxes;
- **imp**: import (products or services bought from other countries);
- **tot_supply**: the total supply (the total amount of a given product or service a supplier offers to consumers at a given period and a given price level);
- **exp**: export (products or services sold abroad);
- **total_cons**: total consumption (the total value of all expenditures on individual and collective consumption goods and services incurred by households and general government units);
- **tot_fixed_inv**: total of fixed investments;
- **invent_variation** the inventory variation (the amount of product sold vs. the amount of product used over a set period of time);
- **tot_invest**: the sum of fixed investment and the inventory variation;
- **tot_users**: total uses, amount of money used.

All these variable are numerical and continuous.
The data analysis was conducted with RStudio software and Microsoft Excel tool.

5 Method/Model

According to Bisio L. and Moauro F. (2018), the integration of the static and dynamic class of models under a uniform analytical setting, the large set of innovations-based statistics, and the possibility of non-linear treatment of logged data represent all together undeniable advantages due to the state-space approach, which, therefore, is a recommended tool within the temporal disaggregation practice. Therefore an ARDL model is appropriate to investigate the dataset.

5.1 Import and adjust data

After correctly importing the data, we first proceeded to implement the initial transformations. We made sure that the variable indicating time, in our case *year*, was of type "Date" and that the entire dataset was of type "xts" except for the time variable.
Then, we moved on to the exploratory analysis of our dataset. As mentioned in the previous section, the dependent variable chosen is gross domestic product at market price, now named *gdp*, and we proceeded to represent it graphically.
Figure 1 shows that *gdp* remains at low levels for the first 10-15 years, then rises quite abruptly until 2011 following what appears to be a linear trend, with only a "slight" lowering around the year 2009.

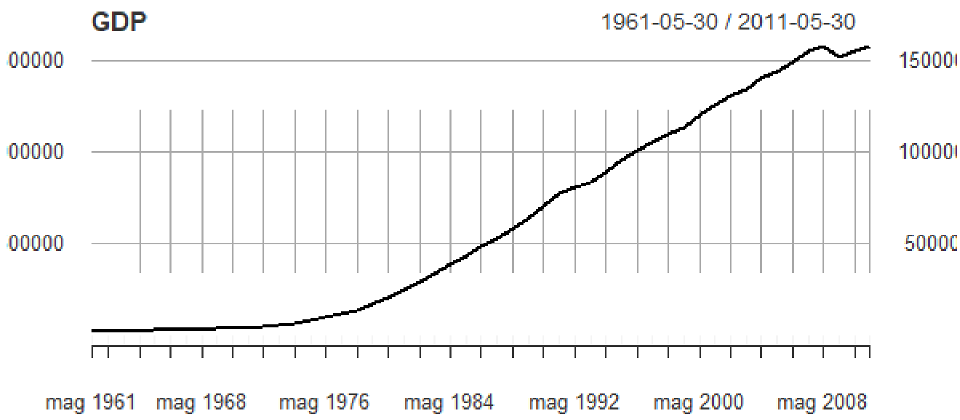

Figure 1: Italian Gross Domestic Product, 1961-2011

However, considering the whole years, it might follow a quadratic trend as well. Nevertheless, it is also important to consider the fact cited above and the global events that affect the economy.

5.2 Stationary tests

As mentioned before, it is quite likely that the *gdp* variable is following some sort of trend, and if so, the variable would not be stationary. This poses a problem since, if non-stationary variables were included in the model, the results we would find would not be reliable. Therefore, in this section we proceed to correctly understand, in primis, what kind of process we are dealing with and, in secundis, to verify the stationary condition of the variables we considered, starting with the dependent variable.

With this aim, the *Augmented Dickey-Fuller test* (ADF) was used, which checks, as null hypothesis, if a unit root is present in a time series sample, which means that the time series is not stationary. However, in order to draw correct conclusions, this test should be accompanied by the *Breusch–Godfrey test*, which tests whether or not there is autocorrelation in the residuals. In case it is present, the lag number of the analyzed variable needs to be increased until no more autocorrelation is found for the first n autocorrelation orders, with "n" decided a priori. To do so, we made use of a preloaded function that outputs the p-values of both tests, along with the corresponding lags.

