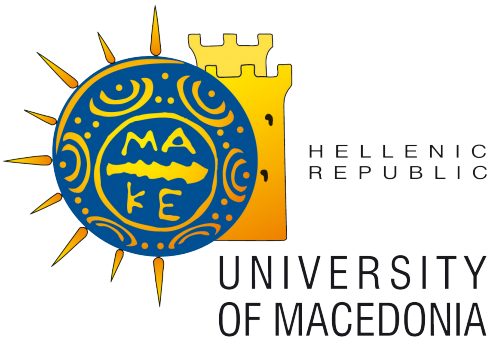

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Public debt and Sovereign Credit Ratings in the Eurozone: A Fixed Effects Panel-Threshold approach

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Abstract

The current research on sovereign credit ratings has been expanded in the last decade, especially in the years following the Global Financial Crisis and the subsequent European Debt Crisis. While the role of debt-to-GDP ratio was always taken into account, there is no previous empirical work to the best of my knowledge that hypothesized that should a certain threshold is surpassed, then its impact on sovereign credit ratings is more severe. Using data from Moody's and Fitch, this thesis employs a Panel Threshold Fixed-Effects methodology to assess the varying effect of debt-to-GDP ratio to the attributed sovereign Credit Ratings for member states of the Eurozone. Based on empirical evidence, the two rating agencies share a similar approach toward public debt but they have different levels of tolerance. Two different thresholds are identified; those are 95.782 and 120.038 for Fitch and Moody's, respectively, resulting in two distinct regimes of 'low' and 'high' implications for the attributed sovereign credit rating. The regime-dependant coefficients in the 'low regime' for Fitch are not statistically significant, implying that public debt does not have harmful consequences at low levels. Overall, the debt-to-GDP ratio erodes more drastically the solvent ability of a sovereign when the estimated threshold is exceeded.

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1. Introduction

Credit Rating Agencies hereafter *CRAs* aim to provide investors an assessment of the creditworthiness of a country *or* of a company. The first publicly available credit rating is dated back in 1909 and was issued by Moody's, while in the coming decades, the other agencies followed suit. The credit rating industry is dominated by three major agencies, namely Standard and Poor's (S&P) and Moody's, which control approximately 80% of international ratings. At the same time, Fitch Group also controls approximately 15% of the global market. In addition, the Canadian Credit Rating Agency DBRS holds around 2%-3% of the global market share. The *CRAs* mentioned above are the only four Agencies recognized by the European Central Bank (ECB). *CRAs* assess the debt serviceability and solvency of an entity, either a sovereign or a company, by assigning a rating grade to the respective debt issuer. In that regard, the three predominant *CRA's* grading system share some similarities; for instance, Moody's rating scale comprises 21 notches running from *Aaa* to *C*. In the same sense, Fitch Group's rating scale runs from *AAA*, considered a *prime* debt to hold, to *D* for *Default*. Furthermore, the rating scale is also divided into two sections, investment-grade ratings, associated with a lower probability of default, and speculative-grade ratings, in which the trade-off between risk and return is higher.

CRAs have been under heavy criticism, especially during the turbulent times that followed suit with the Subprime Mortgage Crisis and the collapse of the Global Financial System back in 2008. Former President of the European Committee Josh Manuel Barroso's remarks about the deficiencies of the working methods of *CRAs* were all over the news at that time, while also denouncing that the three major agencies are way too reliant on market sentiment rather than basing their assessments on fundamentals (Webb, 2010). On top of that, *CRAs* was also criticized for potential conflict of interest, steaming from their reluctance to assign lower ratings to security issuers since the latter was paying the rating agencies to provide rating services (Ryan, 2012). Blatantly, *CRAs* wield a lot more power than expected since they endorse or discourage the efforts of investors to finance companies or countries.

While the ability of governments to access capital markets to raise capital in order to finance short-term needs is crucial, it sometimes comes at a higher cost than expected, especially when *CRAs* decide to change the outlook of an economy to *negative*. A pivotal classification in the rating scale of *CRAs* is that of a debt classified as *investment-grade* and that of a debt or issuer classified as *speculative* or sometimes also commonly referred to as "junk". Due to the data limitation, this thesis focuses on two out of three major *CRAs*, namely Moody's and Fitch. For the former Agency, bonds rated *Baa3* or better fall under the category of *investment-grade*. In contrast, for the latter, bonds rated *BBB-* or higher are also considered *investment-grade*. In contrast, high yield pertains to bonds rated *Ba1* and *BB+* or lower. Table 1 provides an overview of the rating scale for the researched agencies, along with the respective characterization of the debt and the linear transformation of the credit ratings.

