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The role of the EMU in forecasting GDP Growth

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Abstract

This paper aims to gain insight into how a membership in the European Monetary Union could help in GDP growth forecasts. It will attempt to answer this question using panel data, a Fixed Effects model, and an Elastic Net model. In the end, it concludes that an EMU membership has a positive indirect impact on GDP growth through lower effective nominal exchange rate volatility and better institutional quality, and a negative impact on growth through a third unidentified channel. However, the overall impact of being a part of the EMU appears to be neutral.

Keywords: EMU, Economic growth, machine learning, Fixed effects, Panel data

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1. Introduction

In the beginning of 1992, the Maastricht treaty was signed, and seven years later the euro was adopted by 11 European countries, whose monetary policy was now under the authority of the ECB. Prior academic studies on single currency unions predicted that through economic integration, the member countries were expected to get a reduction of the exchange rate volatility within the currency area, lower transaction costs (Mundel 1961), improved price stability, and increased transparency on financial markets through fiscal rules (Barrel 2008). Since exchange rates within the currency area are eliminated, trading should be facilitated, which could have a positive effect on output and welfare (Baldwin 1989).

However, it is also expected that joining a single currency union has some drawbacks. Countries that join currency unions have no currency to depreciate, this means that if demand shifts from one country in the currency area to another, unemployment in the country of low demand can only be avoided at the cost of deflation. This is something that could be avoided with floating exchange rates between countries, as long as labor mobility is high within each country and low between the countries (Mundell 1961). On top of that, member states lose their autonomy to employ and fine-tune monetary policy, which is controlled by the central bank, they also get easier access to loans with lower interest rates (which can lead to excessive public debt), sustain the risk of not being an optimal currency area, and if so, pose different business cycles which, again, cannot all be addressed individually with monetary policy by the central bank.

Taking into account the positive and negative effects of joining the EMU it would be interesting to investigate whether or not being a part of this single currency could help model growth, in terms of GDP per capita, in its member states. Moreover, the goal of this project will be to first assess if indeed the EMU led to bigger stability in the exchange rate, on average, better institutional quality, on average, and what countries benefited more in terms of this stabilization and institutional quality; secondly, to control for the channels through which the EMU might influence GDP growth, to understand if joining the EMU maintains a significant impact on GDP growth, this is the core of the paper and could be of aid for countries to decide whether or not they should join the EMU; thirdly, to deploy new robustness tests using a combination of machine learning algorithms and econometric insights; and lastly to compare the forecasts provided by the Fixed Effects model with a more sophisticated machine learning model.

To be more specific, this paper will be divided into the following categories: 2. Literature Review, 3. Methodology, 4. Preliminary results, 5. Results and finally 6. Conclusion.

2. Literature review

The literature regarding the adoption of a single currency and the literature regarding growth regressions are undoubtedly large, which means that a decent analysis of past work on these subjects was possible. This section will thus analyze the literature on economic growth and single currency first and only then look at the literature that merges the two topics.

The adoption of a single currency entails, naturally, pros and cons. Adopting a single currency will eliminate exchange rates fluctuation, so businesses who operate within the same

currency area will no longer have to worry about exchange rate fluctuation costs. This could stimulate trade and investment within a currency area, in fact, that is just the conclusion made by Glick and Rose in their paper on Currency Unions and Trade (Glick & Rose 2016). After using a fixed-effects model on a data set comprised of over 200 countries, that ranged from 1948 until 2013, they were able to conclude that joining the EMU did expand trading (Glick & Rose 2016), which is expected to have a positive impact on output growth (Baldwin 1989). Due to the exchange rate fluctuation being gone, a single currency will also increase capital integration, foster higher levels of cross-border investment due to lower transaction costs, and improve the efficiency of capital allocation (Silva & Tenreyro 2010). This higher level of cross-border investment could lead to an increase in growth if the country invested in has got enough human capital (Borensztein, de Gregorio, Lee 1995).

Another benefit would be stable and lower levels of inflation, countries with higher inflation may be able to reduce it by merging with countries that have lower inflation in a single currency (Barro & Alesina 2002). This could benefit growth, as Barro finds a positive correlation between price stability and growth (1989). Later on, the same author would find, through a panel of 100 countries and a time window of 30 years, that inflation, even in lower levels, tends to impact negatively on economic growth (Barro 1996). So, overall, the EMU should bring more stability to some of its members in terms of price stability, this is of course a consequence of having the ECB determining monetary policies.

In terms of policymaking, the EMU has been linked with an increase in structural reforms (Mongeli & Vega 2006), which could have an impact on growth. In 2005 Easterly was of the opinion that only "extreme policies" are relevant for growth, and if a country has moderate policies these will not affect growth significantly, notwithstanding, in a more recent paper, the same author seems to find a positive correlation between public policies and growth using a bigger time span of data (Easterly 2019).

However, all of this comes at a cost, as was pointed out by several authors, which is the loss of monetary policy independence and a subsequent inability to react to asymmetric shocks via currency devaluation (Mundell 1961). So taken both the pros and the cons of joining the EMU it is necessary to understand what the overall contribution of the EMU towards GDP growth is.

The literature concerning the impact of the EMU on the growth of its members is not incredibly vast. To the best knowledge of the author, only two papers have been produced about this specific topic. The first is the masters' thesis project made by João Landeira (2018) with Nova SBE, in which the author finds that there is evidence that joining the euro has led to lower growth in the founding countries. Conversely, the other paper that has studied this topic, concludes that the creation of the euro was actually beneficial, in terms of growth, to its core countries. The authors find that these results remain robust when accounting for other variables that may influence growth positively such as FDI and R&D (Barrel 2008). Barrell also justifies the slower growth of the EMU countries at the beginning of the century by arguing that countries like Germany, Spain and Italy had a slower growth of total factor productivity.