Firstly, we decided to use II-type of the Dickey-Fuller test, which analyzes the hypothesis of having a random walk process fluctuating around a linear trend, i.e. *random walk with drift*, since it seems to us the most appropriate choice considering the plot of *gdp* variable. Having chosen an autocorrelation of order 5, the value of the augmentations required to find no autocorrelation in the residuals is 1, and the associated p-value of the ADF test is 0.99, indicating that we cannot reject the null hypothesis, i.e. this is not a stationary process.

To be sure of the specification of the process, we also tried to perform III-type of the Dickey-Fuller test, which indicates a random walk process around a quadratic trend. However, while finding the same conclusion, the number of lags increases from 1 to 2 and the p_value of the corresponding ADF test is about 0.3118, significantly lower than the previous one (0.99). This indicates weaker evidence against the stationarity hypothesis, which led us to conclude that it is better to consider the *gdp* variable as a random walk process with drift.

Once the type of process is understood, it is necessary to make it stationary. We then repeated the same tests for the first differences of *gdp*, but first we made a plot to have a better understanding of the process.

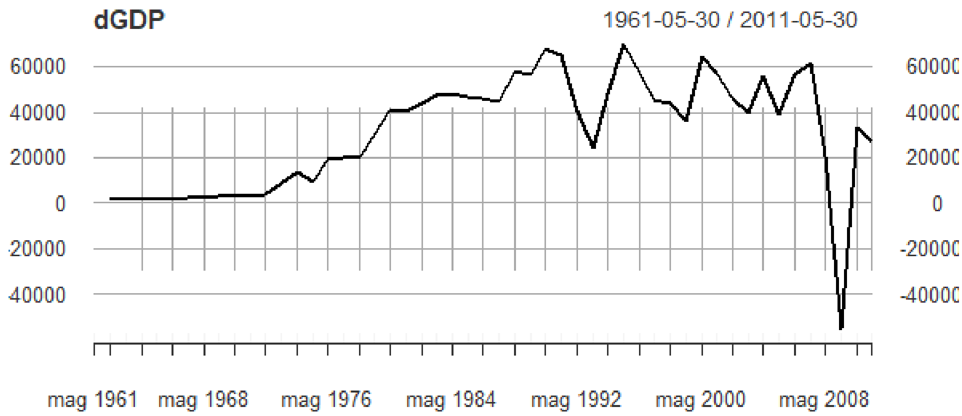

Figure 2: First differences of Italian Gross Domestic Product, 1961-2011

As we can see from the Figure 2, this process does not appear to be stationary. In addition, the variance seems to grow with time.

Always considering up to the fifth order of autocorrelation, the null hypothesis of non-stationarity is rejected (p_adf = 0.0276) at lag 0, meaning that the process is, instead, stationary. This is a bit strange, it is probably due to the fact that we considered a low number of lags. Infact, if we increase the number of the orders, we will find autocorrelation in residuals. However, for the purpose of the analyses, we will consider it stationary.

Given this result, and bearing in mind that the plot of the first difference of *gdp* seems to show an increasing variance, we tried to repeat these analyses for the logarithm of the dependent variable, in the hope of obtaining better results. However, the results found were on average worse, and the variable only satisfies the stationarity condition by calculating the second differences. Thus, we eventually considered the non-logarithmic version of the dependent variable.

To be more sure of the conclusion drawn, we considered two alternative tests: the Phillips-Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Calculating them, the PP test gives the same conclusions as the DF test, but the KPSS leads us to reject the stationarity hypothesis of *diff(gdp)*. However, we conclude by majority: having 2 out of 3 tests saying that *diff(gdp)* is stationary, we consider this variable as such.

We then conducted these analyses for all other variables in the dataset. Almost all of them show a similar behaviour to the dependent variable, i.e. they turn out to be non-stationary but become stationary (at lag 0) by calculating the first differences. Only 2 variables are exceptions: *total_cons* and *invent_variation*.

total_cons is not stationary at the first difference, the second differences must be calculated. On the other hand, *invent_variation* is stationary at the first difference, but the second lag must be taken into account in order not to have autocorrelation in the residuals.

Finally, in the next section we proceed to construct our model in the light of the results obtained.