Governments issue debt to finance their operations either to repay outstanding debt claims, and their

Table 1: Rating Scale

Debt and issuer characterization			
	Fitch	**Moodys**	**Linear transformation**
Prime	AAA	Aaa	21
High quality	AA+	AAa	20
	AA	AA2	19
	AA-	Aa3	18
Strong payment capacity	A+	A1	17
	A	A2	16
	A-	A3	15
Adequate payment capacity	BBB+	Baa1	14
	BBB	Baa2	13
	BBB-	Baa3	12
Likely to fulfil obligations	BB+	Ba1	11
	BB	Ba2	10
	BB-	Ba3	9
High credit risk	B+	B1	8
	B	B2	7
	B-	B3	6
Very high credit risk	CCC+	Caa1	5
	CCC	Caa2	4
	CCC-	Caa3	3
Non default with possibility of recovery	CC+	Ca	2
	CC		
Default	DDD	C	1
	DD		
	D		

debt structures are based on market conditions, government preferences, how much capital they want to tap into, Etc. Government bonds function as a benchmark for companies from the exact country of origin since they are rarely attributed a higher rating grade than the country they operate in. This observation can be easily explained since governments can impose higher taxes to curb government spending to service outstanding debt. In addition, sovereigns have the absolute authority to incur debt, and their probability of default is significantly lower since even if a country defaults on its obligations, it is seldom the case that it will disappear as companies do. As a result, the sovereign debt market has been characterized by an absence of bankruptcy codes (Duffie et al., 2003).

A credit rating reflects to a great extent the overall ability of a country to repay its debt and remain solvent. However, debt should be classified as internal debt and external debt. Internal debt represents the amount owned by internal lenders and can be reduced if the central government decides to recourse on raising taxes or even through money creation (Mellios and Paget-Blanc, 2006). On the other hand, external debt is considered far riskier, and its reduction may be subject to the willingness of investors to restructure short-term debts. External indebtedness affects not only the overall creditworthiness of

a country but the perceptions of investors about its credibility as well. Countries with high debt levels will be subject to higher risk premia when accessing capital markets. Therefore exogenous shocks may render debt even more unsustainable (Cecchetti et al., 2010). While debt sustainability remains a vital component of the analysis carried out by the *CRAs* when they assess a country's creditworthiness, their analysis involves a plethora of macroeconomic variables.

Assessing a country's solvency requires a more profound scrutiny of its fiscal situation. Evidence in the literature suggests that a country's solvency capacity is also associated with current account deficits, a primordial component of debt sustainability since governments cannot run large account deficits without raising funds by accessing capital markets or by imposing higher taxes (Roubini, 2001). Distortionary taxation can lead to a dangerous path since higher tax rates impact economic decisions such as savings, labor and consumption. Thus a country cannot perpetually raise taxes to run primary surpluses to offset short-run primary deficits. Debt cannot be perceived in a manichaistic approach such as good or bad; it is far more complex. To that end, traditional metrics have been developed, such as debt to GDP ratio, debt to revenue, and debt to exports, to name a few, to assist in determining whether a country can be solvent in the long run. Debt to GDP ratio is a crucial macroeconomic variable that should be taken into account since it conveys information on the economic growth of a country and constitutes a reliable indicator of a country's ability to pay back its debt. Countries that can service their debt without continuously refinancing debt outstanding by issuing new debt can be deemed stable. A persistently upward-trending debt-to-GDP ratio indicates that the economic growth of a country is not sufficient enough to service its debt effectively and indicates a greater probability of default. Nevertheless, a country can remain illiquid while remaining solvent if the debt-to-GDP ratio is not increasing. High public debt also means governments cannot employ expansionary fiscal policies to tackle recessions; thus, this counter-cyclical approach is restricted or at least limited to a certain degree. Another approach of high public debt distinguishes the maturity of the debt. While short-term debt is seen as an immediate threat to a country, long-term debt is also a menace since increasing interest rates impact the new cost of borrowing and thus render debt serviceability unsustainable. At the same time, expansionary policies are deemed inappropriate due to high borrowing costs. Literature on debt sustainability is voluminous (Mencinger et al., 2015), (Caner et al., 2010) and indicates that up to a particular point, debt is economically and politically (Kourtellos et al., 2013) sustainable, but a commonly agreed threshold is yet to be determined (Eberhardt and Presbitero, 2015). This thesis employs an econometric approach that identifies that observations fall into discrete regimes rather than identical across all regression functions (Hansen, 1999). It suggests that should an estimated threshold be exceeded; the underlying variable will have a more severe impact on the target variable. This methodology is instrumental when modeling macroeconomic indicators since researchers are more interested in the response of the dependent variable when the researched figure surpasses a certain level. Departing from the literature, certain macroeconomic variables are allegedly the driving factors that drag credit ratings down and are tightly related to the ability of countries to service their debt. Debt to GDP ratio is a critical macroeconomic factor that is part of the methodology of *CRAs* when they evaluate a nation's ability to service its debt. Evidence in the literature suggests that GDP per capita and fiscal balance (Erdem and Varli, 2014) are also among the determinants of sovereign credit ratings. GDP per capita not only provides a dual perspective of a country's ability to service its debt, but it also serves as a prosperity indicator while, at the same time, it takes into account the tax base of a country.

