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Does the Zero Lower Bound affect Euro Area Productivity? A case study

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Does the Zero Lower Bound affect Euro Area Productivity?

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"…So much of barbarism, however, still remains in the transactions of most civilized nations, that almost all independent countries choose to assert their nationality by having, to their own inconvenience and that of their neighbors, a peculiar currency of their own."

(Mill, 1848)

Acknowledgements

To God.

Dedication

To Professor Diptes Bhimjee for all his support, availability and dedication. Without his guidance it would have been impossible to do this Dissertation.

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In Memoriam

To my Mother Maria do Carmo.
That although not physically present, is always present in my heart.

Abstract

The main research question associated with this case study is to contribute modestly to the discussion of the relationship between Zero Lower Bound (ZLB) framework and Productivity of the Euro Area, Germany and the GIIPS. The relationship between ZLB and Unit Labor Costs is also analyzed.

The series analyzed correspond to the period from the first quarter of 2000 to the third quarter of 2018. The purpose of choosing this period is to maximize the quality of the analysis by addressing multiple stages of the global business cycles.

To put this analysis into practice, the Vector Error Correction Model (VECM) was applied and the Granger Causality was analyzed.

It is possible to conclude that only in Portugal does the ZLB affect Productivity and that the ZLB affect unit labor costs in Portugal and Spain exclusively.

Keyword: Zero Lower Bound, Euro Area, Productivity, Unit Labor Costs

JEL Classification: E52, J39, G01, O40

Resumo

A preocupação do presente estudo de caso é contribuir modestamente para a discussão da relação entre a Zero Lower Bound (ZLB) e a produtividade da Área Euro, da Alemanha e dos GIIPS em particular. Foi também analisada a relação entre a ZLB e os Custos Unitários do Trabalho.

As séries analisadas correspondem ao período compreendido entre o primeiro trimestre de 2000 e o terceiro trimestre de 2018. O objetivo da escolha deste período compreende-se com o facto de se pretender maximizar a qualidade da análise, analisando múltiplas fases do ciclo económico global.

Para colocar em prática esta análise foi estimado o modelo Vector Error Correction Model (VECM) e analisada a Causalidade à Granger.

Foi possível concluir que apenas em Portugal a ZLB afeta a produtividade e que a ZLB afeta os Custos Unitários do Trabalho em Portugal e Espanha, exclusivamente.

Palavras-chave: Zero Lower Bound, Produtividade, Custos Unitários do Trabalho, Euro Area

Classificação JEL: E52, J39, G01, O40

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Glossary

Zero Lower Bound - ZLB

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Vector Error Correction Model - VECM

European Central Bank - ECB

European Monetary System - EMS

Economic and Monetary Union - EMU

Total Factor Productivity - TFP

Vector Autoregression (VAR)

Federal Reserve System (United States) - FED

Chapter I - Introduction

The research question of the present case study is to contribute modestly to the discussion of the relationship between the Zero Lower Bound and Productivity. This is how the academic question of this dissertation arises:

"Does the ZLB affect Euro Area Productivity?"

This is a subject little explored academically but of great importance for the EA, as can be seen from the indication given by the European Commission for the creation of National Productivity Boards in all euro area countries (EU, 2016).

In parallel with the main research question, it will be relevant to investigate whether the ZLB affect unit labor costs (ULC) in the EA and what are the differences in behavior between Germany and the GIIPS - Greece, Ireland, Italy, Portugal and Spain.

To answer the above question, quarterly data series were used for the period 2000Q1 to 2018Q3. The choice of this time window is aimed at maximizing the number of data points to be observed to improve the reliability of the analysis, while addressing multiple global business cycles. Data were collected from the following databases:

1. Organization for Economic Cooperation and Development – OECD;
2. European Central Bank – ECB;
3. Eurostat;

Considering the characteristics of the data series to be analyzed, and to maximize the quality of the results obtained, the Vector Error Correction Model - VECM - was chosen (except for the Spanish case)[1]. Also, the Granger Causalities involving the variables Productivity, ULC's, ZLB and GDP were investigated.

The results demonstrate that the ZLB does not affect euro area Productivity. Of the countries under review - Germany, Greece, Ireland, Italy, Portugal and Spain - only in Portugal does the ZLB affect Productivity. Regarding ULC's, it is found that only in the Iberian countries the ZLB affect the corresponding ULC's.

[1] Spain's VAR Output in Appendix A.5.7

This Dissertation is briefly summarized as follows: Chapter II provides a framework and literature review of the ZLB and Productivity. In Chapter III the methodology will be presented. Chapter IV presents the main empirical results of this Dissertation. Chapter V concludes.

Chapter II – ZLB Framework and Literature Review

I – Economic setting that led to the ZLB[2]

"…a few months have passed, and we see that credit flows are actually weak and remain weak"

(Draghi, 2012)

In 2012, the ECB reduced its Deposit Facility Rate to 0.00[3]. Since the start of the ECB's activity in 1999, it has been the first time the rate has reached 0.00.

It is important to understand the rationale of the ECB's decision, whose overriding objective is "maintaining price stability" (EU, 2012) of a decrease of 0.00 to the Deposit Facility rate. To this end, we will briefly discuss the economic climate of the EA when the ZLB arrived in 2012.

a) 2009

"This is without doubt the worst economic crisis since the restoration of democracy (in 1974)."

Papandreu, Greek PM, (Guardian, 2009)

In April 2009, and with the EA's economy already weakening, the European Union called on France, Spain, Ireland and Greece to reduce their budget deficits. Later in October, Papandreu wins the elections in Greece. In the wake of Dubai's sovereign debt crisis in November, fear and concern over EA indebted countries set in. In December, rating agencies downgrades to Greek banks and Greek debt securities begin. At the end of the year, Greece had a public debt of 113% of GDP (almost double the 60% EA limit, imposed by the Stability & Growth Pact) and a public deficit of 15.1% (more than four times the 3% limit). However, Greece was not the only Member State that drew attention

[2] BBC, 2012
[3] ECB's Deposit Facility Rate history in Appendix A.1.

for the worst reasons, as Portugal also had a high public deficit of 9.8% of GDP and Ireland also had a high public deficit of 13.8% of GDP.

b) 2010

"The only way to avoid bankruptcy is to take the money from our European partners and the IMF and to do that we need to enforce these measures"

George Papaconstantinou, Greece Finance Minister (Guardian, 2010)

In 2010 the situation worsened as early as January, when the ECB discovered, and condemned, the irregularities committed by the Greek authorities, which "softened" the public account for 2009. After the decline of the Greek state on May 2, 2010, it agreed a bailout package to save Greece. This package was worth 110bn euros. In November, and following strong aid to its financial system, it was the Irish State's turn to resort to a bailout package of 85bn euros. The year would end with a strong suspicion that Portugal would be the next country to be rescued. Greece would end 2010 with a public deficit of 11.2% of GDP, like Portugal, and Ireland with a public deficit of 32.1% of GDP.

It is interesting to note that Spain had a public deficit of 9.4% of GDP. Regarding public debt Greece had a percentage of 146.2% of GDP, Ireland 86% of GDP and Portugal 96.2% of GDP.

c) 2011

“Risks to euro area financial stability increased considerably in the course of 2011 as the sovereign debt crisis and its impact on the banking sector worsened”

(ECB, 2011)

In April, after a debt issue with very high costs, Portugal would ask for a bailout and in May would receive a bailout package of 78 bn euros. As levels of austerity rose in Greece, so did the rumors that the Hellenics would abandon the single currency. To avoid contagion to other countries, a second bailout package of 109 bn euros was approved for Greece, but fear in the markets remained, and after the Portuguese rescue, the focus was on the Italian and Spanish economies. The economic situation of the euro area worsens.

Spain would end 2011 with a public deficit of 9.6% of GDP, Portugal 7.4% of GDP, Greece 10.3% of GDP, Ireland 12.8% and Italy 3.7% of GDP. The already chronically high Italian public debt increased further to 116.5% of GDP, Ireland 110.9% of GDP, Greece 172.1% of GDP, Portugal 111.4% of GDP, while debt Spanish public service stood at 69.5%.

d) 2012

"The euro area is finally approaching its own day of reckoning (…) we are in a downward spiral that shows no sign of ending."

Gordon Brown, British PM (BBC, 2012)

As early as February 2012, the European Commission estimates that the EA economy will contract by 0.3%. In the following month the euro area unemployment rate reaches a new high. Fear about compliance with the Spanish and Italian states increases, reflecting on debt issuance and the associated high interest rates. It is in this context, that the figures 1 and 2 allow for a perspective on the ZLB[4].

[4] Table with data on Appendix A.2.

