Advanced Macroeconomics Project
Short and long run relation between Government Spending and Real Gross Domestic Product in Italy

Loris Bartesaghi, Andrea Pio Cutrera (967378, 965591)

June 19, 2021

Abstract

Our starting point is the paper *An empirical characterization of the dynamic effects of changes in government spending and taxes on output* by Blanchard and Perotti [BP99]. The two Economists studied how the shocks in government spending and taxes could drive a change in Gross Domestic Product in United States of America in the second half of nineteenth century. We asked ourselves whether in Italy can be found a relationship in last 25 years between the 2 variables in the short and long run, and also investigate the reverse causality. Finding a relation like this could be very interesting because it has been debated since ever how important investments, transfers, and all the kind of government spending are in order to boost economy and increase the wealth of a country. In this paper it is discussed, in particular the relation between spending and output by the Vector Error Correction Mechanism Model (VECM) with the time series of the just mentioned variables.

Keywords— Government Spending, Macroeconomic Empirical Evidence, Vector Error Correction Mechanism

Contents

1 Introduction

In the last 25 years in Italy, like much of the other countries in Europe, it is possible to empirically observe a constant increase in spending by the government and it is maybe partly explained by the *Keynesian* economic assumption that expenditure of the central government can stimulate the increase in wealth of a country, at least in the short run (by making output to increase). The externalities of such a policy had been an issue for scientific and economic debate, and these hidden consequences could be more than expected: a shock in employment, a shock in inflation, and many more [Bar20]. Once we have observed a clear increasing trend in government spending, which are the short-medium and long run effects of a higher government purchase of good and services on gross domestic product in Italy?

Macroeconomic theory is committed to give answers to many questions like this in order to wisely advice economic policies with positive effects on the welfare of the citizens, but theory should match empirical evidence in order to be effective in reality. In particular, for our research question the greatest majority of macroeconomic models (e.g. IS-LM model) forecast an expansionary effect on gross domestic product due to an increase in spending by the government [JG04] (through an increase in consumption).

For the sake of simplicity, we decided to focus just on the relation between central government intervention and maybe the most important and significative measure of wealth of a country: the Real Gross Domestic Product.

We were also interested in the reverse effect of the GDP on Spending because we expected that a higher wealth of a country allows a greater possibility of future expenditures in longer run. This expectation is even in accordance to what *Levitt* and *Joyce* discuss in a paper of 1987 [LJ87]: "Wagner's law predicts and advocates the growth of government expenditure (as a share of national income) on social services and transfers, on infrastructure and on a range of economic services". This macroeconomic law tells us that the level of output clearly affects the decisions of the fiscal authorities in the medium run [Mul09].

Even more, there was, and still there is a classical association with political colour of a tendency to use (or deny) government purchase to boost economy; the parties of the right, the more liberal ones, tended to favour a decrease in taxes, contrary to the left ones which support the increase of the spending by the government in order to increase wealth in the long run.

In our empirical analysis we tried to find out whether there exist a relation between the two time series (namely GDP and Spending), which span from the first quarter of 1995 to the last quarter of 2019. Explicitly it has been dropped the observations of 2020 because of the huge shock of the pandemics in both our variables of interest, which could be a disturbing factor for our expectations.

The analysis starts from the Augmented Dickey Fuller Test, used to detect the presence of unit roots in the time series, which suggests that the order of integration of both time series is one. After having checked for non-stationarity we control the direction of "causality" with the Granger Causality test, and ultimately before constructing the model for the Vector Error Correction Mechanism we check the cointegration between the two variables in order to see whether there exists a linear combination which is stationary, and so a "long run relationship" between the two variables. With the VECM we found that the long run causality exists and it is unidirectional, therefore it is the Real GDP which drives government expenditure.

2 Data and Methodology

2.1 Data Understanding

Our main data source was the Federal Reserve Bank of St.Louis which provides more grained data at quarterly level. These detailed information could give more insights on shocks which takes place in 3-months periods and could allow us to catch shorter run effects of one variable to the other. We decided to measure wealth of the country, namely Italy, with the Real GDP.

- First variable: ***RGDP - Real Gross Domestic Product***

  Quarterly Real Gross Domestic Product in Italy from 1995Q1 to 2019Q4 (measured in Millions of Chained 2010 Euros, Seasonally Adjusted). We multiplied this measure by 1 million in order to have the same unit of measurement of the other variable [Eur21],

- Second variable: ***EXP - Total Government Spending***

  Quarterly Government Final Consumption Expenditure in Italy from 1995Q1 to 2019Q4 (Euros Seasonally Adjusted) [rfF21].