The Global Financial Crisis has brought the Eurozone to its knees battling on multiple fronts, including debt sustainability. The treaty of Maastricht stipulated that the gross government debt should not exceed the threshold of 60%, outlining the importance for countries to have sound fiscal positions. The severity of the crisis also impacted the current accounts, producing excessive deficits which were irreparable for some countries. In the case of Greece, this tight fiscal position that the country was in forced newly elected Prime Minister Georgios Papandreou to disclose the severeness of the situation in a cry for help, leading ultimately to a financial assistance program implemented by Troika (ECB, European Commission, and IMF). In the case of Greece, the intervention of these international financial institutions converted an outright default to a debt restructuring and set a precedent. However, the financial crisis was not the cause of the decline of the fiscal situation in Greece but merely an exogenous shock that brought to the fore the fiscal and macroeconomic imbalances that existed long before this crisis. Literature also suggests that these macroeconomic deficiencies, if they were not treated in a timely and meticulous manner along with the appropriate economic methodology, will not only have adverse effects on this specific country but will create a spillover effect for the other Member States (Bouabdallah et al., 2017). These macroeconomic imbalances suggest that the required effort to bring the debt down to a sustainable level may be economically or politically infeasible. The austerity measures that were later imposed on some Eurozone countries were the afterthought not only of a global financial crisis as well as a natural implication of the structural deficiencies of their budgetary choices. *CRAs* closely monitored how the situation unfolded in the Eurozone, placing a particular interest in countries such as Greece, Portugal, Ireland, and Cyprus. During this period, yields skyrocketed, confirming investors' limited appetite and hesitance to hold bonds issued from the Eurozone countries. Higher yields on sovereign bonds render borrowing costs unsustainable for many countries, leading Greece to miss a payment to IMF, making it the first developed country to default on its obligations. The European Stability Mechanism (ESM), which was created to safeguard the long-term financial stability of European countries, has granted loans with the objective of a macroeconomic adjustment to Greece, Cyprus, Ireland, and Portugal. Eurozone was founded as a monetary union to enhance economic integration between member states. In that regard, *ESM* was born for this particular reason, to promote financial stability within the area by providing financial assistance to countries such as Greece that experience financial difficulties. Despite the presence of a mechanism that aims to prevent defaults in the Eurozone, the European debt crisis prompted the three institutions that constitute *Troika* to implement an enhanced prudential regime to monitor the process of Greece closely. Public debt was at the core of those metrics that the institutions kept an eye on since it had been running rampant for decades.

The remainder of this thesis is organized as follows. Chapter 2 provides an overview of the existing literature. Rather than attempting an exhaustive analysis of the literature, chapter 2 focuses on the set of explanatory variables employed by previous empirical studies and aims at providing an insight into literature suggesting that there is a crucial threshold of debt to GDP ratio that should be surpassed then debt becomes unsustainable and aggravates the attributed sovereign credit rating. Chapter 3 and chapter 4 discuss the data and the employed econometric methodology, respectively. Finally, chapter 5 discusses the empirical results and chapter 6 concludes.

2. Literature review

The existing literature on the determinants of sovereign credit ratings is voluminous and suggests that a reduced number of macroeconomic factors can explain the decisions taken by the rating agencies when assessing the creditworthiness of sovereigns. Opposing the view that credit ratings reflect observable macroeconomic fundamentals, (Cavallo et al., 2013) attempted to research the hypothesis that rating agencies, through their assessments, also provide incremental information on the unobservable sovereign fundamentals. If this hypothesis holds, sovereign credit ratings indicate the information already available for investors and are reflected through the macroeconomic fundamentals of the underlying country. Turning to the observable macroeconomic conditions that can impact a country's solvency, an overwhelming amount of empirical evidence attempted to model the response of the sovereign credit ratings to changes in a set of quantitative and qualitative factors. One should say, however, that rating agencies work in mysterious ways, and even though their rating methodology is available for researchers to study, their rating assessments also express their "opinions". To that end, (Eichengreen et al., 2000), after regressing sovereign credit ratings to a set of macroeconomic fundamentals, interpreted the error term as the *CRAs* opinion on the underlying debt issuer. The seminal paper of (Cantor and Packer, 1996) identified 6 crucial macroeconomic indicators as well as two dummy variables that impact the sovereign credit risk, which explains an incredible 90% of the variability of the credit ratings. Their research suggested that especially for the *non-investment grade* bonds, sovereign ratings influence market yields in a more compact way.