5.3 ARDL Model

It is important to remember that, once the GDP is calculated, the other variables such as consumption, investments, public expenditure, import and export are included, and so duplications accounts could realize. Based on the test results, nevertheless we try to estimate a first ARDL model, and it is composed as follows:

$\Delta\Delta gdp_{2011} = \beta_0 + \alpha_1 \Delta\Delta gdp_{2010} + \alpha_2 \Delta\Delta gdp_{2009} + \beta_1 \Delta va\_tot_{2011} + \beta_2 \Delta net\_indir\_tax_{2011} + \beta_3 \Delta imp_{2011} + \beta_4 \Delta supply_{2011} + \beta_5 \Delta exp_{2011} + \beta_6 \Delta\Delta total\_cons_{2011} + \beta_7 \Delta tot\_fixed\_inv_{2011} + \beta_8 \Delta invent\_variation_{2009} + \beta_9 \Delta tot\_invest_{2011} + \beta_{10} \Delta tot\_users_{2011} + \epsilon_{2011}$.

With this in mind, it was necessary to transform our dataset into an object of type "zoo". However, we encountered a problem here. The model we assumed does not make sense. The summary returns an $R^2 = 1$ and only four significant variables, plus the parameter estimates of the variables and the corresponding t-values give anomalous results. We thought this might be due to the precarious stationarity of the first differences of the dependent variable. In fact, in the section on stationary tests, it was mentioned that *diff(gdp)* was only stationary up to fifth order, but, increasing this number, the stationary condition is broken. Therefore, we decided to use the second differences of this variable and, by doing so, the results seem to provide more plausible values.

We chose the second augmentation of *diff(invent_variation)* because it is the first one that doesn't have autocorrelation in residuals, so p_adf is reliable only at lag 2. Also, trying with several lags on *diff(gdp)*, the best fit appears to be with 2 lags. This makes sense because, since we are dealing with annual data, it is likely that the gross domestic product depends, in some way, on the closest previous years (2 in this case), and less likely that it is linked to more distant years.

The results provided by this model are good: almost all variables are significant, the R^2 index is very high (around 97%) and the null hypothesis of the F-statistic is rejected, i.e. the model makes sense.

To improve the model, we removed the two variables that are not significant, namely *diff(tot_supply)* and *diff(invent_variation)* at lag 2: although the value of the index R^2 remains unchanged, the value of the adjusted R^2 increases slightly, as does the value of the F-statistic, indicating more evidence against the null hypothesis of joint insignificance (except for the intercept) of the regressors.

To get a clearer idea of which model to prefer, we performed an ANOVA test. Analysis of variance (ANOVA) is a statistical technique that tests, in this case, whether there is a significant difference between the two models being compared. Since the p_value is 0.7756, we cannot reject the null hypothesis that the omitted variables are jointly insignificant, so we conclude that the model to be preferred is the second. Therefore, the final model is composed as follows:

$\Delta\Delta gdp_{2011} = \beta_0 + \alpha_1 \Delta\Delta gdp_{2010} + \alpha_2 \Delta\Delta gdp_{2009} + \beta_1 \Delta va\_tot_{2011} + \beta_2 \Delta net\_indir\_tax_{2011} + \beta_3 \Delta imp_{2011} + \beta_4 \Delta exp_{2011} + \beta_5 \Delta\Delta total\_cons_{2011} + \beta_6 \Delta tot\_fixed\_inv_{2011} + \beta_7 \Delta tot\_invest_{2011} + \beta_8 \Delta tot\_users_{2011} + \epsilon_{2011}$.

About the interpretation of coefficients, it is possible to see the following output:

Coefficients	Estimate	Std. Error	t-value	Pr(> $\|t\|$)
(Intercept)	271.30623	1255.21683	0.216	0.830096
L(d(d(gdp)), c(1:2))1	-0.47433	0.05458	-8.691	0.0000000002291 ***
L(d(d(gdp)), c(1:2))2	-0.30422	0.06310	-4.821	0.0000259018901 ***
d(va_tot)	34157.65768	9618.85205	3.551	0.001091 **
d(net_indir_tax)	34157.38947	9618.83273	3.551	0.001091 **
d(imp)	34156.89296	9618.83568	3.551	0.001091 **
d(exp)	1.24964	0.12707	9.834	0.0000000000097 ***
d(d(total_cons))	0.84431	0.10391	8.125	0.0000000011651 ***
d(tot_fixed_inv)	0.86879	0.38774	2.241	0.031310 *
d(tot_invest)	1.11072	0.26155	4.247	0.000146 ***
d(tot_users)	-34158.03663	9618.84408	-3.551	0.001091 **