This paper will differ from all of these because, with the aim to understand what is the role that a euro dummy will have in modeling GDP growth, it will, unlike (Silva 2018) and (Barrel 2008), use a methodology more in line with panel data literature, more specifically the one used by Nazrul (2005). This will be elaborated in the methodology section. The question that will be tackled throughout the rest of this work is the following: Is the EMU beneficial to economic growth, or is a panoply of solid institutions, low effective exchange rates, and low levels of inflation enough for a country to not have the necessity to join the euro?

3. Methodology

3.1. Model

The model used in the preliminary results section is a simple fixed-effects regression. The goal is to understand how joining the EMU actually affected the Effective nominal exchange rate volatility and the institutional quality of its members. Note that the only reason the same is not done for inflation is because, and due to the fact that the sample used is very homogeneous, the fixed effects model never reveals it to be significant in any regression. The data used will have a time span of 24 years (1995-2019), and the countries used are the same as the ones used in the core of the paper.

Throughout the rest of the paper, one thing will be tested, which is whether or not the belonging to the EMU contributed positively to the growth rate of its member countries even whilst controlling for things like institution quality, price stability, and exchange rate volatility. This is,

naturally, assuming that each country seeks for better levels of GDP per capita growth.

The model used to investigate such matter is a growth regression:

$$lny_{i,t} - lny_{i,0} = \alpha - \beta lny_{i,0} + X'_{i,t}\rho + \sigma EMU_{i,t} + u_{i,t}(1)$$

Where $lny_{i,t}$ is the natural logarithm of GDP per capita, $lny_{i,0}$ is the initial level of the logarithm of GDP per capita for each country so that the impact of initial income per capita is controlled for, $X'_{i,t}$ is the transposed vector of control variables that is used, $EMU_{i,t}$ is a dummy variable that captures whether or not a country belongs to the EMU at a given time and $u_{i,t}$ is the error term. This model is similar to the model used by Mankiw when trying to prove that the Solow growth model is in line with experimental data (Mankiw, Romer & Weil 1992), and the variables used in the $X'_{i,t}$vector will closely follow Veiga's growth regression (Veiga 2019). The vector of control variables will thus have the following baseline variables: Population growth, Investment, Education (average number of years of schooling), and Trade. Additionally, other control variables will be added, such as the economic freedom index, effective nominal exchange rate volatility, inflation, or financial market regulation, to understand whether or not the EMU is significant when controlling for these factors.

Before testing this very simple model it should be noted that the calculations will control for heteroskedasticity and autocorrelation, on top that a Hausman test was always conducted to

determine if a fixed-effects model is more suitable than a random-effects one, in all of the regressions the fixed effects model will be used according to the Hausman test results[1].

3.2. Data

The sample used in the core of the paper ranges from 1990 until 2019, and data was collected for 35 countries, all of them are either in the Euro Area or an OECD country, or both. Following the contribution made by Islam Nazrul (2005) the variables on the right side of the equation will all be lagged by a period of 5 years; this is done in order to prevent reverse causality and to avoid business cycle fluctuations. Data will also be averaged in 5-year periods without overlapping, meaning that the value a certain variable in the $X'_{i,t}$vector has got for 1995 will be an average that ranges from 1990 until 1994. The GDP per capita growth is computed as a 5-year growth rate for example the growth rate for 1995 is the difference between the value of GDP per capita in 1995 and 1990.

The sources of data are the OECD data bank, the PWT (pen world table) database, the Barros and Lee database for education, the world bank open data, the Bank for International Settlements Statistics and the EFW annual report from the Fraser Institute.

[1] Before deploying a Fixed-effects model, a Difference in differences models was experimented, using two data instances, prior to 1999 and post 1999. The result was that the term that multiplied the variable Treatment group dummy with the variable post 1999 was never significant. Thus these results will not formally be presented.

4. Preliminary Results

It is suspected that the main channels through which joining a single currency may influence growth are the elimination of exchange rate fluctuations within members, monetary policies being determined by the central bank and perhaps, for some countries only, an increase in the quality of institutions. As a preliminary exercise to this paper, two things will be investigated, the first is if overall joining the EMU acted in fact a stabilizer of the effective nominal exchange rate volatilities, and which countries benefited the most from this volatility reduction, the second is to check which countries benefited in terms of institutional quality when joining the EMU. The exchange rate volatility will be represented as the yearly standard deviation of the effective nominal exchange rate (ENER), for this purpose the yearly standard deviation, using monthly data, is computed. The effective nominal exchange rate is the value of a currency against a weighted average of other countries' currencies, being that the weights are adjusted taking into account the level of trade that said country has with the other ones. This means that countries that have joined the euro and trade mostly with countries that have also adopted the euro are expected to have gained more ENER stability when compared to countries that trade mostly with countries outside of the Euro Area.

When it comes to Institutional quality of a country, the set of variables used by Veiga to proxy for it will be used (2019). This includes the economic freedom index, financial market regulation and the rights for property and legal system quality.