In literature, there are two predominant strands that researchers can refer to. Regarding the employed econometric methodology, probit and ordered probit models have the lion's share as the response variable is in an ordinal scale. This thesis employs a linear transformation of sovereign credit ratings in line with the second central strand of literature (Boumparis et al., 2017). Since a rating is a qualitative ordinal assessment of the likelihood that a debt issuer will repay its debt in principal as well as in interest on time, a linear transformation might not be the most appropriate for several reasons (Afonso et al., 2007). First, it implies that the change between categories is the same, which does not hold since the yield of non-investment grade bonds is typically much higher than securities in the investment grade. Risk premia vary between risk differentials. For instance, ratings between *AAA* and *AA+* and *B+* and *B1* convey different information; based on those observations, an overwhelming amount of empirical research in the literature employ ordered response models that account for this non-linearity (Bissoondoyal-Bheenick, 2005) on sovereign credit ratings.

Contrary to conventional Ordinary Least Square estimates, which assume that the variables have equally spaced intervals, the change in level between values is precisely the same. Thus they fail to convey information on variables depicted in a ranked ordinal scale (Bissoondoyal-Bheenick et al., 2006). An ordered probit model could be considered a more appropriate econometric methodology to analyze the impact of certain macroeconomic variables on the attributed sovereign credit rating since the dependent

variable is in a qualitative ordinal scale and reflects an order of the probability of default. Researchers should consider not only a change in a credit rating but also potential changes in the outlook. Periodically, when the rating agencies anticipate a worsening of the fiscal trajectory of a country and potentially more ominous economic prospects, they reassess their opinions of the underlying country. In that occasion, a linear transformation ceases to be on a scale from 1 to 21, but au contraire, the scale gets expanded significantly to capture the changes in the outlook. Consequently, this approach introduces more variability in the response variable leading to decreased levels of bias. While the rating methodology of the *CRAs* is published and can be easily accessible, researchers remain baffled by some of their decisions. To better comprehend the macroeconomic factors that the rating agencies rely their decisions on, (McKenzie, 2002) employed a *Principal Component Analysis* to identify the variables with the highest explanatory power that help explain the variance of the attributed sovereign credit ratings. Departing from his methodological framework, (Mellios and Paget-Blanc, 2006) employed an ordered logistic model that attempted to predict the probability of the occurrence of default with the use of 9 sovereign credit rating determinants.

Even though literature has shed some light on the working methods of *CRAs*, there remain parameters yet to be determined. Relying on macroeconomic fundamentals is often expressed by researchers. A different angle is associated with overall market sentiment. Therefore, (Freitag, 2015) by incorporating a proxy for business cycles within a panel framework, they researched whether ratings are hooked on business cycles or on past ratings. In that sense, shall a country's rating be higher during expansion and lower during a recession, or should a past low rating mean that the country under consideration should never get past it and its faith is sealed? The credit rating is related to the interest rate that a country faces when accessing the capital markets and is depicted in an ordinal scale (see Table 1). A sovereign credit rating can also be considered as a forward-looking assessment of the probability of default of a country *or* of a company (Bissoondoyal-Bheenick, 2005). Hence any relevant analysis should be based on the willingness and ability of the underlying debt issuer to repay its obligations. Evidence in the literature suggests that debt serviceability rests heavily on current outstanding debt. A continuously persistent debt is associated with a greater probability of default and burdensome interest rates. However, a pivotal public debt threshold should be surpassed in the country in question; its growth rate is expected to be cut in half (Reinhart and Rogoff, 2010). Among the other determinants of sovereign credit ratings, public debt is considered one of the leading macroeconomic indicators on which the *CRAs* base their decision. The assumption that expansionary fiscal policies can reduce public debt no longer exists in a monetary union since printing money is not an option. Debt sustainability therefore resurfaces and regains ground since in a monetary union such as the Eurozone, the member states do not reserve full taxation powers, and they cannot recourse to printing money (Gros, 2011). While public debt constitutes a critically important indicator of a country's creditworthiness, other macroeconomic variables should also not be neglected. In particular, evidence in the literature suggests that the growth rate and inflation rate are among those macroeconomic indicators that can impact the assigned credit rating. Inflation negatively affects the sovereign credit rating as it is associated with price instability and deterioration of household's purchasing power, which also impairs household savings. On a country level, high inflation rates signify a higher degree of uncertainty for investors and thus worsen the incentives for investments (Wüste, 2022). Unemployment and inflation share an inverse relationship; however, evidence in literature (Afonso et al., 2011), (Reusens and Croux, 2017) suggest that they both negatively impact the attributed sovereign credit rating. Persistently high unemployment rates point towards continuous pressure on governments