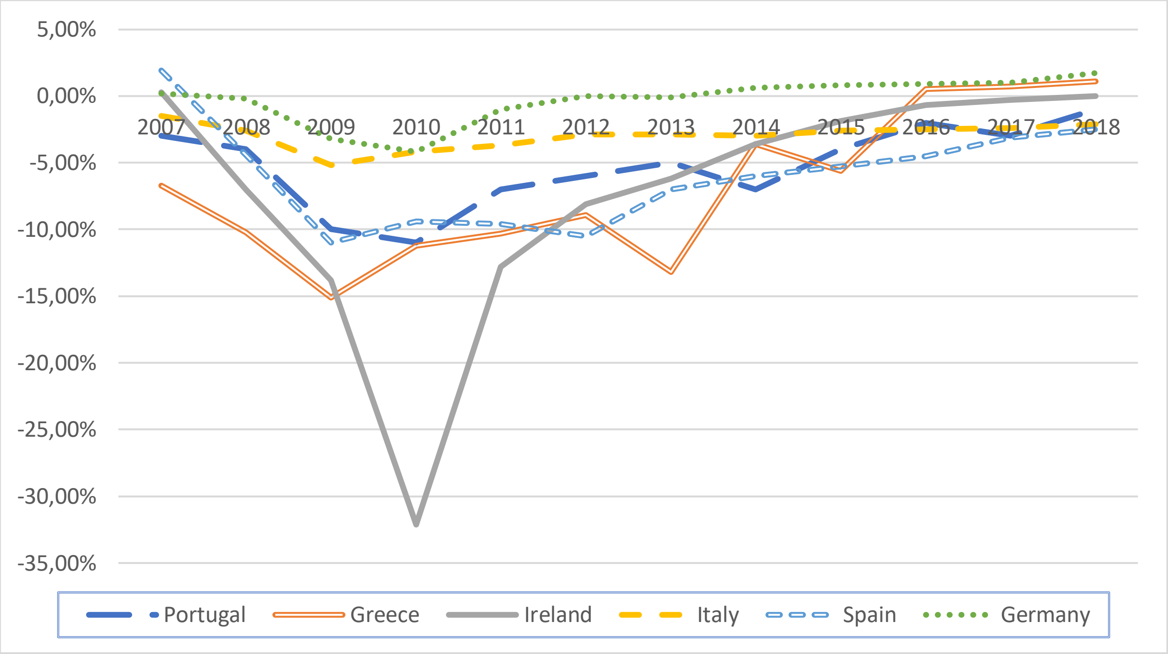

Figure 1 Public Deficits % – Source Eurostat

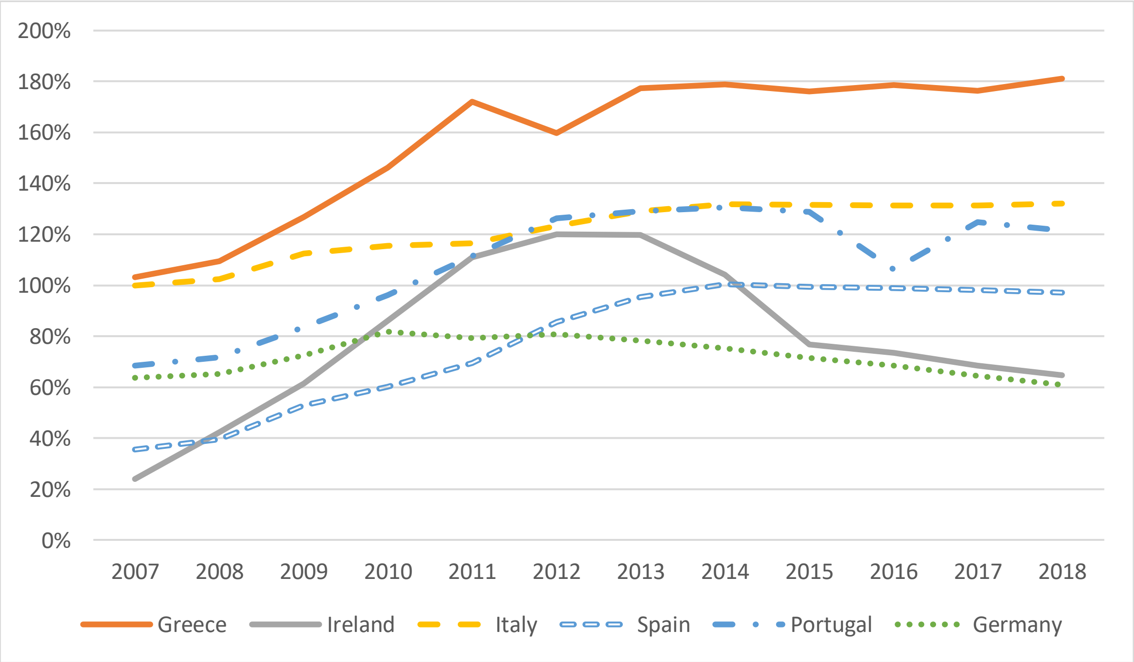

Figure 2 - Debt to GDP Ratio % - Source Eurostat

II – Liquidity Trap

> "There is the possibility, (..), that, after the rate of interest has fallen to a certain level, liquidity-preference may become virtually absolute in the sense that almost everyone prefers cash to holding a debt which yields so low a rate of interest. In this event the monetary authority would have lost effective control over the rate of interest. But whilst this limiting case might become practically important in future, I know of no example of it hitherto."
>
> (Keynes, 1935)

Under normal economic conditions, monetary policy has an effect on aggregate demand through its interest rate, both medium and long term. The reduction in interest rates allows investment and credit to increase, although it might contribute to higher prices. However, in a liquidity trap, this situation is not the case.

An economy finds itself in a liquidity trap when there is no room for maneuver to lower the interest rate, resulting in the ineffectiveness of the monetary policy transmission channel via the interest rate to counteract (or accommodate) negative shocks to the economy (Gameiro and Maximiano, 1999). Thus, economic agents make no distinction between holding money or securities which leads to a slowdown in the speed of currency circulation.

Linked to the liquidity trap is the danger of a deflationary spiral. In particular, if an unfavorable shock hits an economy and causes recession and deflation, the ZLB will imply a rise in the real interest rate, with additional contractionary and deflationary effects on the economy. If nominal wage reductions are rigid, the situation worsens further because the shock would correspond to a rise in real wages, thus aggravating the economic contraction (Gameiro and Maximiano, 1999).

One methodology for observing whether or not an economy is in a liquidity trap situation is to look at whether actual demand falls short of productive capacity, although short-term nominal interest rates are relatively close to zero (Duprat, 2013).

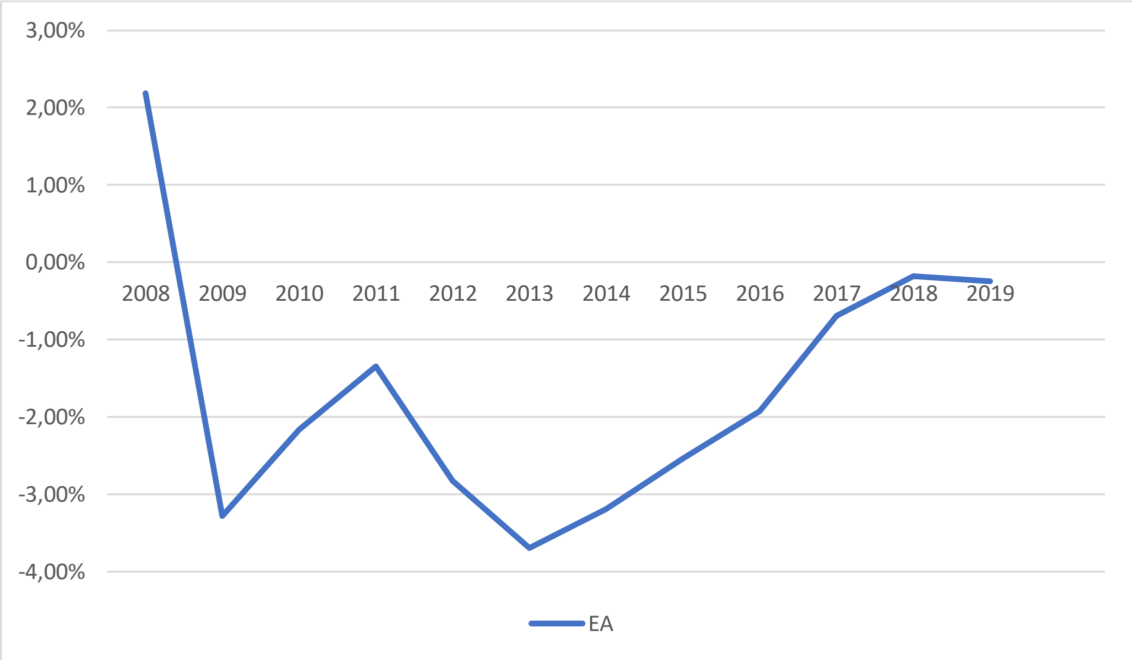

Figure 3 Output Gap Euro Area – Source OECD

Looking at Figure 3, we can see that the EA is, from 2009 to the present year 2019, constantly falling short of its productive capacity. Since 2012 (as we saw in the previous chapter) the deposit facility rate has reached 0.00. This fact, according to Duprat (2014), this symbolizes that the EA is in a liquidity trap situation.

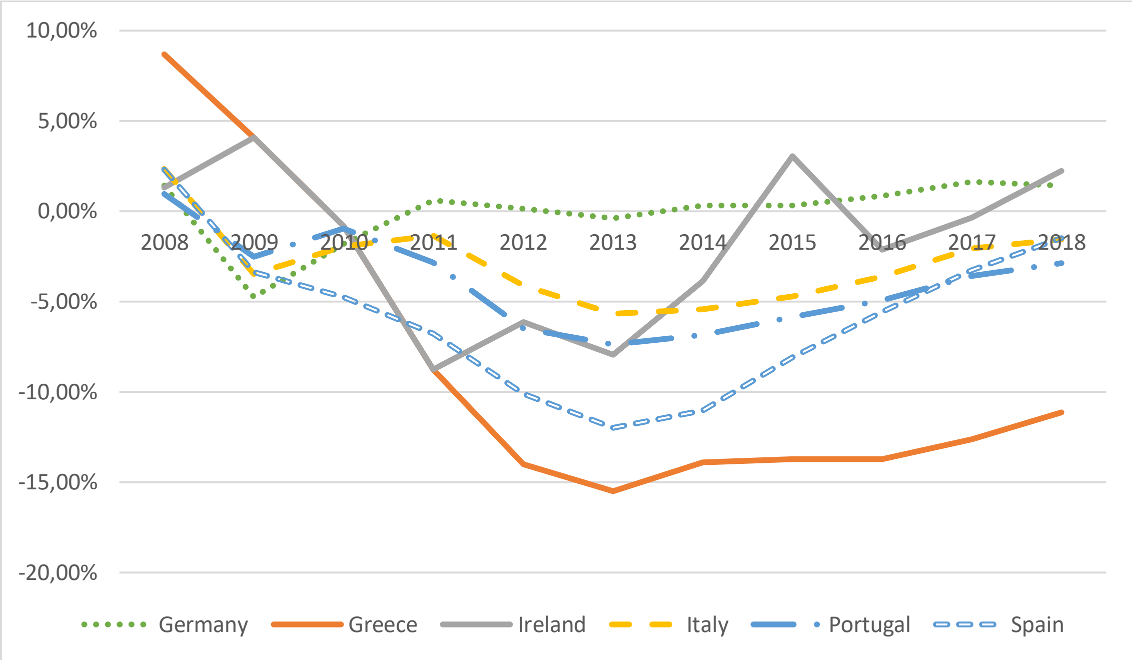

Figure 4 Output Gap Germany & GIIPS - Source OECD[5]

Observing Figure 4, we can conclude that Germany wasn't affected by a liquidity trap, while Ireland recovered from it in 2015. All the other Member States observed in this Dissertation are deemed to be in a liquidity trap situation.