We then decided to take the logarithm to both the measures in order to have more interpretable coefficients, due to the fact that the absolute values of both variables have a huge order of magnitude (thousands of billions). The first variable is the most frequently adopted measure in macroeconomic analysis to describe the wealth of a country; the second one is instead the aggregated amount of total expenditure (purchase of goods and services) done by the government without any distinction of aims.

2.2 Data Visualization

The natural logarithm of Real GDP seems to keep increasing until 2008 financial crisis, then decreasing with fluctuations until 2016, and in the last period again increasing. We decided to omit 2020 because of great shock caused by the exogenous factor of the pandemics, which would have been otherwise disturbing our analysis.

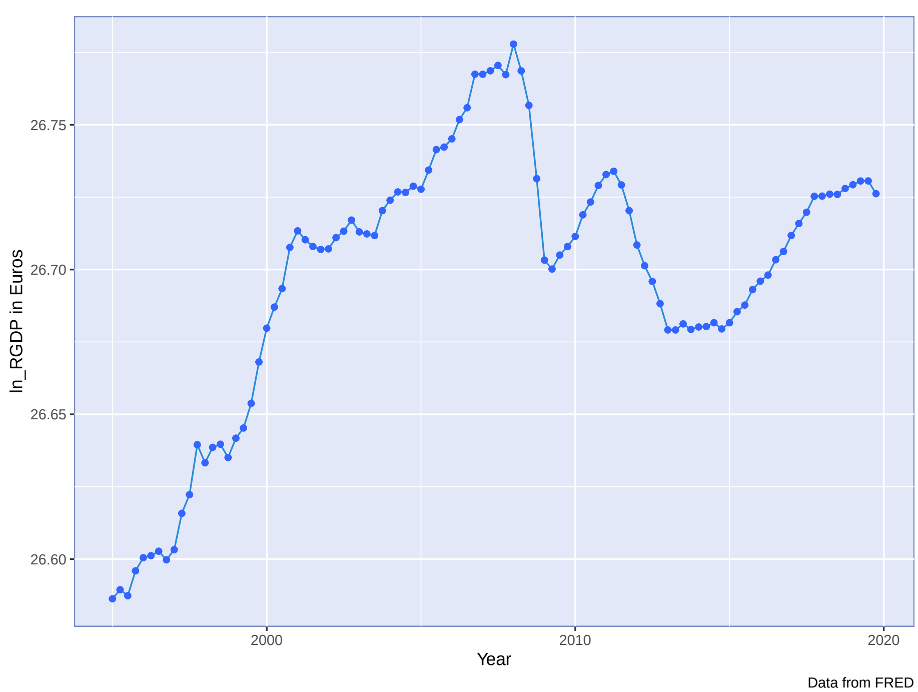


Figure 1: Gross Domestic Product (logarithmic scale)

The total government expenditure's variable show an increase until reaching a maximum in 2010, from then on it seems to remain more or less stationary until 2019.

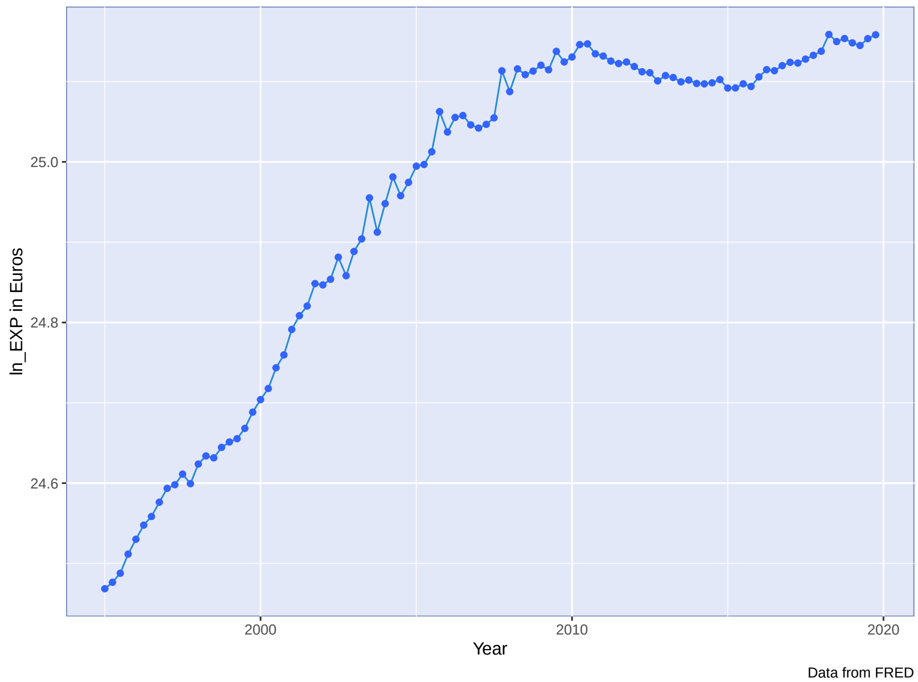


Figure 2: Goverment expenditure (logarithmic scale)