Given that the aim is just to understand what the impact of joining the EMU has got on the ENER volatility and institutional quality, a simple FE regression will be carried out. For this

purpose, yearly data ranging from 1995 until 2019 , for 35 countries will be used, all of which are either OECD or EMU members (or both).

$$ENERrv_{i,t} = \alpha_i + \beta EA_{i,t} + \sigma_t + \mu_{i,t} \quad (2)$$

In this regression the regressor is the volatility of the effective nominal exchange rate, EA is a dummy for the euro area, σ_t is a trend dummy that will serve to capture shocks that are transversal to our pool of countries such as the 2008 crisis or the 2001 .com crises. The country sample was assembled in a way that preserves some degree of homogeneity when it comes to indicators such as democracy levels, index of ethnic factions, or respect for human rights. This set of countries will be the one used throughout the rest of the paper, and this was done so that all of these variables don't have to be taken into account when using a Fixed Effects regression, allowing us to control for more niche parameters and fine-tune the models used.

Equation (2) depicts the example for ENER volatility, but the same regression will be made using different proxies for institutional quality.

Note that heteroskedasticity in the std's and autocorrelation was controlled for, and that the FE model is used in order to control for the country-specific heterogeneities that are time-invariant (again, a Hausman test concluded that FE would be more appropriate than RE). The result is depicted in table 1.

Table 1 EMU effect on ENER volatility and Institutions

VARIABLES	ENER vol	Economic Freedom	Regulation	Property rights
emu	-0.32***	0.19**	0.36***	0.21***
	(0.084)	(0.081)	(0.12)	(0.074)
Trend	-0.27	0.021***	0.053***	0.0020
	(0.22)	(0.0061)	(0.0076)	(0.0041)
Constant	3.262***	7.471***	7.116***	7.195***
	(0.126)	(0.0296)	(0.0341)	(0.0234)
Observations	875	875	875	875
R-squared	0.087	0.107	0.216	0.101
Number of countries	35	35	35	35

The EMU dummy is negative for the ENER volatility regression, as expected, and positive for all of the proxies for institutional quality. This means that when a country enters the euro its ENER volatility drops, on average, around 0,32 points, and this negative relation is in line with the fact that the exchange rate for countries within the EA no longer exists. At the same time when countries join the EMU it's expected that, on average, their institutional quality will rise.

When it comes to the asymmetries in the impact of joining the EMU on exchange rate volatility and institutional quality, it may be assessed that some countries benefited more than others, and the way to check that is through a residual analysis.

Notice that for the ENER volatility the term $\beta EA_{i,t}$ will on average be negative. This means that the country with the lowest residuals is the one that has the lowest value of β. Conversely, given that the term $\beta EA_{i,t}$ is positive for the institutional quality regression, it is the country with the highest residuals that will have benefited the most out the EMU when it comes to institutional quality.

The plot the residuals of equation 2 for ENER volatility shows that EMU countries have achieved negative residuals, in contrast with non-EMU countries. For the purpose of better visual analysis only two EMU countries will be plotted, the one with the highest residuals, and the one with the lowest (fig1 in the appendix). The country with the lowest residuals is Portugal which adds up with the fact that Portugal's biggest trade partners are Germany, Spain, and France. On the other hand, the country that seemed to have benefited the least from the EMU in terms of ENER volatility is Ireland, this is because Irelands' major trading partners are the UK and the USA, meaning that Ireland will be the EMU country with the highest ENER volatility.

When it comes to the residuals of the second regression in table 1, the plot (figure 2 in the appendix) shows that the country that benefited the most out the EMU when it comes to Institutional Quality was Finland, in contrast with Greece, which was the country that benefited the least.

5. Results

At first, a baseline equation is estimated, eq (3), after that the EMU dummy is added, and only then the rest of the controls, the results are presented in tables 2 and 3. The baseline goes as follows:

$$lny_{i,t} - lny_{i,t-5} = \alpha - \beta lny_{i,t-5} + \sigma Pop_{i,t-5} + \Upsilon Educ_{i,t-5} + \phi Invest_{i,t-5} + \omega Trade_{i,t-5} + u_{i,t} \quad (3)$$

Table 2 FE regression output

VARIABLES	Baseline	Model 2	Model 3	Model 4	Model 5
lagInit	-0.402***	-0.391***	-0.368***	-0.406***	-0.340***
	(0.0502)	(0.0535)	(0.0572)	(0.0599)	(0.0572)
lagPop	-0.0814***	-0.0795***	-0.101***	-0.0780**	-0.0956***
	(0.0257)	(0.0255)	(0.0355)	(0.0288)	(0.0348)
lagInvestment	0.804***	0.765***	0.822***	0.810***	0.740***
	(0.256)	(0.267)	(0.261)	(0.258)	(0.256)
lagTrade	0.296***	0.303***	0.191*	0.290***	0.213**
	(0.0831)	(0.0818)	(0.0985)	(0.0755)	(0.1000)
lagSchooling	0.0241	0.0239	0.00875	0.0237	0.00759
	(0.0189)	(0.0186)	(0.0209)	(0.0187)	(0.0203)
lagEMU		-0.0186			-0.0399
		(0.0238)			(0.0279)
lagInf				-0.00540	
				(0.0267)	
lagENER_vol			-0.0010***		-0.00098***
			(0.00021)		(0.000207)
Const	3.582***	3.474***	3.499***	3.633***	3.239***
	(0.398)	(0.436)	(0.495)	(0.548)	(0.501)
Observations	210	210	175	210	175
R-squared	0.497	0.499	0.413	0.498	0.422
Number of id	35	35	35	35	35

The results in table 2, and table 3, are in line with the expected outcome as Investment and Trade have a positive sign, initial GDP per capita and population growth are significant and have a negative impact on output growth, and schooling does not appear to be significant, this insignificance is of no surprise given that the sample is very homogeneous and has got a small number of years (meaning average schooling years didn't change that much for most countries and is thus possibly captured by the FE estimator).