[5] Table with data in Appendix A.3. Ouput Gaps

III – Euro Area framework for optimum monetary areas

> "But if the arguments against the gold standard were correct, then why should a similar argument not apply against a common currency system in a multiregional country? Under the gold standard depression in one country would be transmitted, through the foreign-trade multiplier, to foreign countries. Similarly, under a common currency, depression in one region would be transmitted to other regions for precisely the same rea- sons. If the gold standard imposed a harsh discipline on the national economy and induced the transmission of economic fluctuations, then a common currency would be guilty of the same charge"
>
> (Mundell, 1961)

Optimal currency zone theory has a perfect field of application in the EA.

Since the days of the European Monetary System (EMS) several authors have addressed to the drawbacks and advantages of the common currency. They proposed different solutions, like the dissolution of the EMS or the accelerated advance to the third stage of Economic and Monetary Union - EMU (Mendonça, 1995). However, the focus of this issue within the present Dissertation is: is the EA group of countries an optimal currency zone?

This requires taking into account the characteristics of an optimal currency zone:

1. Perfect labor factor mobility (Mundell, 1961);
2. Federal component that allows spending at local or regional level (Kenen, 1969);
3. Flexible exchange rate system;

Let's start with the first point. The importance of perfect labor factor mobility is apparent in the following example, given by Krugman (2012): Imagine that the state of Florida is hit by an economic shock that significantly reduces its employment level. If workers cannot leave their state, the only way to get jobs back is to cut wages drastically, increasing the state's competitiveness. Falling wages will be much simpler if the state has its own currency. However, if there is high labor mobility, emigration will restore employment prior to the shock (Krugman, 2012).

According to Huart and Tchakpalla (2015), although the monetary union had a positive impact on labor factor mobility migrations within the EA, it did not respond to employment differentials in the EA countries (the authors analyzed the period from 1980 to 2010).

“Labor mobility in Euro area countries has increased (…) but remains limited. In this respect, the Euro area is not close to be an optimal currency area in the Mundellian sense. It remains that labor mobility, not surprisingly, is unlikely to be an option when all countries are faced with a common severe shock at the same time” (Huart and Tchakpalla, 2015).

Addressing the second point, Krugman exemplifies with the state of Florida (Krugman, 2012). This US state is one of the most heavily supported by the US welfare state, a nationally funded program. Following the collapse of the US housing market, Florida was one of the worst affected states, but it eventually received automatic compensation from the rest of the country due to welfare state programs.

However, in the EA, despite the various European programs, there is still no automatic mechanism to correct a potential asymmetric shock within the EA, thus leaving the ECB's unconventional monetary policy measures and wage devaluation as a response.

The third point aims at promoting balance of payments balance and internal stability. Taking an example from Mundell (Mundell, 1961), with two regions (A and B), each with its own currency and flexible exchange rates. If demand shifts from B to A in products, a depreciation in B or an appreciation in A would not only correct the imbalance between regions, but would ease unemployment in B and inflationary pressures in A.

Graphic example below.

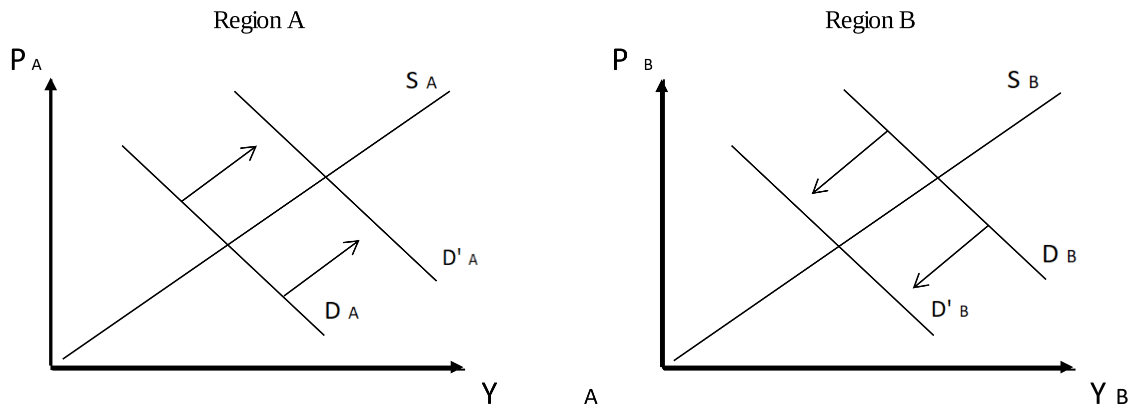

Figure 5 Effects in a shift of demand from B to A (Mendonça, 1995)

Where:

P – refers to the price levels;

Y – output level;

D – aggregate demand;

S – aggregate supply;

This is the only point at which the EA meets the characteristics needed to be an optimal currency zone (EU, 1998).

"The optimum currency area is the region"

(Mundell, 1961)

IV – Literature Review

Christiano *et al.*, (2014) seek to know the driving forces that guided the American economy in the Great Recession. To formalize an answer, a DSGE (Dynamic, Stochastic General Equilibrium) model with the variables: employment, vacancies, force participation rate and unemployment rate is used. Most movements in the real aggregate economy during the Great Recession were due to financial friction. A New Keynesian model was used in which companies face moderate degrees of price rigidity without nominal wage rigidity and a ZLB constraint beginning in 2009. According to the model, the fall in Total Factor Productivity (TFP), and the rise in the cost of labor capital played a pivotal role in the small decline in inflation that occurred during the Great Recession (Christiano *et al.*, 2014).

Did total labor Productivity growth decline prior to the Great Recession in the US?

In order to answer this, Fernald (2014) studies this matter through data analysis and the multi-sector neoclassical growth model. The author concludes that: From the mid-90's to the early 2000s, Productivity growth in total labor factors at its peak was similar to the period from 1940 to the early 70's. But after the boost given by IT innovation, Productivity growth has faded. Over the past four decades, in three of them the Productivity growth has been relatively small, suggesting that this behavior is the benchmark.

The past two decades have been marked by booms and speculative busts in the stock and housing markets, as well as the worst recession since the Great Depression. Despite the strong impact of these facts, the decline in Productivity predated the Great Recession and is not limited to the sectors where the bubbles occurred. The end of high Productivity growth can be linked to industries that produce or use IT intensively (Fernald, 2014).

Contradicting Fernald's results about IT industries, Gomez-Salvador, Musso, Stocker e Turunen use the model developed by Vijselaar and Albers (2004) and analyze the labour Productivity in EA from 1950 (Gomez-Salvador *et al.*, 2006).

Their main findings suggest that the decline in labour Productivity is based on the decline in capital deepening and TFP growth. The decline in capital deepening can be explained by the job creation boom in the 90's and the decline in TFP growth can be explained by the hiring of more lower-skilled workers. Within a sectoral perspective, industries not producing or highly dependable of communication or technology appear to be the most responsible for the decline in labour Productivity since the 90's. Comparing the American and the EA Productivity, the authors conclude that U.S. Productivity growth is higher because the investment in industries of communication and technologies is higher, and also, because there are less barriers to the "diffusion or appropriate use of new technologies" in the U.S. economy (Gomez-Salvador *et al.*, 2006).

According to the ECB's Economic Bulletin (2017), that analyzes the Productivity of the EA from mid-90's, the decline in Productivity growth is based on cyclical and secular factors (ECB, 2017). On the cyclical side, uncertainty and credit restrictions are holding back innovation and the growth of productive firms. On the secular side, the high level of regulation in the labour market and the "deficiencies in institutional and regulatory quality" are pointed as the constraints in business growth (ECB, 2017).

Aiyar, Ebeke and Shao (2016) address the impact of workforce aging on European Productivity, to do so, they use a standard panel technique for a sample that comprises the period from 1950 to 2014 (Aiyar *et al.*, 2016). Their main finding suggests that labour Productivity growth is reduced by the effect of the aging workforce, specially via TFP growth. The authors state that, over the next two decades, TFP growth will be reduced by an average 0.2% only because of the effect of aging workforce. The largest impact will be in the GIIPS economies (Aiyar *et al.*, 2016).

Chapter III – Data & Methodology

In this chapter, the data and methodology used to answer the Dissertation's empirical research question are described.

Variables[6]

The model variables are:

1. GDP – Growth Rate Same Period Previous Year, Seasonally Adjusted - OECD;
2. Labor Productivity - Growth Rate Same Period Previous Year, Seasonally Adjusted - OECD;
3. Unit Labor Costs - Growth Rate Same Period Previous Year, Seasonally Adjusted – OECD;

The analysis period runs from the first quarter of 2000 to the third quarter of 2018 (2000Q1 to 2018Q3), i.e. from the beginning of the 00s to the latest available data in the above series. This time window was chosen to cover multiple global business cycles (dot com bubble and the financial crisis included).

Methodology

For the ZLB period, a dummy variable - ZLB - was generated which, if the period is before 2012, assumes the value of zero, but if the period is equal to or greater than 2012, it assumes one:

$$\text{ZLB} = \begin{cases} t < 2012 = & 0 \\ t \geq 2012 = & 1 \end{cases} \tag{1}$$

All variables were tested for stationarity, using the Augmented Dickey-Fueller test. The test consists in the following equation:

$$\Delta y_t = \alpha + \gamma\, y_{t-1} + \sum_{i=1}^{p} \Delta y_{t-1} + \epsilon_t \ , \tag{2}$$

[6] Summary statistics of variables, per country in Appendix A.4.

Where y_t is the series being tested, and the first difference operator is γ_{t-1}. The null hypothesis is $\gamma = 0$ (Medeiros *et al.*, 2011).