Visualizing the 2 variables in first difference (in Fig.5 together) seems that the first difference of expenditure anticipates the first difference movement of the GDP, and this suggests which one could be the cause and the effect, but data and tests should confirm it.

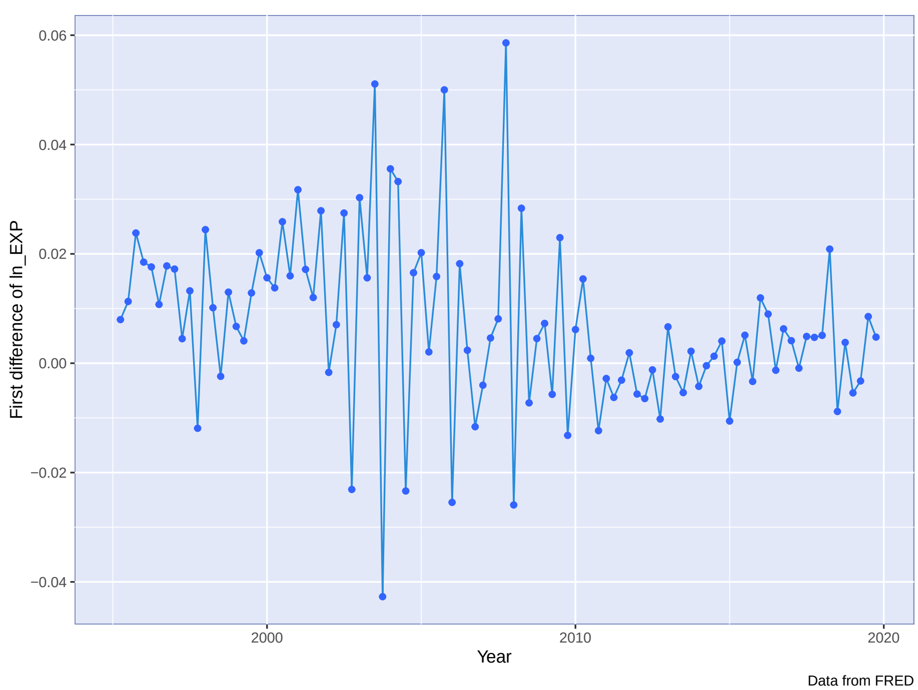


Figure 3: Government expenditure in first difference (logarithmic scale)

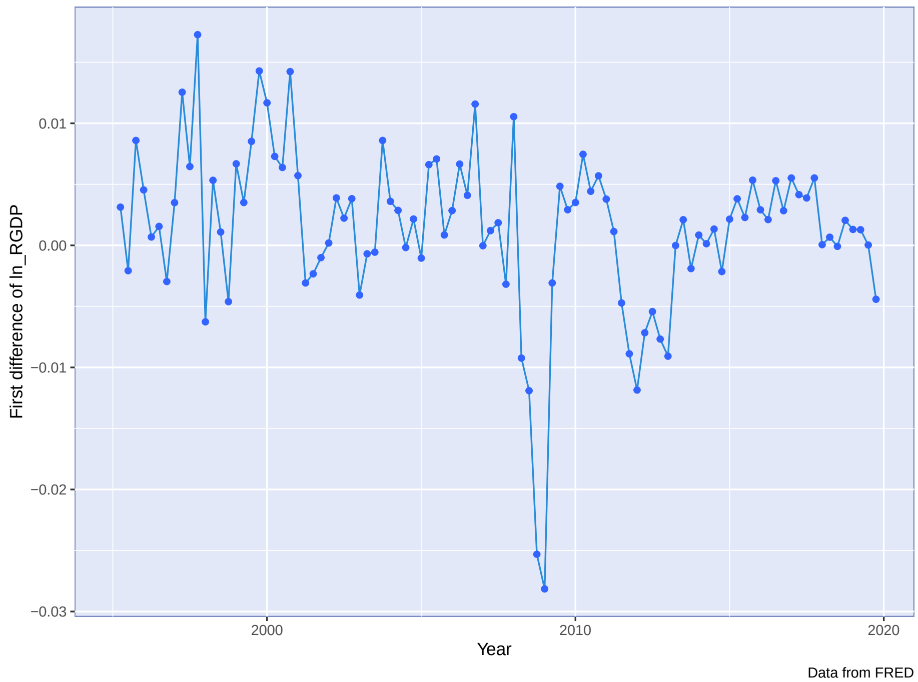


Figure 4: Gross Domestic Product in first difference (logarithmic scale)