since the latter are being forced to increase government spending on welfare allowances and benefits, which ultimately can lead to higher taxation to cope with the increasing pressure on the fiscal balance. The unemployment rate enters consistently into the modeling framework in literature ((Mellios and Paget-Blanc, 2006), (Boumparis et al., 2015), (Yıldız and Günsoy, 2017) since it also provides an insight into the labor market structure and the tax base of the underlying country. People filing for unemployment benefits are net receivers, while those paying taxes are net contributors. An unemployment rate spiraling out of control means that governments are forced to provide allowances to those in need leading to an aggravation of fiscal balance.

The rating methodology of the agencies incorporates not only quantitative factors but also some qualitative ones. Evidence in the literature identified a pool of variables that impact the attributed sovereign credit rating. World Bank publishes an annual report on the regulatory quality of the countries around the world, which reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development (Ozturk, 2014). The willingness to service debt is crucial when determining credit ratings since investors are holding back in buying bonds from countries that continuously play the debt restructuring card. Notwithstanding, little empirical evidence exists on the political framework that dictates the decisions behind the assignment of sovereign credit ratings; the omission of variables accommodating for the political risk can induce bias for the selected economic variables (Ul Haque et al., 1998). Hence, as a proxy for political stability, (Archer et al., 2007) incorporated certain political factors, such as the tenure of the elective government and election variables. Admittedly, governments with stable political institutions elicit higher ratings. Empirical work on the determinants of sovereign credit ratings includes a dummy variable to reflect the default history of countries (Boumparis et al., 2015). Default history can be perceived as a willingness of a country to maintain a solid reputation and showcase credibility to investors. Countries that have defaulted on their obligations are more likely to default again; hence default history is also part of the rating methodology of *CRAs*. The narrative of the European Stability Mechanism was to provide financial assistance to countries facing fiscal imbalances with the ultimate goal of preventing the potential default of the member states of the Eurozone. Bearing this in mind, since default history consistently entered the equation without being statistically significant, I opted to exclude it as an explanatory variable.

Shifting our interest again to the debt-to-GDP ratio which constitutes a prominent macroeconomic factor that the rating agencies incorporate in their analysis when assessing a country's solvency. The relationship between economic growth and a country's indebtedness has been extensively researched (see (Chudik et al., 2018), (Pescatori et al., 2014), (Baum et al., 2013)), the latter investigated the differentiating effects of public debt by employing a Panel Threshold Fixed-Effects specification. While public debt at low levels is not detrimental to economic growth and can boost aggregate demand, at high levels can deteriorate the fiscal position of a country. Within a panel framework, previous work on literature included public debt among the explanatory variables when examining the determinants of sovereign credit ratings. To preserve future access to credit markets, countries should maintain a sound fiscal balance. Debt-to-GDP ratio is a critical variable that can be used as a proxy of public debt. Previous empirical work employed Fixed-Effects estimates to determine the impact of public debt on sovereign credit ratings, however their assumption was that the impact of public debt is linear. Researchers have been trying to identify this magic threshold beyond which public debt becomes unsustainable and has severe repercussions for economic growth. Higher public debt levels are associated with a higher probability of defaults since

they burden a country's efforts to repay its debt. While classical Fixed-Effects estimates incorporate the heterogeneity of intercepts, (Hansen, 1999) empirical work considers the heterogeneity of slopes. Thus for a given estimated threshold, the effect of public debt as interpreted by the reported coefficient is different. To the best of my knowledge, while non-linearity has been taken into account when researching the effect of public debt on sovereign credit ratings, no previous empirical work has employed a Panel Fixed-Effects Threshold methodology to assess the impact of debt-to-GDP ratio on sovereign credit ratings. This thesis contributes to the literature by allowing public debt, hereafter the threshold variable, to fall into different regimes depending on whether the threshold variable exceeds the estimated threshold. By treating the debt-to-GDP ratio as a threshold variable, I aim to quantify the severity of the increase in public debt and the response of sovereign credit rating when public debt falls into the 'low regime' or into the 'high regime'. Reasonably, the attributed sovereign credit rating will be acutely aggravated if the public debt exceeds a certain threshold; thus, we obtain different regression slopes reflected in the regime-dependent coefficients. Since the rating methodologies of the agencies differ, we expect not to find a common threshold. Empirical evidence overwhelmingly supports (Mencinger et al., 2015) the claims that higher indebtedness has a direct effect on economic growth. Since the economic prospects are inextricably associated with the attributed sovereign credit ratings, the expectation is that the public debt will have a negative sign.