In case of non-stationarity, differences were calculated until the variables became stationary (only for the Spanish GDP, the second difference was calculated) thus undermining the model solution in the long run (Brooks, 2002). The following table shows the variables that were used in the model:

Country	GDP	Labour Productivity	Unitary Labour Costs
EA19	Level***	Level***	Level***
Germany	Level***	Level***	Level***
Greece	1st difference***	1st difference***	Level***
Italy	Level***	Level***	1st difference***
Ireland	Level**	Level***	Level***
Portugal	1st difference***	Level***	1st difference***
Spain	2nd difference***	1st difference***	1st difference***

Table 1 Stationary tests (ADF test)

Where:

* - 10%

** - 5%

*** - 1%

Cointegration tests of the variables were performed through the Johansen test, and only in the Spanish case there was no cointegration.

The optimal number of lags for each country was calculated, as EViews provides 5 selection criteria - LR, FPE, AIC, SC and HQ- the number of lags chosen was according to the majority criteria. The following table shows the results of lag length criteria and the tests that support it:

Country	Optimum lag length test
EA19	LR, FPE, AIC 3 lags
Germany	LR, AIC 6 lags
Greece	LR, FPE, AIC, HQ 5 lags
Italy	LR, FPE, AIC, HQ 6 lags
Ireland	LR, FPE, AIC, SC, HQ 5 lags
Portugal	LR, FPE, AIC 6 lags
Spain	LR, FPE, AIC, SC, HQ 5 lags

Table 2 Lag Length Criteria

For cases where cointegration existed, a Vector Error Correction Model (VECM) model was estimated, but in the Spanish case an unrestricted Vector Autoregression (VAR) was estimated.

A VECM can be represented in the following way:

$$\Delta y_t = \Pi_1 y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \ldots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t \qquad (3)$$

Where $\Pi = (\sum_{k=0}^{n} \beta_j) - I_g$; Δy_t *is a vector of differences with* n variables, being $u_t \sim (0, \sum)$ (Medeiros *et al.*, 2011).

And a VAR can be represented in the following way:

$$y_t = A_0 + A_1 y_{t-1} + \ldots + A_p y_{t-p} + B_0 z_t + B_1 z_{t-1} + \ldots + B_p z_{t-r} + \varepsilon_t \qquad (4)$$

Where *y* is an *n* x 1vector that comprises the endogenous variables of the model; *z* is an *m* x 1 vector that includes the model's exogenous variables; A_0 is an *n* x 1 vector of intercepts; the coefficient matrices *n* x *n* that link endogenous variables lag values to their current values are $A_1 \ldots A_p$; the coefficient matrices m x m that link exogenous variables current values to endogenous variables values are $B_1 \ldots B_p$; and the vector *n* x 1 of random disturbances is ε_t (Medeiros *et al.*, 2011).

Finally, Granger Causality tests were also estimated, which will be duly presented in Chapter IV of this Dissertation.[7]

[7] All tests were performed using EViews 10 software.

Chapter IV – Empirical results and discussion

The results for the Granger Causality test among the variables described in the previous chapter demonstrate heterogeneity within the Euro Area, and even within the so-called GIIPS economies [8].

Granger Causality	P value						
	EA 19	PT	GR	ES	IE	IT	DE
GDP does not Granger Cause LabourProductivity	0,1285	0,7506	0,6387	0,0137**	0,5771	0,0002***	0,5956
LabourProductivity does not Granger Cause GDP	0,8578	0,411	0,6239	0,0763*	0,0799*	0,242	0,8544
UnitCostLabour does not Granger Cause LabourProductivity	0,0661*	0,4651	0,0198**	0,0989*	3.E-13***	0,0158**	0,1123
LabourProductivity does not Granger Cause UnitCostLabour	0,0005***	0,9376	0,1015	0,1773	0,0509*	0,1589	0,081*
ZLB does not Granger Cause LabourProductivity	0,9758	0,0228**	0,4925	0,7853	0,333	0,5432	0,9515
LabourProductivity does not Granger Cause ZLB	0,6568	0,159	0,1692	0,6106	0,9837	0,8248	0,4676
UnitCostLabour does not Granger Cause GDP	0,1504	0,3513	0,0062***	0,0006***	4.E-08***	0,0023***	0,6662
GDP does not Granger Cause UnitCostLabour	E.4-05***	0,3561	0,0912*	0,6742	0,025**	0,0204**	0,0829*
ZLB does not Granger Cause GDP	0,8818	0,2632	0,0804	0,1394	0,2882	0,5284	0,8796
GDP does not Granger Cause ZLB	0,6197	0,5387	0,6091	0,6497	0,9844	0,7764	0,2928
ZLB does not Granger Cause UnitCostLabour	0,4907	0,0175**	0,1499	0,0001***	0,6036	0,9985	0,8907
UnitCostLabour does not Granger Cause ZLB	0,5801	0,976	0,3814	0,9357	0,9995	0,9644	0,334

Table 3 Output Granger Causality Test

Where:

* - 10%

** - 5%

*** - 1%

[8] VECM and VAR outputs in Appendix A.4.

Before we begin analyzing the findings, it is relevant to note that "the term causality itself is somewhat misnomer" (Brooks, 2002) since finding a Granger Causality does not imply that movements in one variable cause absolute movements in another.

As shown in the previous chapter, not all variables are stationary, and as such, their first differences were calculated (in the case of Spanish GDP the second difference was calculated). This fact is relevant to our interpretation of the results obtained. Equally relevant is the fact that only Irish and Italian models are homoscedastic according to White's test.

Starting with the analysis, we see in the first line of Table 3 that only in Spain and Italy alone, the GDP Granger Causes Productivity (in the Spanish case, the second difference in GDP Granger Causes the first difference in Productivity). The inverse relationship, that is, the Productivity Granger Causes GDP, is not verified at a 5% level, nor is it in the average of the 19 countries of the Euro Area.

Unit labor costs Granger Causes Productivity in Greece (ULC Granger Causes the first Productivity difference), Ireland and Italy (ULC first difference Granger Causes Productivity). Interestingly, Productivity only Granger Causes ULC's in the average of the EU countries, not in any State in our sample.

The result that answers the question of this dissertation is that ZLB Granger Causes Productivity, exclusively in Portugal. One possible justification for this is that this ECB policy has been matched by a cleansing effect in both Portuguese industry and services (Dias and Marques, 2018).

We can verify that Productivity does not Granger Cause ZLB in any of the States of the sample, and in the average of EA.

Another case where, once again, Portugal is the exception (but this time exclusively within the GIIPS) is that ULC's do not Granger Cause GDP. Germany and the average of EA countries follow the behavior of the Portuguese economy. It should be noted that in the Greek case ULC Granger Causes the first difference in GDP, in the Spanish case, the first ULC's difference Granger Causes the second difference in GDP and, finally, in the Italian case, the first ULC's difference Granger Causes GDP. Of our sample, only Italy and Ireland meet the EA average, with GDP Granger Causing ULC (in the Italian case, GDP Granger Causes the first difference in ULC).

Following Duprat (2014) as a proof of the liquidity trap, in no State in our sample, including the EA average, does ZLB Granger Cause GDP. Proving thus that the conventional measure of monetary policy is ineffective (ceteris paribus). It is also observed that GDP does not Granger Cause ZLB, most likely because the ECB's main concern is price stability and the forward guidance associated with this policy.

Only in two countries, Portugal and Spain, does the ZLB Granger Causes the ULC (more precisely, ZLB Granger Causes the first difference in ULC).

Unsurprisingly, ULC’s do not Granger Cause the ZLB.

The implications of these results to Portugal are of great importance. When we analyze the growth of Portuguese Productivity we can observe that there is a “lack of convergence with developed economies since the 1990’s” (Alves, 2017). There are about 30.000 wage floors in Portugal (Martins, 2014) and even in the private sector, 90% of all wage earners are affected by these minimum wages (even though most of the workers are not unionized). This implies that in Portugal, there is “downward and upward nominal wage rigidity” (Guimarães *et al.*, 2017). These facts bring to light that the Portuguese labour market is very exposed to shocks and since, according to our results, the ZLB affect Productivity, it is a major opportunity for Portuguese authorities to apply reforms that improve resource allocation and Productivity growth (like the Single Employment Contract which aims to simplify the Portuguese labour market (Centeno, 2013)). This is also an opportunity for Portuguese firms to grow in size and in exports and to lower their debt level.

Chapter V – Conclusion

This Dissertation aims to answer the following research question: "Does ZLB affect the Productivity of the Euro Area?".

The answer is negative if we consider the EA average. However, by studying the behavior of GIIPS economies vs Germany, it can be seen that ZLB Granger Causes Productivity in Portugal. Interestingly, it is the only case in our sample that meets the results of the FED (Moran and Queralto, 2017) where it is proven that there is a link between the ZLB and Productivity, justified by business technological innovation.

The secondary question “Does the ZLB affect the unit labor costs of the euro area?” once again had Portugal and Spain as major players. But on average, the ZLB does not Granger Cause Unit Labor Costs.

The answer to the third question “What is the behavioral difference between GIIPS and Germany?” is that in Germany there is no Granger Causality between any of the variables discussed in Chapter III. This is not the case in any other State, nor is the AE average, where Productivity and GDP Granger Cause the ULC.

The major advantage of this research is that it contributes to the discussion of the relationship between ZLB and Productivity, while exposing the heterogeneity of the Euro Area and demonstrating the importance of the liquidity trap. The major limitation of this Dissertation was due to the lack of literature on the relationship between ZLB and Productivity, and we hope that further studies on this subject will emerge, especially those connected to the Euro Area.

Thus, there is scope for future research that could extend this analysis to future years to see whether the ZLB actually affect Productivity. Another interesting research lead would be to see if this relationship between the ZLB and Productivity can change depending on ZLB's period of activity or if the ECB’s interest rate is lower than the interest rate determined by the Taylor Rule (do too low for too long interest rates have impact on Productivity?). This is relevant because the duration of the ZLB is strongly linked to the creation of speculative bubbles (Hott and Jokipii, 2012).

In order to promote economic growth and structural development, Productivity growth is essential. The slowdown in Productivity growth in countries with more developed economies (Goldin *et al.*, 2018) "a kind of puzzle (or paradox) that must be studied with precision", for the sake of the economic and political stability of the European Project.