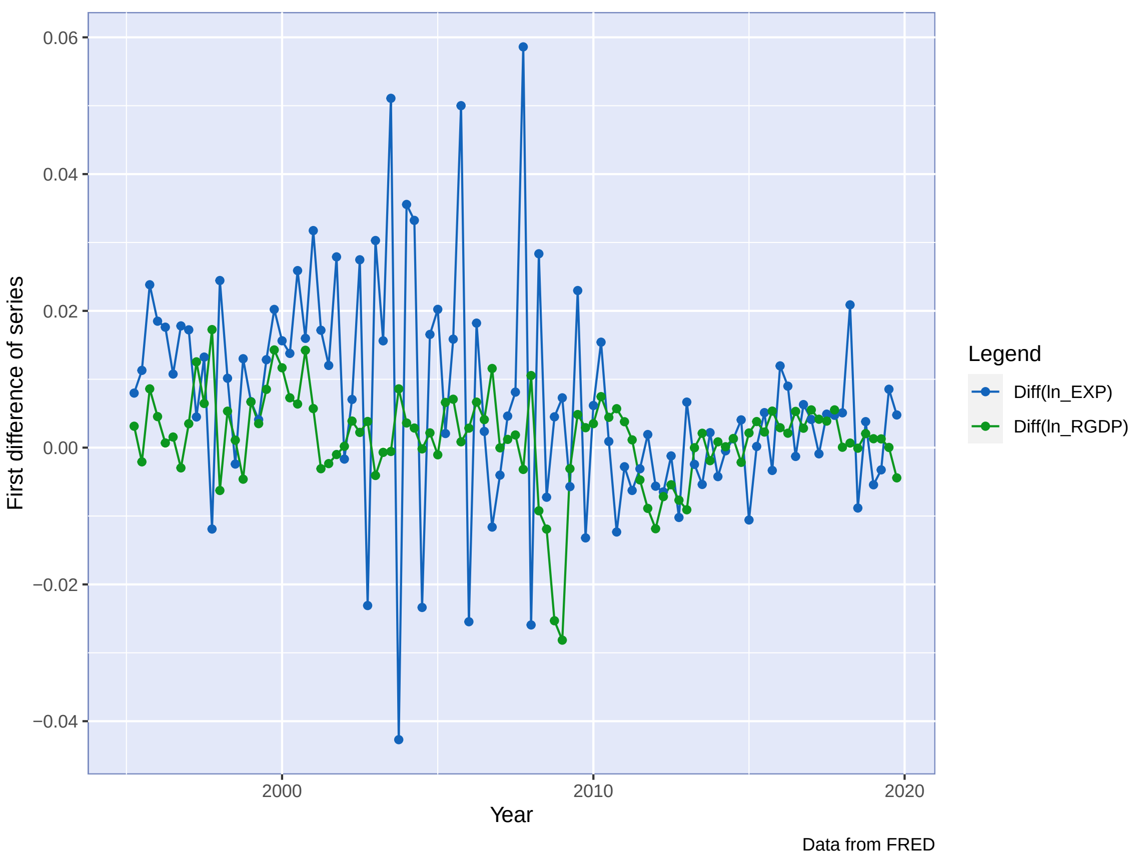


Figure 5: First Differences of the 2 variables (logarithmic scale)

2.3 Methodology

2.3.1 Augmented Dickey Fuller Test - Unit root testing

In order to understand whether the variables under consideration are stationary or not we decided to use the well-known Augmented Dickey Fuller Test. The null hypothesis to assess in this test is $H_0 : \phi = 1$, while the alternative hypothesis is $H_1 : \phi < 1$. The test is done under the model (with intercept and time trend)

$$Y_t = c + \phi Y_{t-1} + \delta t + A_1 \Delta Y_{t-1} + \cdots + A_p \Delta Y_{t-p} + \epsilon_t$$

Where δ is the deterministic trend coefficient, ϵ_t is the zero mean innovation process and Δ is the differencing operator. The number of lagged difference terms to use in the model is determined by p, and this parameter must be chosen looking at the property of the data. A very useful information to infer about H_0 is the *t-value* used on the ϕ coefficient. This statistic is computed by

$$t_{stat} = \frac{\hat{\phi} - 1}{SE(\hat{\phi})}$$

Where $\hat{\phi}$ is the estimate of ϕ and *SE* is the standard error [AP14].