Table 3 FE regression output

VARIABLES	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
lagInit	-0.394***	-0.349***	-0.400***	-0.395***	-0.430***	-0.441***	-0.456***
	(0.0640)	(0.0544)	(0.0491)	(0.0532)	(0.0693)	(0.0686)	(0.0581)
lagPop	-0.0763**	-0.0892**	-0.0802*	-0.0877**	-0.0659**	-0.0713**	-0.068***
	(0.0282)	(0.0359)	(0.0395)	(0.0358)	(0.0254)	(0.0275)	(0.024)
lagInvestment	0.772***	0.771***	0.437	0.746**	0.756**	0.505	0.560*
	(0.271)	(0.244)	(0.363)	(0.280)	(0.283)	(0.335)	(0.318)
lagTrade	0.297***	0.189	0.176	0.149	0.219**	0.207**	0.194**
	(0.0742)	(0.119)	(0.117)	(0.127)	(0.0954)	(0.0890)	(0.093)
lagSchooling	0.0236	0.00704	0.00878	0.00339	0.0206	0.0287	0.028
	(0.0184)	(0.0194)	(0.0169)	(0.0178)	(0.0180)	(0.0171)	(0.0172)
lagEMU	-0.0183	-0.0397	-0.0469*	-0.0489*	-0.0267	-0.0171	
	(0.0239)	(0.0278)	(0.0265)	(0.0272)	(0.0256)	(0.0267)	
lagInf	-0.00513	-0.0179	0.00218	-0.0110	-0.00361	0.00938	
	(0.0267)	(0.0275)	(0.0216)	(0.0252)	(0.0245)	(0.0225)	
lagENER_vol		-0.00080**	-0.00087***	-0.0011***			
		(0.000318)	(0.000243)	(0.000289)			
lagEFI			0.0925***			0.0819***	0.079***
			(0.0307)			(0.0271)	(0.029)
lagReg				0.0422**	0.0400		
				(0.0174)	(0.0237)		
Const	3.523***	3.362***	3.236***	3.601***	3.693***	3.449***	
	(0.593)	(0.492)	(0.428)	(0.494)	(0.628)	(0.619)	
Observations	210	175	175	175	210	210	
R-squared	0.499	0.427	0.492	0.456	0.526	0.546	
Number of id	35	35	35	35	35	35	

Inflation is never significant, which is, at first sight, a bit concerning, given that according to the literature it should be significant, but the fact is that, again, the sample used in this paper is very homogeneous, and it uses mostly developed countries which tend to have lower levels of inflation. It has been stated in the literature review that in Barros' paper on the impact of inflation on output growth, the author used a sample of 100 countries, in which there were very high levels of inflation present, so this difference in the datasets used should justify the difference in the results

(Barros 1996). Conversely, ENER volatility is always significant and negative, which is the expected sign. Regulation and Economic Freedom Index are added and when significant are always positive, it's noteworthy that similar results are obtained when controlling for Property rights, these variables are the ones used by Veiga (2019) to investigate the impact of institutions on growth and they are highly correlated with each other which why they may proxy the same thing: Institutional Quality.

Lastly, the EMU variable is not significant until the regression controls for both effective nominal exchange rate volatility and Institutional Quality. When this happens, EMUs' coefficient is negative. As seen in the preliminary results section, the EMU has had a negative impact on ENER volatility and a positive one on Institutions, this means that the expected sign on the EMU coefficient in Model 2 should be positive because the EMU dummy should encompass the positive effect it has got on GDP growth through better institutions and lower ENER volatility. But this does not happen, and it leads to believe that there may be another channel through which the EMU could impact on growth in a negative way.

As a robustness check and given that the sample in use includes the year of 2008, in which a great financial occurred, the same regressions will be made using a sample that includes the average growth until 2010 only. This means that all of the variables in the right side of equation 3 will range from 1990 until 2009.

Table 4 Growth Regression-1990-2010

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4	(5) Model 5	(6) Model 6	(7) Model 7
lagInit	-0.496***	-0.495***	-0.551***	-0.496***	-0.513***	-0.555***	-0.557***
	(0.0831)	(0.102)	(0.0722)	(0.0878)	(0.0761)	(0.0747)	(0.0721)
lagPop	-0.0642**	-0.0639**	-0.0890**	-0.0645**	-0.0810**	-0.0331	-0.0628*
	(0.0263)	(0.0275)	(0.0407)	(0.0288)	(0.0392)	(0.0358)	(0.0344)
lagInvestment	0.305	0.299	0.664*	0.305	0.531	-0.245	0.259
	(0.395)	(0.444)	(0.361)	(0.397)	(0.400)	(0.380)	(0.396)
lagTrade	0.316***	0.316***	0.231	0.316***	0.220	0.156	0.104
	(0.0840)	(0.0850)	(0.158)	(0.0752)	(0.162)	(0.109)	(0.153)
lagSchooling	0.0643**	0.0644**	0.0708*	0.0645**	0.0690*	0.0394	0.0465
	(0.0245)	(0.0239)	(0.0362)	(0.0249)	(0.0355)	(0.0264)	(0.0304)
lagEMU		-0.00232			-0.0337	-0.0426	-0.0571*
		(0.0345)			(0.0295)	(0.0304)	(0.0296)
lagENER_vol			-0.000733***		-0.000630*	-0.000938***	-0.00121***
			(0.000194)		(0.000357)	(0.000291)	(0.000373)
lagInf				0.000612	-0.0121	0.0165	-0.00438
				(0.0266)	(0.0310)	(0.0225)	(0.0255)
lagEFI						0.135***	
						(0.0267)	
lagReg							0.0695***
							(0.0187)
Constant	4.224***	4.208***	4.707***	4.219***	4.402***	4.311***	4.739***
	(0.626)	(0.805)	(0.649)	(0.725)	(0.708)	(0.632)	(0.682)
Observations	140	140	105	140	105	105	105
R-squared	0.586	0.586	0.515	0.586	0.524	0.662	0.597
Number of id	35	35	35	35	35	35	35