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Appendixes

Appendix A.1. ECB's Deposit Facility

Year	Day	Deposit Facility Rate
2016	16 Mar.	−0.40
2015	9 Dec.	−0.30
2014	10 Sep.	−0.20
	11 Jun.	−0.10
2013	13 Nov.	0.00
	8 May.	0.00
2012	11 Jul.	0.00
2011	14 Dec.	0.25
	9 Nov.	0.50
	13 Jul.	0.75
	13 Apr.	0.50
2009	13 May	0.25
	8 Apr.	0.25
	11 Mar.	0.50
	21 Jan.	1.00
2008	10 Dec.	2.00
	12 Nov.	2.75
	15 Oct.4	3.25
	9 Oct.3	3.25
	8 Oct.	2.75
	9 Jul.	3.25
2007	13 Jun.	3.00
	14 Mar.	2.75
2006	13 Dec.	2.50

Year	Day	Deposit Facility Rate
2006	11 Oct.	2.25
	9 Aug.	2.00
	15 Jun.	1.75
	8 Mar.	1.50
2005	6 Dec.	1.25
2003	6 Jun.	1.00
	7 Mar.	1.50
2002	6 Dec.	1.75
2001	9 Nov.	2.25
	18 Sep.	2.75
	31 Aug.	3.25
	11 May	3.50
2000	6 Oct.	3.75
	1 Sep.	3.50
	28 Jun.2	3.25
	9 Jun.	3.25
	28 Apr.	2.75
	17 Mar.	2.50
	4 Feb.	2.25
1999	5 Nov.	2.00
	9 Apr.	1.50
	22 Jan.	2.00
	4 Jan.	2.75
	1 Jan.	2.00

Table 4 ECB's Deposit Facility- Source ECB

Appendix A.2. Public Deficits and Debt to GDP Ratio in %

Appendix A.2.1. Public Deficits %

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Portugal	-3	-4	-10	-11	-7	-6	-5	-7	-4	-2	-3	-1
Greece	-6,7	-10,2	-15,1	-11,2	-10,3	-8,9	-13,2	-3,6	-5,6	0,5	0,7	1,1
Ireland	0,3	-7,	-13,8	-32,1	-12,8	-8,1	-6,2	-3,6	-1,9	-0,7	-0,3	0,
Italy	-1,5	-2,6	-5,2	-4,2	-3,7	-2,9	-2,9	-3,	-2,6	-2,5	-2,4	-2,1
Spain	1,9	-4,4	-11,	-9,4	-9,6	-10,5	-7,	-6,	-5,3	-4,5	-3,1	-2,5
Germany	0,2	-0,2	-3,2	-4,2	-1	0	-0,1	0,6	0,8	0,9	1	1,7

Table 5 Public Deficits % – Source Eurostat

Appendix A.2.2. Debt to GDP Ratio %

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Greece	103	109	127	146	172	160	177	179	176	179	176	181
Ireland	24	42	62	86	111	120	120	104	77	74	69	65
Italy	100	102	113	115	117	123	129	132	132	131	131	132
Spain	36	40	53	60	070	86	96	100	99	99	98	97
Portugal	68	72	84	96	111	126	129	131	129	106	125	122
Germany	64	65	73	82	79	81	78	075	72	69	65	61

Table 6 Debt to GDP Ratio% - Source Eurostat

Appendix A.3. Output Gaps

Appendix A.3.1. Output Gap – EA

Country	Year											
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
EA	2,182	-3,283	-2,164	-1,346	-2,822	-3695	-3,191	-2,532	-1,928	-0,693	-0,175	-0,245

Figure 6 Output gap % - EA - Source OCDE

Appendix A.3.2. Output Gap – Germany & GIIPS

Country	Year										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Germany	1,411	-4,749	-1,821	0,599	0,141	-0,41	0,326	0,302	0,847	1,623	1,399
Greece	8,666	4,067	-0,83	-8,757	-14,022	-15,481	-13,894	-13,719	-13,738	-12,613	-11,141
Ireland	1,307	-5,252	-5,092	-3,612	-6,143	-7,937	-3,871	3,047	-2,151	-0,371	2,211
Italy	2,315	-3,491	-1,965	-1,367	-4,131	-5,688	-5,432	-4,716	-3,621	-2,078	-1,581
Portugal	0,954	-2,514	-0,95	-2,838	-6,508	-7,378	-6,865	-5,87	-4,94	-3,579	-2,885
Spain	2,307	-3,362	-4,749	-6,771	-10,109	-11,975	-11,021	-8,096	-5,582	-3,278	-1,498

Figure 7 Output gap %-Germany & GIIPS- Source OCDE

Appendix A.4. Variables Summary Statistics

Appendix A.4.1. Euro Area

Variables Summary Statistic - EA					
Labour Productivity		*GDP*		*ULC*	
Mean	0,661296851	Mean	1,452	Mean	1,419519068
Standard Error	0,135511403	Standard Error	0,215066384	Standard Error	0,149356301
Median	0,706132714	Median	1,8	Median	1,080308344
Mode	#N/A	Mode	2,2	Mode	#N/A
Standard Deviation	1,173563176	Standard Deviation	1,862529521	Standard Deviation	1,293463506
Sample Variance	1,377250528	Sample Variance	3,469016216	Sample Variance	1,67304784
Kurtosis	5,478166865	Kurtosis	4,915940699	Kurtosis	3,116492809
Skewness	-1,681828796	Skewness	-1,889466237	Skewness	1,384787349
Range	7,21888373	Range	10	Range	7,282059414
Minimum	-4,261645193	Minimum	-5,5	Minimum	-0,939350584
Maximum	2,957238537	Maximum	4,5	Maximum	6,34270883
Sum	49,59726386	Sum	108,9	Sum	106,4639301
Count	75	Count	75	Count	75

Figure 8 Summary Statistic for EA variables

Appendix A.4.2. Germany

Variables Summary Statistic - Germany					
Labour Productivity		*GDP*		*ULC*	
Mean	0,701203149	Mean	1,439374508	Mean	1,084994358
Standard Error	0,23078902	Standard Error	0,262947409	Standard Error	0,229587272
Median	0,814845863	Median	1,730997104	Median	1,118123558
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	1,998691546	Standard Deviation	2,27719136	Standard Deviation	1,988284098
Sample Variance	3,994767895	Sample Variance	5,185600492	Sample Variance	3,953273655
Kurtosis	6,380035934	Kurtosis	4,138606452	Kurtosis	3,386647413
Skewness	-1,906371266	Skewness	-1,548995739	Skewness	1,274901239
Range	11,74181346	Range	12,50589201	Range	11,22517091
Minimum	-7,561807857	Minimum	-6,935628904	Minimum	-2,318672787
Maximum	4,180005603	Maximum	5,570263102	Maximum	8,906498123
Sum	52,5902362	Sum	107,9530881	Sum	81,37457684
Count	75	Count	75	Count	75

Figure 9 Summary Statistic for Germany's variables

Appendix A.4.3. Greece

Variables Summary Statistic - Greece					
Labour Productivity		*GDP*		*ULC*	
Mean	0,372112208	Mean	0,311283959	Mean	1,630319779
Standard Error	0,314884017	Standard Error	0,525833226	Standard Error	0,520951039
Median	0,16737792	Median	0,981449967	Median	0,62160302
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	2,726975584	Standard Deviation	4,553849321	Standard Deviation	4,511568343
Sample Variance	7,436395833	Sample Variance	20,73754364	Sample Variance	20,35424891
Kurtosis	-0,097437645	Kurtosis	-0,263068272	Kurtosis	-0,302414191
Skewness	-0,219387414	Skewness	-0,766834074	Skewness	0,296006482
Range	13,23711532	Range	17,00603206	Range	21,6210958
Minimum	-7,172682771	Minimum	-10,22835693	Minimum	-9,574800431
Maximum	6,06443255	Maximum	6,777675134	Maximum	12,04629537
Sum	27,90841563	Sum	23,34629691	Sum	122,2739834
Count	75	Count	75	Count	75

Figure 10 Summary Statistic for Greece's variables

Appendix A.4.4. Italy

Variables Summary Statistic - Italy					
Labour Productivity		*GDP*		*ULC*	
Mean	-0,191746065	Mean	0,424697808	Mean	1,867355338
Standard Error	0,188424746	Standard Error	0,253060693	Standard Error	0,218190234
Median	0,024405449	Median	0,994235048	Median	1,226665331
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	1,631806171	Standard Deviation	2,191569885	Standard Deviation	1,889582857
Sample Variance	2,662791381	Sample Variance	4,80297856	Sample Variance	3,570523372
Kurtosis	1,902641975	Kurtosis	2,721935363	Kurtosis	-0,563322305
Skewness	-0,958190794	Skewness	-1,384665871	Skewness	0,621472712
Range	8,747666145	Range	11,33428166	Range	7,849703371
Minimum	-5,944145697	Minimum	-7,154096327	Minimum	-1,189681979
Maximum	2,803520447	Maximum	4,180185334	Maximum	6,660021392
Sum	-14,3809549	Sum	31,85233559	Sum	140,0516504
Count	75	Count	75	Count	75

Figure 11 Summary Statistic for Italy variables

Appendix A.4.5. Ireland

Variables Summary Statistic - Ireland					
Labour Productivity		*GDP*		*ULC*	
Mean	3,255383368	Mean	5,011355683	Mean	0,007348981
Standard Error	0,615552937	Standard Error	0,766641421	Standard Error	0,357907001
Median	2,635540972	Median	4,932534363	Median	0,276923808
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	5,33084481	Standard Deviation	6,639309462	Standard Deviation	3,099565548
Sample Variance	28,41790639	Sample Variance	44,08043013	Sample Variance	9,607306584
Kurtosis	5,333211918	Kurtosis	3,336062758	Kurtosis	11,88619679
Skewness	1,86825122	Skewness	1,21466899	Skewness	-2,412337717
Range	31,69424932	Range	39,07395754	Range	22,98686939
Minimum	-6,783524963	Minimum	-9,896538615	Minimum	-17,03422111
Maximum	24,91072435	Maximum	29,17741892	Maximum	5,952648282
Sum	244,1537526	Sum	375,8516763	Sum	0,551173578
Count	75	Count	75	Count	75