2.3.2 Pairwise Granger Causality Test

For the purpose of finding the direction of the short run relationship between the 2 variables we used the Granger Causality test, which is based on the concept that the cause occurs prior to the effect. To perform this test, the series considered must be stationary.
To estimate the linear Granger Causality Test, an unrestricted VAR (vector autoregressive model) of the two variables is performed

$$Y_{1,t+1} = \sum_{j=0}^{P-1} \alpha_{1,j} Y_{1,t-j} + \sum_{j=0}^{P-1} \beta_{1,j} Y_{2,t-j} + \epsilon_{1,t-j}$$

Where $\alpha_{1,j}$ and $\beta_{1,j}$ are the coefficient of the model and ϵ_1 the residual fitting the model [AP14]. Performing the restricted VAR, omitting $\sum_{j=0}^{P-1} \beta_{1,j} Y_{2,t-j}$, we find the following model

$$Y_{1,t+1} = \sum_{j=0}^{P-1} \alpha_{1,j} Y_{1,t-j} + \tau_{1,t-j}$$

Denoting $\hat{\epsilon}$ and $\hat{\tau}$ the residuals of the two regressions and

$$RRSU = \sum_{t=j+1}^{T} (\hat{\epsilon})^2; \qquad RRSS = \sum_{t=j+1}^{T} (\hat{\tau})^2$$

The test will be performed under the null hypothesis

$$H_0 : T\frac{RRSS - RRSU}{RSSU} \rightarrow_d \chi^2_p$$

2.3.3 Johansen Cointegration Test

To assess the presence of a long-term relationship between the non stationary series considered, the Vector Error Correction Mechanism is the proper model to prove it. Hence, the Johansen Cointegration Test is necessary to establish the existence of the cointegrating equation in the model mentioned before. Johansen introduced a method based on a VAR estimated object of order p

$$Y_t = \mu + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + \epsilon_t$$

Where Y_t is the vector of k non-stationary processes and ϵ_t is the vector of innovations. The previous model can be re-written as

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma \Delta Y_{t-1} + \epsilon_t$$

where

$$\Pi = \sum_{i=1}^{p} A_i - I \qquad \Gamma = -\sum_{j=i+1}^{p} A_j$$

In the case in which the matrix Π has rank $r < k$, then r cointegrating equations exists and the matrix $\Pi = \alpha\beta'$ and $\beta' Y_t$ is stationary (each α and β are k x r matrix with r rank) [EVi20].
The aim of the Johansen Cointegration Method is to estimate the matrix Π from an unrestricted VAR of order p (using the proper method to select the lags to consider in the model) and to test the rejection introduced by the rank reduction forced by the introduction of the matrix Π.

2.3.4 Vector Error Correction Mechanism

Identified the existence of the cointegrating equation(s) between the variables, the Vector Error Correction Mechanism allows to improve the knowledge about the dynamic relation between Expenditure and Real Gross Domestic Product. In fact, the model is fundamental to understand the long-run equilibrium state on which the cointegrated series will converge. It is possible to have the following representation of the model as

$$Y_{1,t} = \alpha_1(ECT_{t-1}) + \sum_{i=1}^{n} \gamma_{11} \Delta Y_{1,t-i} + \sum_{j=1}^{n} \gamma_{12} Y_{2,t-j} + \epsilon_{1,t}$$

$$Y_{2,t} = \alpha_2(ECT_{t-1}) + \sum_{i=1}^{n} \gamma_{21} \Delta Y_{2,t-i} + \sum_{j=1}^{n} \gamma_{22} Y_{1,t-j} + \epsilon_{2,t}$$

The coefficients α of the Error correction Term are crucial to understand which variable influences the other one, forcing it to converge to the long-run equilibrium. The coefficient give also the information about the speed of adjustment to the stability of the variables.
The expectation is that at least one of the coefficient (α) will have negative and significant value, which means that there is a mechanism that will bring to the long-run equilibrium the series analysed. For example, in this case if α_1 is negative and significative, the interpretation will be that there is unilateral causality of Y_2 on Y_1; in other words, Y_2 will drive towards the equilibrium Y_1.
The VECM model is useful to confirm the results of the Granger Causality Test. Indeed, the lagged terms of Y_1 and Y_2 are present in each other regression, and the coefficient of the variables and their t-statistics are useful to infer causality in the short-run [Mis11].
The Error Correction Term is the equation that represent the long run equilibrium, and explain how a shift in the value of one variable affect the other one.