It is possible to say that, on the short-term multiplier, if each independent variable increases by one unit, the impact of each coefficient on the GDP expected change is equal to the estimate visible in the table.
In the long-term multiplier is possible note that, if each variation of each independent variable increases by one unit, the impact of each coefficient on the GDP expected change is equal to the estimate visible in the table.
Is important to notice that, when each variable increases in unit over the long-run, the expected change would be of estimate units on the price, statistically significant with a 5% level of significance.
Most importantly, except intercept, all the other variables are statistically significant.

5.4 Diagnostics

In this section we are going to implement the various diagnostic tests to check the correctness of our model.

5.4.1 RESET test

The Ramsey Regression Equation Specification Error Test (RESET) test is a general specification test for the linear regression model. Since we do not have a linear model here but an ARDL model, it does not make much sense to calculate this test. We know that a strong omitted variable bias is present because our regression is a reduced form, in fact we selected only the add value for the data analysis. This shows that, if such a test were to be calculated, it would require some additional analyses that investigate if any output of other standard determinants could add any additional explanatory power.

5.4.2 Breusch-Pagan test

The Breusch-Pagan test is used to determine whether or not heteroscedasticity is present in a regression model. The p-value is 0.09243 and, being greater than 0.05, we cannot reject the null hypothesis of homoscedasticity of the residuals.

5.4.3 Breusch-Godfrey test

As already mentioned, this is in fact a general test for autocorrelation of any order (i.e. residuals may be correlated over more than one period). Considering a number of five periods, the p_value associated with each period is always > 0.05, so we can conclude that there is no autocorrelation in the residuals.

5.4.4 Jarque-Bera test

Finally, the Jarque-Bera test, a type of Lagrange multiplier test, is a test for normality. It measures if sample data has skewness and kurtosis that are similar to a normal distribution. Again, having a p_value of 0.8254, we cannot reject the null hypothesis. Therefore, this means that the residuals are normally distributed.

5.5 ARIMA Models

As a final part, we constructed and subsequently compared an ARIMA model with the previously found ARDL model.

Although interesting, the goal is to estimate the 2011's GDP. Since the dependent part contains an integrated autoregressive process, this is one whose characteristic equation has a root on the unit circle, and that means non stationary. This does not have sense from an economic perspective because we have to consider that only the gdp of previous year influenced our the estimation of gdp of current year. Therefore, it is likely to make some duplications mistake for our balance, since we expect that ARIMA model is worst than ARDL. Essentially, it does not make sense to integrate one component repeatedly over time.

In order to successfully generate an ARIMA model, we must identify the respective AR, I and MA values. To do this, we will follow the Box-Jenkins procedure. First of all, we must analyse the plots of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) of our dependent variable *gdp*. Based on their trend, we can get an idea of the p and q values of the process.