Figure 12 Summary Statistic for Ireland's variables

Appendix A.4.6. Portugal

Variables Summary Statistic - Portugal					
Labour Productivity		*GDP*		*ULC*	
Mean	0,753005702	Mean	0,722671354	Mean	1,338978471
Standard Error	0,152302631	Standard Error	0,253761504	Standard Error	0,26844647
Median	0,612811435	Median	1,317974725	Median	1,62073128
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	1,318979479	Standard Deviation	2,197639092	Standard Deviation	2,324814628
Sample Variance	1,739706866	Sample Variance	4,82961758	Sample Variance	5,404763054
Kurtosis	-0,079729122	Kurtosis	0,02732901	Kurtosis	-0,50759128
Skewness	0,306527769	Skewness	-0,951852008	Skewness	-0,417406295
Range	6,65372087	Range	8,836442452	Range	9,991450881
Minimum	-2,648344798	Minimum	-4,466513412	Minimum	-4,41309413
Maximum	4,005376072	Maximum	4,36992904	Maximum	5,578356751
Sum	56,47542763	Sum	54,20035158	Sum	100,4233853
Count	75	Count	75	Count	75

Figure 13 Summary Statistic for Portugal's variables

Appendix A.4.7. Spain

Variables Summary Statistic - Spain					
Labour Productivity		*GDP*		*ULC*	
Mean	0,665682121	Mean	1,884315021	Mean	1,466441809
Standard Error	0,098588474	Standard Error	0,298149006	Standard Error	0,263858846
Median	0,5400094	Median	3,033116943	Median	2,183768735
Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	0,853801229	Standard Deviation	2,582046132	Standard Deviation	2,285084633
Sample Variance	0,728976539	Sample Variance	6,666962229	Sample Variance	5,221611781
Kurtosis	0,872912564	Kurtosis	-0,338189301	Kurtosis	-0,543722799
Skewness	0,769004468	Skewness	-0,937781271	Skewness	-0,213891259
Range	4,162273756	Range	9,848705813	Range	11,063548
Minimum	-1,073947724	Minimum	-4,262478769	Minimum	-4,894187139
Maximum	3,088326032	Maximum	5,586227044	Maximum	6,169360858
Sum	49,92615911	Sum	141,3236266	Sum	109,9831357
Count	75	Count	75	Count	75

Figure 14 Summary Statistic for Spain's variables

Appendix A.5. VECM & VAR output

Appendix A.5.1. Euro Area Output – VECM

Vector Error Correction Estimates
Date: 09/16/19 Time: 13:50
Sample (adjusted): 2000Q4 2018Q3
Included observations: 72 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LABPROD(-1)	1.000000		
GDP(-1)	-0.138251 (0.04318) [-3.20198]		
ULABCOSTS(-1)	0.414749 (0.06584) [6.29957]		
C	-1.032895		
Error Correction:	**D(LABPROD)**	**D(GDP)**	**D(ULABCO...**
CointEq1	-0.995963 (0.18671) [-5.33419]	-0.640925 (0.27522) [-2.32873]	1.089489 (0.18272) [5.96254]
D(LABPROD(-1))	0.286633 (0.28845) [0.99371]	-0.073608 (0.42519) [-0.17312]	-0.283507 (0.28228) [-1.00434]
D(LABPROD(-2))	0.351619 (0.27146) [1.29527]	0.419149 (0.40015) [1.04747]	-0.472061 (0.26566) [-1.77692]
D(GDP(-1))	0.308988 (0.15783) [1.95768]	0.501940 (0.23266) [2.15744]	-0.308299 (0.15446) [-1.99597]
D(GDP(-2))	-0.061556 (0.15918) [-0.38671]	-0.349070 (0.23464) [-1.48770]	0.095957 (0.15578) [0.61599]

D(ULABCOSTS(-1))	0.081330	-0.187408	-0.253752
	(0.23426)	(0.34532)	(0.22926)
	[0.34717]	[-0.54272]	[-1.10685]
D(ULABCOSTS(-2))	0.049317	-0.290228	0.019612
	(0.21895)	(0.32275)	(0.21427)
	[0.22524]	[-0.89925]	[0.09153]
C	0.171697	0.049604	-0.198677
	(0.07961)	(0.11736)	(0.07791)
	[2.15660]	[0.42268]	[-2.54999]
ZLB	-0.457076	-0.172742	0.524480
	(0.14792)	(0.21804)	(0.14476)
	[-3.09003]	[-0.79225]	[3.62316]
R-squared	0.560829	0.456694	0.549759
Adj. R-squared	0.505061	0.387702	0.492585
Sum sq. resids	13.63568	29.62800	13.05903
S.E. equation	0.465230	0.685774	0.455287
F-statistic	10.05652	6.619586	9.615621
Log likelihood	-42.26042	-70.19751	-40.70487
Akaike AIC	1.423901	2.199931	1.380691
Schwarz SC	1.708484	2.484514	1.665274
Mean dependent	-0.017757	-0.030556	0.014199
S.D. dependent	0.661291	0.876394	0.639151

Determinant resid covariance (dof adj.)	0.001612
Determinant resid covariance	0.001080
Log likelihood	-60.57548
Akaike information criterion	2.515986
Schwarz criterion	3.464596
Number of coefficients	30

Figure 15 EA's VECM output

Appendix A.5.2. Germany Output – VECM

Vector Error Correction Estimates
Date: 09/16/19 Time: 13:54
Sample (adjusted): 2001Q3 2018Q3
Included observations: 69 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LABPROD(-1)	1.000000
GDP(-1)	2.253640 (1.87197) [1.20389]
ULABCOSTS(-1)	-0.948119 (1.91799) [-0.49433]
C	-2.610121

Error Correction:	D(LABPROD)	D(GDP)	D(ULABCO...
CointEq1	-0.067766 (0.02327) [-2.91190]	-0.063373 (0.02441) [-2.59623]	0.075966 (0.02092) [3.63187]
D(LABPROD(-1))	0.199604 (0.56827) [0.35125]	0.044002 (0.59604) [0.07382]	0.071872 (0.51075) [0.14072]
D(LABPROD(-2))	-1.077152 (0.48206) [-2.23447]	-1.137751 (0.50562) [-2.25021]	1.252953 (0.43326) [2.89190]
D(LABPROD(-3))	-0.067174 (0.47755) [-0.14066]	-0.067039 (0.50089) [-0.13384]	-0.065913 (0.42921) [-0.15357]
D(LABPROD(-4))	0.114622 (0.44400) [0.25816]	0.394091 (0.46570) [0.84623]	-0.598709 (0.39906) [-1.50031]

D(LABPROD(-5))	-0.795661	-0.800484	0.999460
	(0.43716)	(0.45853)	(0.39291)
	[-1.82006]	[-1.74577]	[2.54374]
D(GDP(-1))	-0.333304	-0.108158	0.068382
	(0.54753)	(0.57429)	(0.49210)
	[-0.60874]	[-0.18833]	[0.13896]
D(GDP(-2))	0.542885	0.663770	-0.874535
	(0.46997)	(0.49294)	(0.42240)
	[1.15515]	[1.34656]	[-2.07042]
D(GDP(-3))	0.043494	0.064289	0.105053
	(0.48609)	(0.50985)	(0.43689)
	[0.08948]	[0.12609]	[0.24046]
D(GDP(-4))	-0.686268	-0.967158	0.795890
	(0.45371)	(0.47588)	(0.40778)
	[-1.51258]	[-2.03236]	[1.95177]
D(GDP(-5))	0.663075	0.711504	-0.737384
	(0.43166)	(0.45276)	(0.38797)
	[1.53609]	[1.57148]	[-1.90063]
D(ULABCOSTS(-1))	-0.658472	-0.675308	0.519116
	(0.32413)	(0.33997)	(0.29132)
	[-2.03152]	[-1.98638]	[1.78196]
D(ULABCOSTS(-2))	-0.821046	-0.767194	0.694274
	(0.30257)	(0.31736)	(0.27194)
	[-2.71356]	[-2.41743]	[2.55300]
D(ULABCOSTS(-3))	-0.278536	-0.247266	0.102752
	(0.30252)	(0.31731)	(0.27190)
	[-0.92070]	[-0.77926]	[0.37790]
D(ULABCOSTS(-4))	-0.339916	-0.397734	0.042775
	(0.30298)	(0.31778)	(0.27231)
	[-1.12192]	[-1.25159]	[0.15708]
D(ULABCOSTS(-5))	-0.604734	-0.550470	0.627027
	(0.28747)	(0.30152)	(0.25837)
	[-2.10362]	[-1.82563]	[2.42682]
C	0.036872	0.055178	0.003274
	(0.14229)	(0.14925)	(0.12789)
	[0.25913]	[0.36971]	[0.02560]
ZLB	-0.024783	-0.035436	0.036778
	(0.22635)	(0.23741)	(0.20343)
	[-0.10949]	[-0.14926]	[0.18079]

R-squared	0.593621	0.577537	0.571999
Adj. R-squared	0.458162	0.436716	0.429331
Sum sq. resids	41.28254	45.41632	33.34779
S.E. equation	0.899701	0.943672	0.808627
F-statistic	4.382275	4.101218	4.009322
Log likelihood	-80.18525	-83.47765	-72.82129
Akaike AIC	2.845949	2.941381	2.632501
Schwarz SC	3.428760	3.524192	3.215311
Mean dependent	-0.027555	-0.007282	0.049113
S.D. dependent	1.222259	1.257353	1.070425

Determinant resid covariance (dof adj.)	0.005960
Determinant resid covariance	0.002407
Log likelihood	-85.70063
Akaike information criterion	4.136250
Schwarz criterion	5.981817
Number of coefficients	57

Figure 16 Germany's VECM Output

Appendix A.5.3. Greece Output – VECM

Vector Error Correction Estimates
Date: 09/16/19 Time: 13:58
Sample (adjusted): 2001Q2 2018Q3
Included observations: 70 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LABPROD(-1)	1.000000
GDP(-1)	2.805874
	(0.93893)
	[2.98836]
ULABCOSTS(-1)	-5.588663
	(1.53515)
	[-3.64047]
C	8.775635