The last regression in table 4 points towards some robustness in the previous results, even though when using Economic Freedom Index as a proxy for institutions, the EMU dummy is not significant anymore. Still, when controlling for market regulation quality the EMU dummy has a significant and negative impact on growth, which leaves room for suspicions that indeed there may

be a channel through which the EMU impacts on GDP growth negatively. So, in order to further investigate this the following regression will be performed:

$$EMU = \alpha + \beta ENER_{vol} + \rho EFI + u_{i,t} \quad (4)$$

The goal is to extract the indirect effect that the EMU may have on output growth through ENER volatility and Institutional quality and to keep only the negative effect it may have on output growth through a third channel. This is done by saving the residuals and inserting them into equation (3) as the proxy for this third channel through which the EMU could impact negatively on GDP growth. The results of such exercise are presented in table 5.

Table 5 Growth regression using eq5 residuals

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
lagInit	-0.324***	-0.337***	-0.340***	-0.400***
	(0.0562)	(0.0534)	(0.0542)	(0.0491)
lagPop	-0.0933**	-0.0849**	-0.0834**	-0.0802*
	(0.0345)	(0.0357)	(0.0352)	(0.0395)
lagInvest	0.674**	0.708**	0.645**	0.437
	(0.284)	(0.273)	(0.255)	(0.363)
lagSchool	0.00889	0.00788	0.00659	0.00878
	(0.0191)	(0.0180)	(0.0183)	(0.0169)
lagtarde	0.206**	0.178	0.201*	0.176
	(0.0945)	(0.113)	(0.114)	(0.117)
3rd channel	-0.0710***	-0.0676**	-0.0690***	-0.0469*
	(0.0247)	(0.0251)	(0.0250)	(0.0265)
lagInflation		-0.0219	-0.0137	0.00218
		(0.0267)	(0.0270)	(0.0216)
lagENER_vol			-0.000866***	-0.000918***
			(0.000308)	(0.000251)
lagEFI				0.0795**
				(0.0312)
Constant	3.062***	3.250***	3.279***	3.320***
	(0.493)	(0.484)	(0.492)	(0.415)
Observations	175	175	175	175
R-squared	0.429	0.437	0.447	0.492

Notice that the proxy for this third channel is constantly significant and negative, while ENER volatility and EFI maintain their significance and coefficient signs. This largely supports the thesis that the EMU can have an impact on growth through these channels, one of which is not duly identified.

At the same time, one could suspect of a multicollinearity problem, especially when the variable ENER volatility is introduced. When this happens it is clear to see that some variables change their coefficients by a lot, and not just the Trade variable (which would be expected as less exchange rate volatility could enhance the levels of trade), but also Population growth for example. In order to deal with this lack of robustness in the variable coefficients and even significance, a machine learning method will be used to compute the last regression, more concretely an Elastic Net regression.

The Elastic Net regression will add two penalty terms to the calculation of the coefficients in the regression, one is known as the L1 penalty term and the second one is the L2 penalty term. These penalty terms will be added to the cost function that is used when the algorithm computes the gradient descent that will deliver the estimates of the coefficients for the regression[2]. This means that redundant variables will have either no coefficient or a very insignificant one.

[2] Note that using gradient descent is an alternative way to compute the estimate of the coefficients in the regression it will use the following equation: $\beta_{new} = \beta_{old} + \alpha * \nabla_{\beta} J(\beta)$. This equation will iteratively reach the best estimate by computing the gradient of a cost function, usually the mean squared error. In the case of the Elastic Net this function will be of the type: $J(\beta) = \sum_{i=0}^{n} (y_i - X_i * \beta_i)^2 + r\alpha \sum_{i=0}^{n} ||\beta_i|| + \frac{(1-r)*\alpha}{2} \sum_{i=0}^{n} \beta_i^2$, where the first term is the MSE, the other two terms are the L1 and L2 penalty terms combined. This method is known to be a great way to deal with multicollinearity without resolving to dimensionality reduction techniques such as PCA or Partial Least Squares, so in the end it is easier to interpret the results.

When computing the Elastic net algorithm all of the variables in the right-side of eq (3) must be scaled in order for the gradient descent to converge properly (or at least faster). At the same time, given that it the regression should not account for country specific effects the within estimation is applied to the data, which means that the following results will be a combination of the Elastic Net regression with the within estimator. A baseline result is present in figure 3.