$$ECT_{t-1} = Y_{1,t-1} - \beta_0 - \beta_1 Y_{2,t-2}$$

3 Empirical Results and Interpretation

3.1 Augmented Dickey Fuller Test

The Augmented Dickey Fuller test on the natural logarithm of Expenditure and Real Gross Domestic Product is performed testing the null hypothesis of unit-root under the assumption of intercept and time trend. The ADF performed on the first difference of the variables considered, tested the existence of unit-root under the hypothesis of intercept only. The choices of assumption for the Augmented Dickey Fuller Test have been done considering the Figure 1 to 4.

Augmented Dickey Fuller test				
Variable	Level	Critical value (95%)	First difference	Critical value (95%)
Expenditure	-1.073506	-3.456319	-3.902448	-2.891234
Gross domestic product	-2.043874	-3.456319	-5.299944	-2.891234

The results in the table confirm that both the logarithm of Expenditure and Gross Domestic product are integrated of order 1. So, the time series we are considering are both non stationary, and this implies that it is possible the cointegration between the variables.

3.2 Pairwaise Granger Causality Test

To perform this test, it is necessary that the variables considered are stationary. Given this necessary condition, the test is performed using the first differences of the logarithm of the Expenditure and of Real Gross Domestic Product. The results are shown in the table below.

Pairwise Granger Causality Tesr		
Null Hypotesis	F-statistic	Prob.
Expenditure (in difference) does not Granger cause GDP(in difference)	5.37350	0.0062
GDP(in difference) does not Granger Cause Expenditure (in difference)	2.47724	0.0896

The null hypothesis for which the first difference of the logarithm of the expenditure does not Granger cause the first difference of natural logarithm of GDP is rejected with a 5% level of significance. Therefore, it has been proved that in Italy in the period 1995-2019 the Keynesian theory on government spending and the relative positive effects of them on the Real Gross Domestic Product works as theory suggests. To the contrary, the null hypothesis for which the logarithm of the GDP (in difference) does not Granger cause the natural logarithm of Expenditure (in difference) is failed to be rejected with a 5% level of significance, finding no evidence for reverse causality in the short run.

3.3 Johansen Cointegration Test

An important assumption to correctly perform the Johansen Cointegration Test and the Vector Error Correction Mechanism is to specify the model (the possible introduction of trend and intercept in the Error Correction Mechanism or in the Vector Autoregressive Model) that the two cointegrated variables fit. To understand what are the parameters to consider in the model all assumptions are considered, and the specification chosen by the Akaike Information Criterion and by Schwarz Criterion are used to test the number of cointegrating equations and to perform the VECM.

Johansen Cointegration Test					
Data trend	None	None	Linear	Linear	Quadratic
Cointegrating equation	No intercept No trend	Intercept No trend	Intercept No Trend	Intercept Trend	Intercept Trend
Akaike Information Criterion by Rank (rows) and Model (columns)					
0	-12.93588	-12.93588	-13.09209	-13.09209	-13.22287
1	-13.25528	-13.29296*	-13.27402	-13.26865	-13.28726
2	-13.17674	-13.25506	-13.25506	-13.23204	-13.23204
Schwarz Criterion by Rank (rows) and Model (columns)					
0	-12.83037	-12.83037	-12.93383	-12.93383	-13.01185
1	-13.04426	-13.05557*	-13.01025	-12.97850	-12.97073
2	-12.86021	-12.88578	-12.88578	-12.81000	-12.81000

The model to be considered in our analysis is specified by the software with the symbol "*". The results show that a cointregrating equation exists, as we expect, for both the Criteria, and it is one and only one. Furthermore, the software's output shows that the model to consider in the following steps is the one with an intercept and no trend in the cointragrated equation, but without any linear or quadratic trend in data.

3.4 Vector Error Correction Mechanism

The purpose of the paper is to investigate the influence of the Real Gross Domestic Product on Expenditure and viceversa. A previous attempt to understand their behaviour and relation in short run is done by introducing the Granger Causality Test, which has shown a short term direction of causation from the Government Expenditure to the Real Gross Domestic Product.
A more complete understanding of the relation could be pursued through the Vector Error Correction Mechanism whose model allows to understand the long-run equilibrium on which both the variables will converge, and also the process after a short-term deviation that brings back to the long-term equilibrium both the variables [Mis11].