Error Correction:	D(LABPROD)	D(GDP)	D(ULABCO...
CointEq1	-0.025031	-0.011369	0.112862
	(0.01250)	(0.01215)	(0.02655)
	[-2.00291]	[-0.93592]	[4.25059]
D(LABPROD(-1))	-0.354400	-0.267604	-0.738614
	(0.20151)	(0.19587)	(0.42812)
	[-1.75875]	[-1.36622]	[-1.72524]
D(LABPROD(-2))	-0.148006	-0.187427	0.454010
	(0.19911)	(0.19354)	(0.42303)
	[-0.74334]	[-0.96840]	[1.07323]
D(LABPROD(-3))	-0.256330	-0.177783	-0.019103
	(0.19899)	(0.19343)	(0.42278)
	[-1.28816]	[-0.91913]	[-0.04519]
D(LABPROD(-4))	-0.396472	0.026950	-0.170027
	(0.19345)	(0.18804)	(0.41101)
	[-2.04947]	[0.14332]	[-0.41368]
D(GDP(-1))	0.215193	0.163013	0.261465
	(0.20238)	(0.19673)	(0.42999)
	[1.06329]	[0.82863]	[0.60807]

D(GDP(-2))	0.150682	0.275305	-0.937371
	(0.19634)	(0.19085)	(0.41714)
	[0.76746]	[1.44253]	[-2.24712]
D(GDP(-3))	0.220356	0.229642	-0.692530
	(0.20585)	(0.20009)	(0.43735)
	[1.07048]	[1.14769]	[-1.58348]
D(GDP(-4))	-0.193153	-0.648942	-0.653258
	(0.19968)	(0.19410)	(0.42425)
	[-0.96730]	[-3.34334]	[-1.53980]
D(ULABCOSTS(-1))	-0.104526	-0.011734	0.004215
	(0.06529)	(0.06346)	(0.13871)
	[-1.60104]	[-0.18491]	[0.03038]
D(ULABCOSTS(-2))	-0.129045	-0.083649	-0.127409
	(0.06407)	(0.06228)	(0.13612)
	[-2.01415]	[-1.34316]	[-0.93599]
D(ULABCOSTS(-3))	-0.222112	-0.195130	0.145073
	(0.05913)	(0.05747)	(0.12562)
	[-3.75650]	[-3.39508]	[1.15483]
D(ULABCOSTS(-4))	-0.017961	-0.022955	-0.123654
	(0.05641)	(0.05483)	(0.11984)
	[-0.31843]	[-0.41866]	[-1.03183]
C	-0.449481	-0.551911	0.161434
	(0.24380)	(0.23698)	(0.51797)
	[-1.84368]	[-2.32895]	[0.31167]
ZLB	0.906824	1.231597	-0.748426
	(0.43436)	(0.42221)	(0.92284)
	[2.08774]	[2.91701]	[-0.81100]
R-squared	0.541869	0.595170	0.567731
Adj. R-squared	0.425254	0.492122	0.457699
Sum sq. resids	117.5649	111.0821	530.6860
S.E. equation	1.462034	1.421152	3.106258
F-statistic	4.646639	5.775676	5.159689
Log likelihood	-117.4730	-115.4878	-170.2243
Akaike AIC	3.784944	3.728223	5.292124
Schwarz SC	4.266765	4.210043	5.773944
Mean dependent	-0.047734	-0.049847	-0.054668
S.D. dependent	1.928499	1.994165	4.218104

Determinant resid covariance (dof adj.)	14.01518
Determinant resid covariance	6.798181
Log likelihood	-365.0600
Akaike information criterion	11.80171
Schwarz criterion	13.34354
Number of coefficients	48

Figure 17 Greece's VECM Output

Appendix A.5.4. Italy Output – VECM

Vector Error Correction Estimates
Date: 09/16/19 Time: 14:00
Sample (adjusted): 2001Q3 2018Q3
Included observations: 69 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LABPROD(-1)	1.000000		
GDP(-1)	-0.223904		
	(0.05253)		
	[-4.26250]		
ULABCOSTS(-1)	0.258859		
	(0.09173)		
	[2.82209]		
C	-0.131483		
Error Correction:	**D(LABPROD)**	**D(GDP)**	**D(ULABCO...**
CointEq1	-1.183932	-0.763631	1.017579
	(0.20761)	(0.21648)	(0.42593)
	[-5.70278]	[-3.52749]	[2.38910]
D(LABPROD(-1))	0.359774	0.272150	-0.504821
	(0.20277)	(0.21144)	(0.41601)
	[1.77426]	[1.28712]	[-1.21347]
D(LABPROD(-2))	0.527204	0.328560	-0.140732
	(0.18353)	(0.19138)	(0.37654)
	[2.87250]	[1.71679]	[-0.37375]
D(LABPROD(-3))	0.153976	0.253308	-0.396278
	(0.16348)	(0.17046)	(0.33539)
	[0.94189]	[1.48600]	[-1.18155]
D(LABPROD(-4))	-0.075352	0.218995	-0.427843
	(0.14466)	(0.15084)	(0.29678)
	[-0.52091]	[1.45185]	[-1.44164]
D(LABPROD(-5))	0.293371	0.170279	-0.312673
	(0.15091)	(0.15736)	(0.30961)
	[1.94401]	[1.08209]	[-1.00990]
D(GDP(-1))	0.805355	0.839585	-0.629548
	(0.18761)	(0.19563)	(0.38489)
	[4.29279]	[4.29179]	[-1.63563]
D(GDP(-2))	-0.202523	-0.012607	-0.396275
	(0.21893)	(0.22829)	(0.44916)
	[-0.92505]	[-0.05522]	[-0.88226]

D(GDP(-3))	0.167714	-0.108725	0.131102
	(0.20574)	(0.21454)	(0.42210)
	[0.81516]	[-0.50679]	[0.31059]
D(GDP(-4))	-0.028107	-0.436211	0.252856
	(0.20230)	(0.21094)	(0.41503)
	[-0.13894]	[-2.06790]	[0.60924]
D(GDP(-5))	0.216294	0.366010	-0.560050
	(0.20930)	(0.21824)	(0.42940)
	[1.03343]	[1.67707]	[-1.30428]
D(ULABCOSTS(-1))	0.199563	0.213631	-0.730828
	(0.08712)	(0.09084)	(0.17874)
	[2.29065]	[2.35161]	[-4.08883]
D(ULABCOSTS(-2))	0.116225	0.148364	-0.252084
	(0.08619)	(0.08988)	(0.17683)
	[1.34842]	[1.65074]	[-1.42554]
D(ULABCOSTS(-3))	0.051748	-0.070671	-0.024098
	(0.08266)	(0.08620)	(0.16959)
	[0.62601]	[-0.81988]	[-0.14209]
D(ULABCOSTS(-4))	0.130945	0.020951	-0.591385
	(0.08159)	(0.08508)	(0.16739)
	[1.60493]	[0.24626]	[-3.53298]
D(ULABCOSTS(-5))	-0.078241	-0.043005	-0.521435
	(0.08016)	(0.08359)	(0.16446)
	[-0.97604]	[-0.51449]	[-3.17057]
C	0.217353	0.095580	-0.311995
	(0.10164)	(0.10599)	(0.20853)
	[2.13840]	[0.90180]	[-1.49616]
ZLB	-0.470369	-0.213318	0.588689
	(0.17388)	(0.18131)	(0.35674)
	[-2.70510]	[-1.17651]	[1.65020]

R-squared	0.761585	0.726399	0.532184
Adj. R-squared	0.682113	0.635198	0.376245
Sum sq. resids	16.51633	17.95847	69.51867
S.E. equation	0.569078	0.593403	1.167524
F-statistic	9.583094	7.964860	3.412776
Log likelihood	-48.58014	-51.46823	-98.16513
Akaike AIC	1.929859	2.013572	3.367105
Schwarz SC	2.512670	2.596382	3.949915
Mean dependent	-0.009341	-0.025313	0.003066
S.D. dependent	1.009335	0.982474	1.478287

Determinant resid covariance (dof adj.)	0.052848
Determinant resid covariance	0.021340
Log likelihood	-160.9928
Akaike information criterion	6.318631
Schwarz criterion	8.164198
Number of coefficients	57

Figure 18 Italy's VECM Output

Appendix A.5.5. Ireland Output – VECM

Vector Error Correction Estimates
Date: 09/16/19 Time: 14:02
Sample (adjusted): 2001Q2 2018Q3
Included observations: 70 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LABPROD(-1)	1.000000
GDP(-1)	-0.351998 (0.06850) [-5.13868]
ULABCOSTS(-1)	1.683846 (0.32194) [5.23027]
C	-1.350459

Error Correction:	D(LABPROD)	D(GDP)	D(ULABCO...
CointEq1	-0.413422 (0.15955) [-2.59118]	-0.452536 (0.18216) [-2.48430]	0.638241 (0.31545) [2.02327]
D(LABPROD(-1))	-0.406367 (0.24876) [-1.63356]	-0.873620 (0.28401) [-3.07600]	-0.432889 (0.49183) [-0.88015]
D(LABPROD(-2))	0.190980 (0.27600) [0.69196]	0.027072 (0.31511) [0.08591]	-0.458040 (0.54568) [-0.83939]
D(LABPROD(-3))	-0.429566 (0.28350) [-1.51524]	-0.400572 (0.32367) [-1.23760]	-0.043606 (0.56051) [-0.07780]
D(LABPROD(-4))	0.534905 (0.24747) [2.16154]	0.809058 (0.28253) [2.86361]	-0.504263 (0.48927) [-1.03064]
D(GDP(-1))	0.428658 (0.24308) [1.76343]	0.880006 (0.27753) [3.17089]	0.360095 (0.48060) [0.74926]
D(GDP(-2))	-0.098844 (0.27139) [-0.36422]	0.086166 (0.30984) [0.27810]	0.635396 (0.53657) [1.18419]
D(GDP(-3))	0.443126 (0.27625) [1.60408]	0.444002 (0.31539) [1.40777]	0.006044 (0.54618) [0.01107]
D(GDP(-4))	-0.557956 (0.24118) [-2.31343]	-0.789876 (0.27536) [-2.86855]	0.524647 (0.47685) [1.10024]