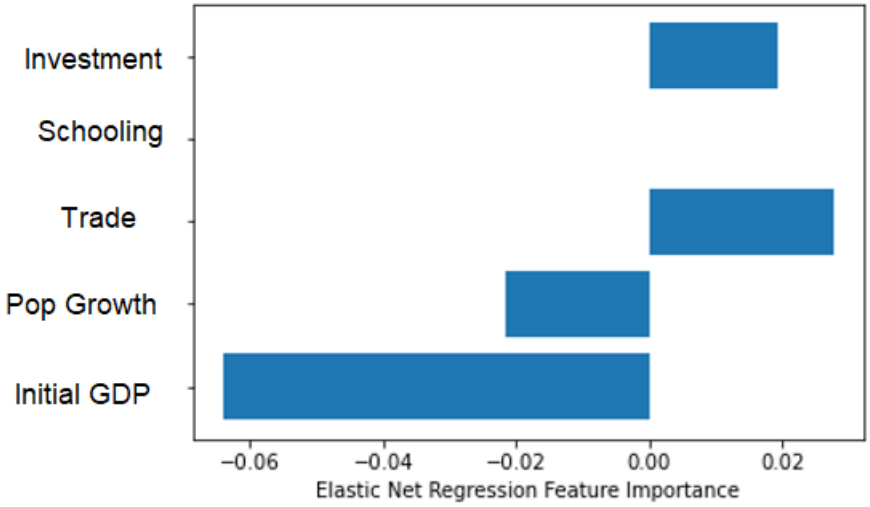

Figure 3 Elastic Net baseline regression

Comparing the first result provided by the EN regressor with the Baseline Model in table 2 should shine light on the robustness of this machine learning method, as the only variable that it picked as irrelevant is the same as the one that is statistically insignificant in the FE regression, and at the same time the signs on the coefficients are also a match with the standard FE regression. This should provide some confidence in the interpretation of the next results which are depicted in figures 4 and 5.

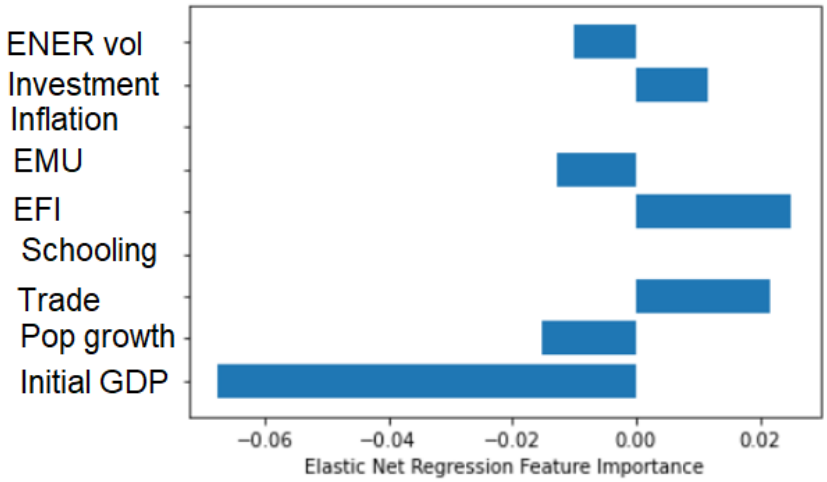

Figure 4 Elastic Net equivalent of Model 8 of table 3

Figure 4 is the equivalent of the FE regression presented in table 3 as "Model 8" and when comparing the results, it is possible to assess that the main difference lies in two variables, Trading, and Investment. Note that at first, when using the FE regression both these variables used to be significant, but after the introduction of more variables they ceased to be so. When using the EN algorithm, and thus dealing with multicollinearity, the variables are significant again and maintain the correct sign. Inflation and Schooling seem to be overall insignificant for the model as in the FE estimator.

Lastly, the proxy for the third channel through which it is believed that the EMU may impact GDP growth is added to the previous regression (figure 5), and the result is that EMU is now redundant (as expect given that it is a linear combination of other variables), and this proxy seems to have a negative impact in growth forecasting. It is thus safe to say that the EMU does have a channel through which it impacts GDP growth negatively.

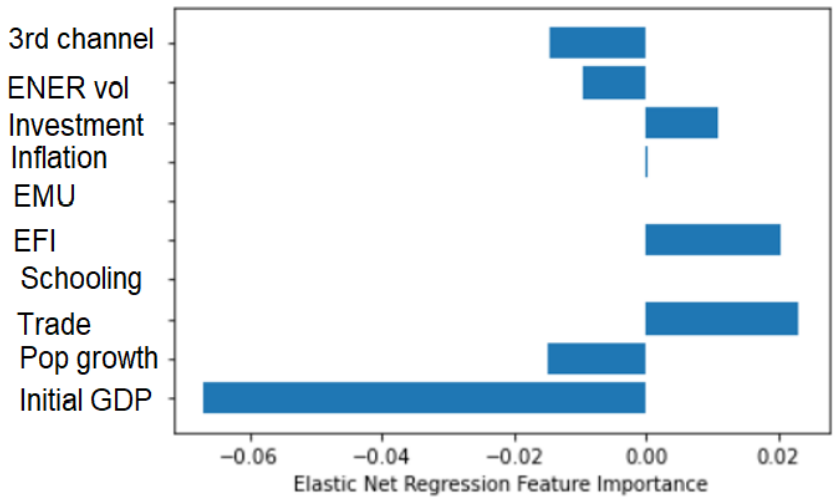

Figure 5 Elastic Net using the residuals from eq 4

Before heading towards the conclusion, it should be stated that even though the EN algorithm can be of great use when dealing with multicollinearity, it is not of great aid in terms of forecasting, as it does not add much to the forecasts that a simple FE model produces. For this purpose, there are much more sophisticated algorithms that could produce a much better result, and given that the aim of this paper is to aid countries making a decision on whether or not they should join the EMU, should they have the chance, it could be useful to present a more powerful forecasting method, such as XGBoost (XGB), which is a sophisticated method that has been awarded with a victory in a few data science competitions in the past. XGB uses a boosting technique which consists in taking a lot of weak machine learning methods, in this case small decision trees, and combining them into a more robust method. It does this by using these weaker learners sequentially and by giving a bigger weight to the mistakes the first learners make, thus making sure that these mistakes will be mitigated (Chen 2016).