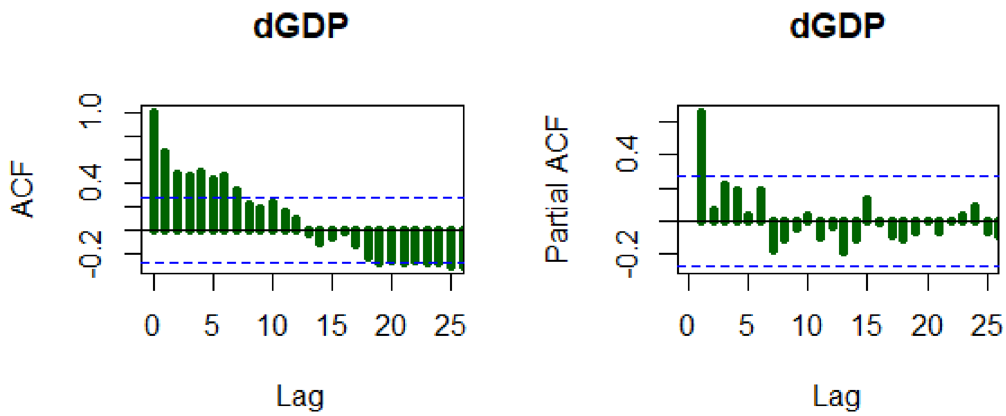

Figure 3: ACF and PACF of gdp

In Figure 3 it can be seen that the ACF plot gradually decays towards 0, while the PACF plot shows an abrupt dropoff after the first lag. These two plots indicate that we are likely dealing with an *AR(1)* process. To be precise, our model appears to be an *ARIMA(1,1,0)*, since we have to calculate the first differences in order to make the dependent variable stationary.

After identifying the starting values of p and q, we implemented the model and focused on the significance of the coefficients via the "coeftest" function. Having only one autoregressive component, it was significant, with a very low p_value. After that, the next step was to check the autocorrelation of the residuals using the Ljung-Box test. This test gives a p-value of 0.1488, thus leading us to conclude that there is no autocorrelation in the residuals.

The model would seem to be fine, however we tried to calculate other models that might be more efficient than the one we have just found.

First, we implemented the same model with the only difference of adding drift, and we found better results (both the intercept and the autoregressive component are significant, and the p_value of the Ljung-Box test is 0.4247). Furthermore, we used the "auto.arima" function to try to work out, of all of them, which p, d and q values produce the best model based on Akaike's information criterion (AIC).

The best model was found to be an ARIMA(4,1,2). This is a bit strange, but we know that the AIC criterion gives us more advanced models (generally with more lags) compare with BIC criterion, which is more tolerant but shows less tolerance at higher numbers. Moreover, since we have yearly data, the sufficient number of lags with this frequency is usually 3 or 4, and this is in line with the output found.

As a last step, we removed the non-significant variables from the ARIMA(4,1,2) model, i.e. we kept only the first and fourth autoregressive components.

Having four models in the end, we decided to compare them with both Akaike and Bayesian information criteria (BIC), and then compare the best of these with the previously calculated ARDL model.
The ARIMA(1,1,0) model with drift is preferable to the same model without constant, since it has a smaller value for both information criteria. The automatically found ARIMA(4,1,2) shows a lower AIC than ARIMA(1,1,0) with drift, but at the same time the value of the BIC criterion is higher, perhaps because we have included non-significant variables in this model. But the best ARIMA model is the last one calculated, i.e. ARIMA(4,1,2) after removing the non-significant variables.

6 Results & Findings

Comparing the last calculated ARIMA(4,1,2) model with the ARDL model, the best model of all those calculated turned out to be the ARDL model, with AIC and BIC values of 929.5 and 951.7 respectively, instead of 1124.62 and 1130.35 in the ARIMA model. This finding is in line with our predictions since, as we explained at the beginning of this section, implementing an ARIMA model for our data does not make much sense. In summary, ARDL is better than ARIMA, but neither it is appropriate for the estimation because duplications accounts may be occur.
The surprising result is that the models found are inappropriate to conduct our analysis. Thus, we can conclude that a spurious regression where the lags of GDP indicate the autoregressive part and the independent variables form the linear regression part is, from a theoretical point of view, better. The model would be as follows:

$$gdp_{2011} = \alpha_1 gdp_{2011-10} + \alpha_2 gdp_{2011-20} + \alpha_3 gdp_{2011-30} + \alpha_4 gdp_{2011-40} + \alpha_5 gdp_{2011-50} + \mu_{2011} + \beta_0 va\_tot_{2011} + \beta_1 net\_indir\_tax_{2011} + \beta_2 gdp_{2011} + \beta_3 imp_{2011} + \beta_4 supply_{2011} + \beta_5 exp_{2011} + \beta_6 total\_cons_{2011} + \beta_7 tot\_fixed\_inv_{2011} + \beta_8 invent\_variation_{2011} + \beta_9 tot\_invest_{2011} + \beta_{10} tot\_users_{2011} + \epsilon_{2011}.$$

It might be interesting to analyze how this model might be developed and implemented in future works.

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