3. Data and model specification

This thesis employs a balanced panel dataset with annual observations that span from 2002 to 2021 for the member states of the Eurozone of 19, $\{y_{i_t}, q_{i_t}\overline{X}_{i_t} : 1 \leq i \leq n, 1 \leq t \leq T\}$. The subscript *i* indexes the member states, and the subscript *t* indexes time. Table 1 reports the employed variables, a brief overview of them, and their source. Table 2 reports the descriptive statistics of the variables under consideration, including the within statistics. The dependent variable is the attributed sovereign credit rating on the 31st of December. Due to data limitations, this thesis only used the attributed sovereign credit ratings for Moody's and Fitch. The threshold variable, namely gross debt, is multifaceted, is perceived as a crucial indicator of a country's ability to repay its obligations, and has a special place in every rating agency's methodology.

Moreover, central government debt and debt-to-revenue provide invaluable insight into a country's debt burden. Figure 3 plots the Government gross debt of the 19 countries of the Eurozone, revealing that for Countries such as Greece, debt sustainability was an issue that government officials should deal with urgently. The dependent variable was transformed from an ordinal to a linear scale. The adopted model specification takes the form:

$$CRA_{it} = \delta + \theta_1 q_{it} I(q_{it} > \gamma_1) + \theta_2 q_{it} I(q_{it} \leq \gamma_2) + \phi \overline{X}_{it} + u_i + cD_{crisis}x_{it} + e_{it} \tag{1}$$

where CRA_{it} is the attributed sovereign credit rating on the 31st of December, δ and θ_j are parameters to be estimated, (j=1,2), q_m is the threshold parameter (m=1), q_{it} is the *gross debt* (threshold variable), $\overline{X}_{it}$ is a matrix of k exogenous variables (unemployment rate, the regulatory quality index and debt to revenue), ϕ is a vector of coefficients, u_i is the individual country effect and e_{it} is the disturbance term which is assumed to be independent and identically distributed with mean zero and finite variance σ^2. Finally, $D_{crisis}x_{it}$ refers to an interaction term which is the product of a dummy variable that takes the value 1 during 2009-2013 and the accumulated current account as a percent of GDP.To deal with potential endogeneity issues that may arise, gross debt enters the specification lagged one year. Another compact representation of (1) is to set:

$$CRA_{it}(\gamma) = \begin{pmatrix} I\overline{X}(q_{it} \leq \gamma_1) \\ I\overline{X}(q_{it} > \gamma_2) \end{pmatrix}$$

where $I(\bullet)$ is an indicator function which takes the value one if the threshold variable exceeds a certain threshold and zero otherwise.

As the literature indicates (see (Monfort and Mulder, 2000) (Cantor and Packer, 1996), (Afonso, 2003)), I employed a parsimonious set of variables that were derived after researching a theoretical framework, empirical studies, and the rating methodology of the underlying *CRAs*. In line with (Boumparis et al., 2017), a crisis dummy variable has been created, which takes the value 1 during the years of crisis

between 2009-2013 and zero otherwise. The year 2013 has not been chosen arbitrarily as the last year of crisis. On the contrary, it is the year when former Central Bank President Mario Draghi declared that he will do "whatever it takes" to preserve the Euro. Since then, sovereign bond yields have started to decline, reflecting a renewed appetite and trust for debt issued by Eurozone countries. The crisis dummy interacts with the accumulated current account, suggesting that the fiscal sector was of vital importance during the crisis and especially within a monetary union framework (Gros, 2011). Figure 4 illustrates the accumulated current account, suggesting that during the years of the crisis, the fiscal position of vulnerable countries was aggravated even more; vertical lines were drawn starting from 2009 when the crisis started to unfold until 2013 where the infamous "whatever it takes" signaled the beginning of the end of the Eurozone debt crisis. Remarkably, during the Subprime Crisis and the subsequent European Debt crisis, the two *CRAs* under consideration revised their assessments more often than not, ultimately leading the Greek bond in 2011 and 2012 one notch away from being qualified as "junk." Table 3 reports the number of downgrades and upgrades of each rating agency per year in an attempt to shed some light on the turbulent period of the European Debt Crisis. Notice also that the "Draghi effect" may be linked with a wave of upgrades after 2013. Available literature suggests that the determinants of sovereign ratings cannot be reduced to observed factors and macroeconomic indicators. However, all the explanatory variables were selected from a pool of 15 variables that were identified during the preliminary research of this thesis. To determine the variables that exert an impact in a statistically significant way, I followed a stepwise regression approach, during which variables that were consistently entering the specification without a statistically significant effect were eliminated. Hence, the reported regressors were all identified during the model selection process and were those whose effect was continuously statistically significant.