Having that into account it is time to understand how being a part of the EMU impacts GDP growth forecasts. For such task, Portugal data will be separated from the dataset, and given that the EMU dummy is mainly insignificant when alone one can only assess its' contribution to the forecast via the three channels found. Commencing with fixed effects, the forecast for Portugal's GDP growth is not only more accurate – without the EMU channels the R squared was of 0.64 and with the three channels it became 0.72 point more in the R squared – but also more optimistic when accounting for the EMU effects, meaning that in Portugal's case being a part of the EMU as probably brought more benefits than drawbacks. Note that data leakage was never a problem as the coefficients provided by the fixed effects model in this case did not take into consideration Portugal's data.

In order to obtain some robustness on these results the XGB method was implemented. The overall result of such implementation is that adding the EMU channels contributes to a more accurate forecast, even when using the same set of parameters. However, given that there are not a lot of events in the dataset the method was not able to overperform the fixed effects method, attaining a R squared of 0.59 (with the EMU channels). This may hint that for simple tasks, for which not a lot of data is available, a more parsimonious method could be more beneficial than these sophisticated methods. Nevertheless, it would be expected that this last method would overperform the fixed effects method in a context of a bigger dataset.

6.Concluding remarks

The main goal of this paper is to understand if joining the European Monetary Union is positive, negative, or neutral for GDP growth, even if controlling the main channels through which it may act. The overall result was that joining the EMU seems to have a negative relevant impact on the modeling of GDP growth when controlling for the main channels through which it may have an influence on it, ENER volatility and institutional quality. It is assumed that inflation is also one of the channels through which the EMU could have an impact on output growth because of the efforts by the ECB to keep it a low level, however, this could not be tested in the dataset used due to a high level of homogeneity in the countries chosen. Nevertheless, these results seem to be robust, even with the introduction of methods such as the elastic net. This means that there is a channel through which the EMU has a negative influence on GDP growth. This could represent the lack of flexibility that member countries have to react to asymmetric shocks through currency depreciation, but further investigation would have to be done to assert that this is the effect that the third channel is capturing. In terms of the overall effect of the EMU on GDP growth one must conclude from the results section that it is, on average, neutral, and that countries with low levels of ENER volatility and a panoply of solid institutions would not have much to gain in joining the euro.

The second finding of this paper is that extending econometric models to machine learning models could be beneficial when it comes to extracting economic insight and forecasting. For example, the Elastic Net model is very good when it comes to dealing with multicollinearity, and

more sophisticated models like XGB could provide better forecasts than simple FE models, if the models' hyperparameters are properly tuned and there is a large amount of data of course.

Finally, if there is a question that arises from this paper, it would be the following: is the channel through which being a part of the EMU has a negative impact on output growth in fact the lack of flexibility that members have when dealing with asymmetric shocks, given that they now may not depreciate their currency, or is there another channel, or channels, through which this effect may come to play?