D(ULABCOSTS(-1))	-0.329834	-0.275460	-2.331107
	(0.29598)	(0.33792)	(0.58520)
	[-1.11437]	[-0.81515]	[-3.98346]
D(ULABCOSTS(-2))	-0.445927	-0.449964	-1.935655
	(0.24973)	(0.28512)	(0.49375)
	[-1.78564]	[-1.57818]	[-3.92034]
D(ULABCOSTS(-3))	-0.663197	-0.620737	-1.033554
	(0.20319)	(0.23198)	(0.40172)
	[-3.26400]	[-2.67586]	[-2.57280]
D(ULABCOSTS(-4))	-0.873454	-0.852451	-0.456384
	(0.12308)	(0.14053)	(0.24335)
	[-7.09637]	[-6.06616]	[-1.87539]
C	-0.127673	-0.181065	-0.060498
	(0.24235)	(0.27669)	(0.47916)
	[-0.52681]	[-0.65439]	[-0.12626]
__ ZLB	0.197509	0.293427	-0.017667
	(0.40442)	(0.46173)	(0.79960)
	[0.48837]	[0.63549]	[-0.02209]
R-squared	0.924984	0.905050	0.695598
Adj. R-squared	0.905889	0.880881	0.618113
Sum sq. resids	128.6479	167.6901	502.8889
S.E. equation	1.529396	1.746113	3.023811
F-statistic	48.44105	37.44671	8.977274
Log likelihood	-120.6261	-129.9025	-168.3413
Akaike AIC	3.875032	4.140071	5.238322
Schwarz SC	4.356853	4.621891	5.720143
Mean dependent	-0.003635	-0.009195	0.002909
S.D. dependent	4.985390	5.059206	4.893137

Determinant resid covariance (dof adj.)	14.45670
Determinant resid covariance	7.012341
Log likelihood	-366.1456
Akaike information criterion	11.83273
Schwarz criterion	13.37456
Number of coefficients	48

Figure 19 Ireland's VECM Output

Appendix A.5.6. Portugal Output – VECM

Vector Error Correction Estimates
Date: 09/16/19 Time: 14:04
Sample (adjusted): 2001Q3 2018Q3
Included observations: 69 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LABPROD(-1)	1.000000
GDP(-1)	-0.147617 (0.04593) [-3.21381]
ULABCOSTS(-1)	0.314585 (0.05163) [6.09329]
C	-1.009182

Error Correction:	D(LABPROD)	D(GDP)	D(ULABCO...
CointEq1	-0.946619 (0.29089) [-3.25417]	-0.057486 (0.31931) [-0.18003]	-0.227245 (0.47860) [-0.47481]
D(LABPROD(-1))	0.495550 (0.26116) [1.89753]	0.168550 (0.28667) [0.58796]	0.122836 (0.42967) [0.28588]
D(LABPROD(-2))	0.203896 (0.22430) [0.90903]	-0.030872 (0.24621) [-0.12539]	0.164597 (0.36904) [0.44602]
D(LABPROD(-3))	0.251977 (0.18485) [1.36316]	0.084169 (0.20291) [0.41482]	0.060663 (0.30412) [0.19947]
D(LABPROD(-4))	-0.129433 (0.16480) [-0.78540]	-0.059117 (0.18090) [-0.32680]	0.413382 (0.27114) [1.52462]
D(LABPROD(-5))	0.191316 (0.15175) [1.26070]	-0.049471 (0.16658) [-0.29698]	0.469812 (0.24968) [1.88168]
D(GDP(-1))	0.120560 (0.18534) [0.65048]	0.223036 (0.20345) [1.09629]	-0.022111 (0.30494) [-0.07251]
D(GDP(-2))	0.337729 (0.17497) [1.93021]	0.352411 (0.19206) [1.83487]	-0.261550 (0.28787) [-0.90856]
D(GDP(-3))	0.056417 (0.16968) [0.33250]	0.005240 (0.18625) [0.02814]	0.015632 (0.27917) [0.05600]

D(GDP(-4))	-0.027910	-0.390505	-0.441597
	(0.15724)	(0.17261)	(0.25871)
	[-0.17749]	[-2.26241]	[-1.70692]
D(GDP(-5))	-0.355218	0.021232	0.151242
	(0.16509)	(0.18122)	(0.27162)
	[-2.15168]	[0.11716]	[0.55682]
D(ULABCOSTS(-1))	0.257073	0.132771	-0.015071
	(0.12110)	(0.13293)	(0.19924)
	[2.12282]	[0.99880]	[-0.07564]
D(ULABCOSTS(-2))	0.286235	0.090932	-0.068689
	(0.10823)	(0.11881)	(0.17807)
	[2.64462]	[0.76538]	[-0.38573]
D(ULABCOSTS(-3))	0.074944	0.094641	-0.037797
	(0.10511)	(0.11538)	(0.17293)
	[0.71301]	[0.82027]	[-0.21857]
D(ULABCOSTS(-4))	-0.047903	-0.062394	-0.403848
	(0.09833)	(0.10794)	(0.16179)
	[-0.48714]	[-0.57804]	[-2.49616]
D(ULABCOSTS(-5))	-0.074525	0.006631	0.002435
	(0.09772)	(0.10727)	(0.16077)
	[-0.76265]	[0.06182]	[0.01514]
C	0.586353	-0.028629	-0.199834
	(0.24593)	(0.26995)	(0.40462)
	[2.38427]	[-0.10605]	[-0.49389]
ZLB	-1.453006	0.066335	0.429981
	(0.52645)	(0.57788)	(0.86615)
	[-2.76001]	[0.11479]	[0.49642]
R-squared	0.464707	0.429311	0.375491
Adj. R-squared	0.286276	0.239082	0.167321
Sum sq. resids	33.38213	40.22320	90.36333
S.E. equation	0.809044	0.888082	1.331101
F-statistic	2.604411	2.256808	1.803774
Log likelihood	-72.85680	-79.28840	-107.2125
Akaike AIC	2.633530	2.819954	3.629348
Schwarz SC	3.216341	3.402764	4.212159
Mean dependent	-0.011380	-0.009371	-0.042851
S.D. dependent	0.957650	1.018086	1.458721

Determinant resid covariance (dof adj.)	0.236672
Determinant resid covariance	0.095568
Log likelihood	-212.7170
Akaike information criterion	7.817883
Schwarz criterion	9.663450
Number of coefficients	57

Figure 20 Portugal's VECM Output

Appendix A.5.7. Spain Output – VAR

Vector Autoregression Estimates
Date: 09/16/19 Time: 14:19
Sample (adjusted): 2001Q4 2018Q3
Included observations: 68 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(LABPROD)	D(GDP,2)	D(ULABCO...
D(LABPROD(-1))	0.123517	-0.094450	-0.844165
	(0.14587)	(0.14083)	(0.42309)
	[0.84678]	[-0.67065]	[-1.99523]
D(LABPROD(-2))	0.213532	0.085925	-0.262720
	(0.13039)	(0.12589)	(0.37820)
	[1.63762]	[0.68252]	[-0.69465]
D(LABPROD(-3))	0.023007	-0.090520	0.181230
	(0.13077)	(0.12625)	(0.37929)
	[0.17594]	[-0.71696]	[0.47781]
D(LABPROD(-4))	-0.427019	0.081508	-0.382966
	(0.12554)	(0.12121)	(0.36412)
	[-3.40156]	[0.67248]	[-1.05175]
D(LABPROD(-5))	0.187155	-0.228422	-0.823289
	(0.13232)	(0.12775)	(0.38379)
	[1.41444]	[-1.78800]	[-2.14514]
D(GDP(-1),2)	-0.315495	0.150476	0.538214
	(0.14026)	(0.13542)	(0.40682)
	[-2.24943]	[1.11121]	[1.32299]
D(GDP(-2),2)	-0.188904	-0.015504	-0.140384
	(0.10168)	(0.09817)	(0.29493)
	[-1.85780]	[-0.15793]	[-0.47599]
D(GDP(-3),2)	0.188069	0.309175	-0.542251
	(0.10329)	(0.09973)	(0.29959)
	[1.82080]	[3.10026]	[-1.80995]
D(GDP(-4),2)	-0.009666	-0.691207	-0.136793
	(0.11165)	(0.10780)	(0.32384)
	[-0.08657]	[-6.41209]	[-0.42241]
D(GDP(-5),2)	-0.301404	-0.113307	0.590585
	(0.14151)	(0.13663)	(0.41047)
	[-2.12986]	[-0.82929]	[1.43882]
D(ULABCOSTS(-1))	0.161193	-0.100267	-0.459324
	(0.04981)	(0.04809)	(0.14448)
	[3.23598]	[-2.08481]	[-3.17908]
D(ULABCOSTS(-2))	-0.030811	-0.131138	0.308926
	(0.04999)	(0.04826)	(0.14499)
	[-0.61636]	[-2.71710]	[2.13062]

D(ULABCOSTS(-3))	-0.052856	-0.074856	0.292773
	(0.05214)	(0.05034)	(0.15122)
	[-1.01382]	[-1.48712]	[1.93608]
D(ULABCOSTS(-4))	-0.016910	-0.039950	-0.349045
	(0.05062)	(0.04887)	(0.14681)
	[-0.33409]	[-0.81749]	[-2.37751]
D(ULABCOSTS(-5))	0.063358	0.053249	-0.137155
	(0.05229)	(0.05049)	(0.15167)
	[1.21169]	[1.05475]	[-0.90432]
ZLB	-0.084731	0.022471	0.109646
	(0.08358)	(0.08070)	(0.24243)
	[-1.01378]	[0.27846]	[0.45229]
C	0.035291	-0.018999	-0.086886
	(0.05093)	(0.04917)	(0.14771)
	[0.69301]	[-0.38642]	[-0.58822]
R-squared	0.573695	0.676534	0.422996
Adj. R-squared	0.439952	0.575055	0.241976
Sum sq. resids	4.871839	4.541490	40.98737
S.E. equation	0.309073	0.298410	0.896479
F-statistic	4.289538	6.666709	2.336728
Log likelihood	-6.862589	-4.475233	-79.27553
Akaike AIC	0.701841	0.631624	2.831633
Schwarz SC	1.256718	1.186501	3.386510
Mean dependent	-0.004864	-0.000189	-0.030477
S.D. dependent	0.412999	0.457770	1.029671

Determinant resid covariance (dof adj.)	0.005894
Determinant resid covariance	0.002486
Log likelihood	-85.56718
Akaike information criterion	4.016682
Schwarz criterion	5.681313
Number of coefficients	51

Figure 21 Spain's VAR Output