The estimation of a Vector Error Correction Mechanism Model (VECM) requires selection of an appropriate lag length. Both "Akaike Information criterion" (AIC) and "Schwarz Criterion" (BIC - Bayes Information Criterion) select as the proper value, for performing a Vector Autoregressive Model two lags. The existence of lagged values in VECM model, force to use 1 lag as specification to fit the model.

Lag Length Criteria						
Lag	LogL	LR	FPE	AIC	BIC	HQ
0	227.5565	NA	2.54e-05	-4.903403	-4.848581	-4.881276
1	590.9913	703.1672	1.03e-08	-12.71720	-12.55274	-12.65082
2	622.4124	59.42687*	5.67e-09*	-13.31331*	-13.03921*	-13.20268*
3	625.2304	5.207247	5.82e-09	-13.28762	-12.90387	-13.13273
4	626.3740	2.063391	6.19e-09	-13.22552	-12.73213	-13.02638

Furthermore, the previous Johansen Cointegration Test gives the information relative to the expected "form" of the VECM, that is without trend and with an intercept in the Error Correction Term. The output of the Vector Error Correction Mechanism performed with the previous specification is displayed in the following table.

Vector Error Correction Mechanism		
Cointegrating equation	Equation	
$\Delta lnEXP$	1.000000	
$\Delta lnRGDP$	-2.821162	
Standard Error	(0.51486)	
T-statistic	[-5.47951]	
Coefficient	50.36650	
Dependent variable	$\Delta lnEXP$	$\Delta lnRGDP$
Error Correction Term Coefficient	-0.058877	0.004422
Standard Error	(0.01109)	(0.00448)
T-statistic	[-5.31134]	[0.98642]
$\Delta lnEXP$	-0.394797	0.129926
Standard Error	(0.08975)	(0.03929)
T-statistic	[-4.39908]	[3.57988]
$\Delta lnRGDP$	0.151289	0.587823
Standard Error	(0.21693)	(0.08773)
T-statistic	[0.69740]	[6.70052]
Coefficient	0.009494	-0.000378
Standard Error	(0.00155)	(0.00063)
T-statistic	[6.13558]	[-0.60445]

The estimated coefficients for the lagged variables are fundamental to understand the short-term dynamics between the Expenditure and the Real GDP (and to have a confirm of the results of the Granger Causality Test we have done in the previous section).
When Government Expenditure is considered as target variable, the estimated coefficient of $\Delta lnRGDP$ is not significant at 5 % level of confidence, and this implies that the short-term dynamic which causes the Expenditure is driven only by his pasts values.
On the opposite, when Real Gross Domestic Product is considered as target variable, the estimated coefficients of $\Delta lnEXP$ and $\Delta lnRGDP$ are significant at 5 % level of confidence, which imply that the short-term dynamic of the Real GDP is driven by both the variables. The interpretation of the estimated coefficients of the VECM, confirm the results that the Granger Causality Test gave.

The coefficient estimate of the Error Correction Term, in the case of Government Expenditure is negative and strongly significative. Hence, the causality is inverted with respect to the short-run finding; in fact, this coefficient explains that a deviation from the long-run equilibrium of the Government Expenditure is pushed back to steady state of the two variables by the Real GDP.

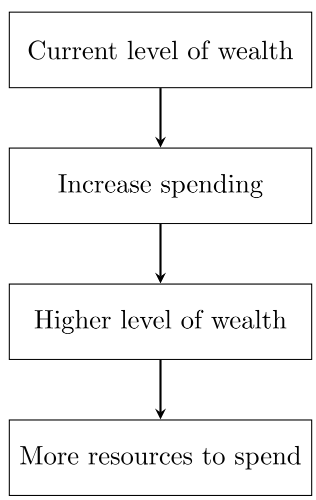
Furthermore, this estimated coefficient specifies the rate of convergence to the equilibrium state per year. More precisely, the speed of adjustment of any disequilibrium towards a long-run equilibrium is corrected about 5.86 % of the disequilibrium in Government Expenditure each year.
To the other hand, the coefficient estimate of the Error Correction Term for Real Gross Domestic Product as target variable, is positive but not significative. This implies that a deviation from the long-run equilibrium is not corrected by the Government Expenditure.
Furthermore, from the table it's possible to derive the equation that describe the long run equilibrium