A major strand of literature, e.g., (Afonso, 2003), (Boumparis et al., 2015) (see also references therein), includes the debt-to-GDP as a regressor in the adopted model specification aspiring to detect a causal relationship between the debt burden of a country and its attributed sovereign credit rating. Bearing in mind that *CRAs* are constantly on the lookout for countries that do not have sound fiscal positions, this thesis considers debt-to-revenue as a potential macroeconomic indicator that can influence the decisions of the rating agencies. A country with limited sources of income will struggle to keep its public debt at moderate levels. In addition, a country's revenue also provides insight into how it ranks compared to other countries in terms of exports. It should also be taken into consideration that Moody's believes that high debt-to-revenue ratios should be addressed immediately. Arguably, higher debt-to-revenue ratios can adversely impact the attributed sovereign ratings; thus, we expect a negative sign.

4. Econometric methodology and threshold estimation

A threshold methodology captures the jumping character that stirs things up between the variables and suggests that observations can be divided into distinguished classes based on an observed variable. Similar to (Hansen et al., 1996) Threshold Autoregressive models, which are pretty popular in time series literature. Threshold models are widely employed primarily in macroeconomics since they are able to capture structural breaks of the response variable. Even though their intuitive appeal to researchers, their estimation is complex due to the existence of nuisance parameters. The modelling process requires many parameters that should be taken into account, but inferential decision and interest is only constrained to a reduced number of factors. A nuisance parameter is considered any parameter which is unspecified (Wackerly Dennis, 2014). However, it should be accounted for when we formulate and carry out hypothesis testing and derive an accurate confidence interval estimate of the regression slope.

To estimate the threshold parameter γ, one should search within a subset of the threshold variable q_{it}. Since it is undesirable for the threshold to be estimated by allocating too many observations in either regime, the search is restricted within quantiles of q_{it}. In order to determine the number of significant thresholds for our response variable, this thesis employs the sequential testing approach suggested by Hansen (1999) of zero and one threshold and calculates the F_j statistics *(j=1,2)*. First, I test the null hypothesis of no threshold effect in equation (1), which poses a linear constraint represented as $H_o : \beta_0 = \beta_1$. Under the H_0, the threshold parameter γ is not identified, and *F* follows a non-standard asymptotic distribution. (Hansen, 1999) proved that γ is unknown, and thus the model differs from the ordinary linear model. He argued that $\hat{\gamma}$ is a non-biased estimator for γ and the null hypothesis of $\gamma = \gamma_0$ could be tested by constructing confidence intervals using the method of "non-rejection region" with the use of a Likelihood-Ratio (LR) statistic.

Following (Hansen, 1999) approach, this thesis calculates the associated *p-values* based on a bootstrap framework with 1000 replications to assess the statistical significance of the threshold effect. Tables 1 and 2 report the estimated thresholds, the F_j statistics *(j=1,2)* along with the respective *p-values* at the conventional significance levels and the bootstrapped *p-values* for the two *CRAs* under investigation.

Notice that the estimated threshold differs across the *CRAs*, implying that while public debt is of significant importance, Fitch accords greater emphasis on the debt-to-GDP ratio than Moody's since the estimated threshold for the former is lower than the latter. The following chapter will discuss further the estimated results. Tables 1 and 2 suggest that the null hypothesis of linearity against the alternative of one threshold is rejected at all conventional significance levels *(p-values=0.000)* for Moody's, while for Fitch the null hypothesis can be rejected at $\alpha = 0.05$. Proceeding, the null hypothesis of one threshold against the alternative of two thresholds failed to be rejected for both Moody's and Fitch. Thus, evidence supports the presence of one threshold resulting in two regimes for each rating agency. Given the estimated threshold, the resulting regimes are the following $[0 - 120.0380)$ and $[120.0380 - 211)$ for Moody's, while

Table 1: Testing for threshold effects within a panel framework for Moody's

Threshold	Threshold estimate	F-stat	*p-value*	10% critical	5% critical	1% critical
Signle	120.0380^{***}	37.46	0.0000	21.0287	25.6743	128.2281
Double	97.414	13.57	0.34	19.5529	25.0014	41.9504

Notes: *** denotes the rejection of the null hypothesis over the alternative at the 0.01 significance level. All trimming values are set equal to 0.05. The reported critical values along with the respective p-values are derived by implementing the bootstrap method with 1,000 replications.