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Appendix

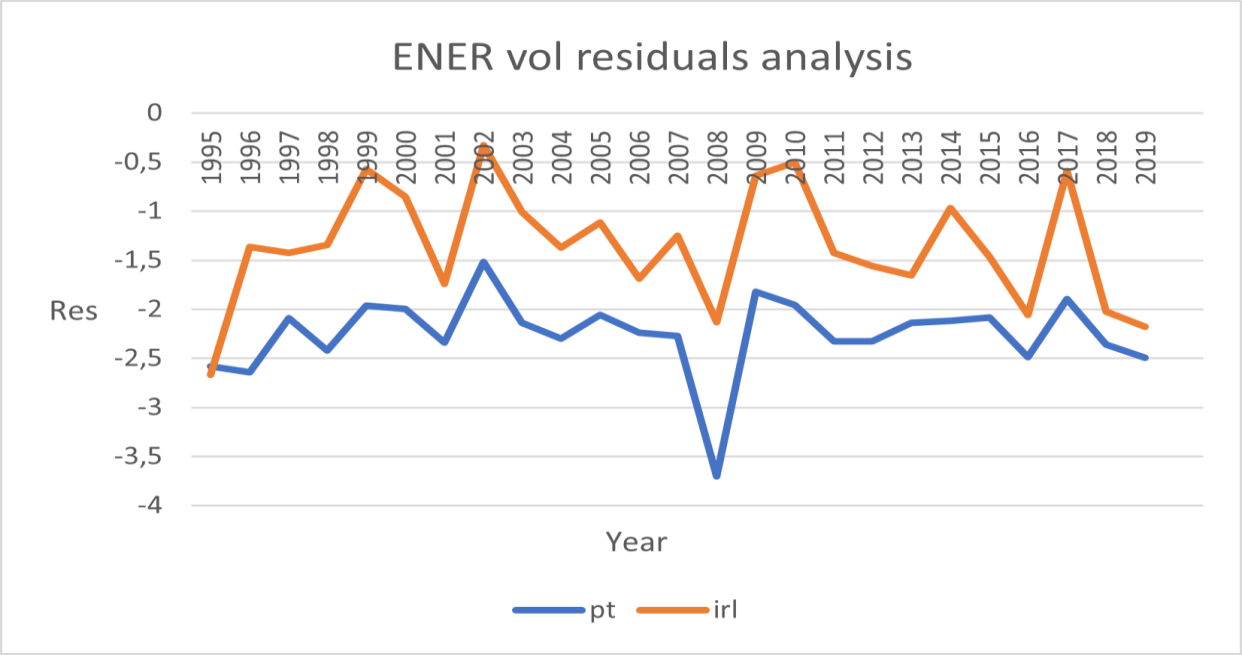

Figure 1 Residuals of the regression in equation 2

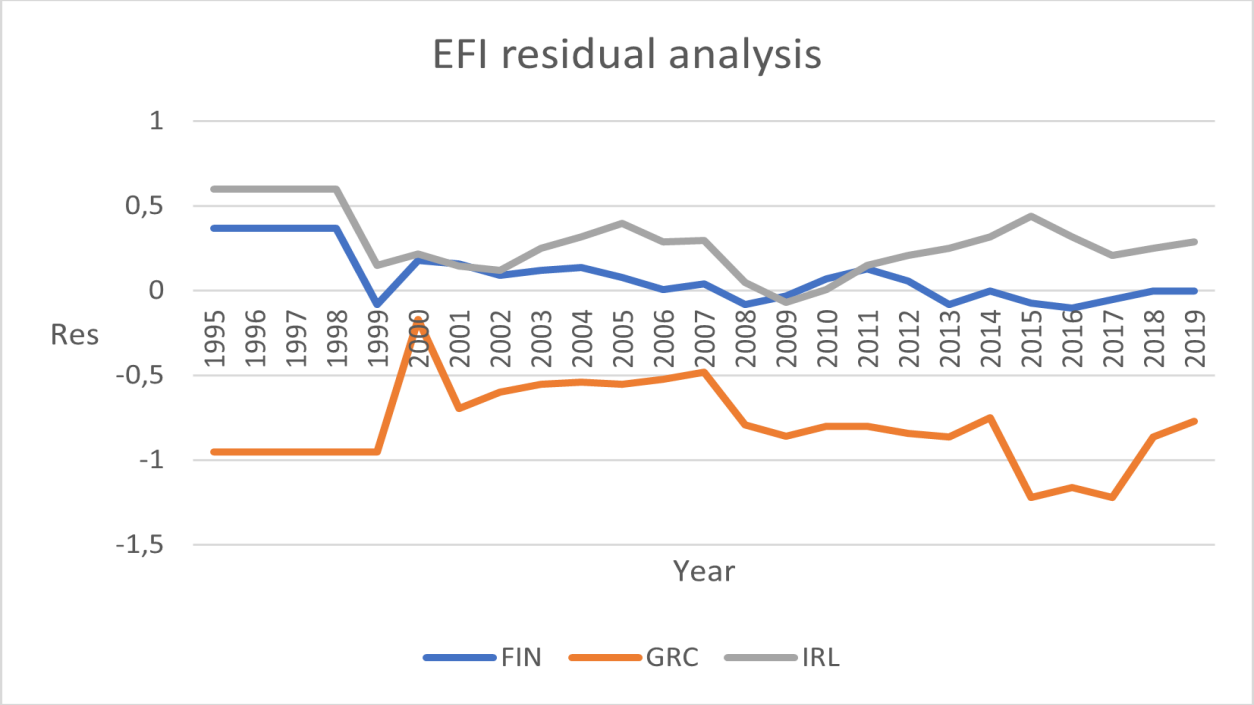

Figure 2 Residuals of the institutional quality regression

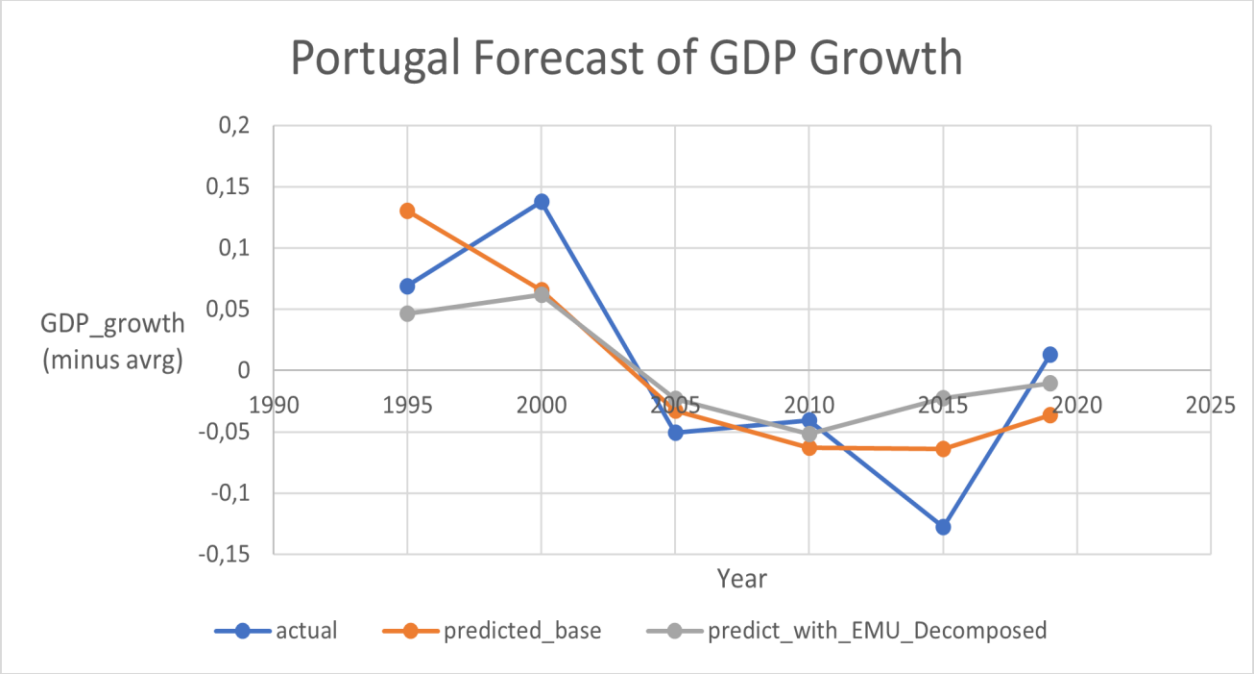

Figure 6 FE forecast of Portugal's GDP growth