$$ln(Exp) = -50.36650 + 2.81162 * [ln(Rgdp)]$$

Using this equation it is possible to find, in a particular quarter, if the Government Expenditure is above the long run equilibrium with Real Gross Domestic Producuct. For example, a good sample could be the first quarter of 2009, where the Government Expenditure rise because of the crisis of labour market.
The Real Gross Domestic Product was of 26.70325, and the theoretical Government Expenditure, computed by the previous cointegrating equation, had to be of 23.07413905. However, the observed value is 25.12040. Working with math, it is possible to find that the difference between theoretical Government Expenditure and the real one is about 7'072'304'806. A very realistic value, because the Total Debt for Italy in 2019 increase by an amount of 28,7 billions.
Interpreting the coefficient of $ln(Rgdp)$ which is 2.81162, remembering that both variables are expressed with natural logarithm of the initial values, an increase of 1% in the Real Gross Domestic Product correspond to an increase of the Government Expenditure of 2.81162%. This interpretation tells us the the Government Expenditure is increasing more(in percentage) than the Real Gross Domestic Product, which is another confirmation of Wagner's Law Theory.
In fact, "The theory holds that for any country, public expenditure rises constantly as income growth expands. The law predicts that the development of an industrial economy will be accompanied by an increased share of public expenditure in gross national product:The advent of modern industrial society will result in increasing political pressure for social progress and increased allowance for social consideration by industry." [Wik21]

4 Conclusions

With this analysis we tried to find an answer to a widely debated macroeconomic issue with some empirical evidence for the last 25 years in Italy. We asked ourselves whether or not the government expenditure can affect the gross domestic product of the country in the short run, and through the Pairwise Granger Causality test, which provides the existence and eventually the direction of causality between a pair of variables, we found a confirmation of the Keynesian theory: investments, transfers, and all the kind of government spending have important effects on the output. Furthermore the estimates of the coefficients of the Vector Error Correction Mechanism model confirms that it is only the spending that influence the GDP and not the reverse in the short run.
Since the GDP and the government spending are non-stationary and cointegrated time series, as ADF and Johansen Tests suggest, it means that they are correlated and they cannot depart much from their equilibrium in the long run. With the VECM model we were ultimately able to describe the long run relationship between the 2 variables and through the coefficient of the error correction term, which is negative and statistically significative, it is possible to prove that there exist a unidirectional effect of GDP on government spending. This finding is even more interesting because it shows that in the long run the relationship is reversed with respect to the shorter run behaviour: it is the wealth of the country which allows to invest many more resources for the public. So, our expectation, which is matched with this evidence is actually in accordance with the Wagner's Law which predicts that the level of output affects the decisions of the fiscal authorities in the medium run [Mul09].
Ultimately what our empirical results suggest is that Government Expenditures of today have a crucial role in the near future output level, which would imply possibilities to increase for a greater amount of investments. Moreover, higher wealth of the country today allows more resources to be spent in the future. It is exactly a mechanism that has the shape of an endless cycle, and it can be synthesized in the following schema:



References

[AP14] D. Kugiumtzis C. Diks A. Papana, C. Kyrtsou. Identifying causal relationships in case of non-stationary time series. May 2014.

[Bar20] Brian Barnier. Keynesian economics, 2020.

[BP99] Oliver Blanchard and Roberto Perotti. An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *NATIONAL BUREAU OF ECONOMIC RESEARCH 1050 Massachusetts Avenue Cambridge, MA 02138*, July 1999.

[Eur21] Federal Reserve Bank of St. Louis Eurostat, retrieved from FRED. Real gross domestic product for italy [clvmnacscab1gqit], 2021.

[EVi20] EViews. Johansen cointegration test, 2020.

[JG04] Javier Vallés Jordi Galí, J. David López-Salido. Understanding the effects of government spending on consumption. *International research forum on monetary policy*, April 2004.

[LJ87] M. Levitt and M.A.S. Joyce. The growth and efficiency of public spending. *Cambridge University Press, Cambridge*, 1987.

[Mis11] P. K. Mishra. The dynamics of relationship between exports and economic growth in india. *International Journal of Economic Sciences and Applied Research*, September 2011.

[Mul09] Kabey Clement Mulamba. Long run relationship between government expenditure and economic growth: Evidence from sadc countries. 2009.

[rfF21] Federal Reserve Bank of St. Louis retrieved from FRED. Organization for economic cooperation and development, government final consumption expenditure in italy [itagfceqdsmei], 2021.

[Wik21] Wikipedia. Wagner's law theory, 2021.