Table 2: Testing for threshold effects within a panel framework for Fitch

Threshold	Threshold estimate	F-stat	*p-value*	10% critical	5% critical	1% critical
Single	95.7820^{**}	33.87	0.03	24.3307	30.5154	38.0065
Double	114.961	11.12	0.58	21.7381	25.8693	28.3953

Notes: ** denotes the rejection of the null hypothesis over the alternative at the 0.05 significance level. All trimming values are set equal to 0.05. The reported critical values along with the respective p-values are derived by implementing the bootstrap method with 1,000 replications.

the estimated threshold for Fitch is lower and ranges from $[0-95.7820)$ to $[95.7820-211)$. The existence of a threshold effect confirms our work assumption that public debt has a non-linear effect on the attributed sovereign credit ratings.

5. Empirical results

We proceed by examining the empirical results based on (1). Given the estimated threshold for the two leading *CRAs*, it becomes clear that the effect of *gross debt* on sovereign credit ratings is not linear and exerts an even more substantial impact on the high regime. For the case of Fitch, it is remarkable that in the low regime, the reported coefficient is not statistically significant, while its effect becomes more remarkable and statistically significant in the 'high regime'. Consequently, we can assume that if gross debt does not exceed the estimating threshold has no explanatory value on the response variable. On the other hand, should the estimated threshold be exceeded, it exerts a negative and more severe effect on sovereign credit ratings. Since gross debt can also be associated with expansionary fiscal policies and can drive economic dynamics, it is entirely possible that countries may be accessing the capital markets to raise funds in order to pursue investments related to capital formation. Hence, if the public debt remains under control and without exceeding the estimated threshold it may not lead to the deterioration of a country's probability of default. Failing to do so, the prospects of economic growth are getting hammered. According to (Reinhart and Rogoff, 2010), countries facing a debt-to-GDP ratio greater than 90% have lower output growth potential in the long term. This finding is consistent with the views expressed on (Ghosh et al., 2013), which explain that if public debt arises beyond a threshold can compromise the solvency of nations resulting in a "fiscal fatigue" and an inability to continue to generate an increase on primary balances. Countries with irreparable public finances face a higher probability of defaults and are assigned lower credit ratings.

Moving on to the estimation of specification (1) for the two rating agencies under investigation, Tables 1 and 2 report the estimated coefficients and the threshold variable as determined in equation (1). To conduct any statistical inference for the adopted specification, a diagnostic testing should be executed to determine if the adopted specification does not suffer from problems such as heteroscedasticity, serial correlation, and cross-sectional dependence. Since endogeneity is a common characteristic of macroeconomic variables, I proceed by testing the threshold variable *gross debt* to determine whether it is strictly exogenous. Thus, the executed test proposed by (J.M., 2010) implies that the threshold variable is strictly exogenous *(p-value=0.132)* and *(p-value=0.376)* for Moody's and Fitch, respectively. While panel data appeal to researchers, they often violate all the assumptions of OLS and produce biased standard errors leading to inaccurate confidence intervals. To prevent such a case, the adopted specifications are first tested for the homoscedasticity of the error term. After the implementation of (Greene, 2003) test for groupwise homoscedasticity, the resulted *(p-value=0.000)* evidence suggests that the disturbance term is not homoscedastic. In a panel data framework, one of the possible variations of the error term is variance specific to the cross-section dimension. Especially for panel data, the assumption of a homoscedastic error term is even more stringent since we assume that the error variances do not differ across units as well as within units.

Moreover, following again (Greene, 2003), I execute the test proposed by Breusch-Pagan, which assumes cross-sectional independence of the error term. Resulted evidence suggests that the adopted specification suffers from cross-sectional correlation. A likely deviation of the independent error term in a panel data framework is contemporaneous correlation across countries. One of the assumptions in a panel data framework is that the disturbances are independent across cross-sections. Cross-sectional dependence refers to the fact that the cross-sectional units are not randomly sampled. Therefore, I implement the parametric testing procedure proposed by (Pesaran, 2004) to test the null hypothesis of cross-sectional independence, which fails to be rejected at all conventional levels. Previous empirical work (Boumparis et al., 2015) followed the common correlated effects approach proposed by (Pesaran, 2006) that includes the cross-section averages as additional explanatory variables in the adopted model. In case cross-sectional dependence is present in our sample, also referred to as the unobservable common factor (Eberhardt, 2012), this would point towards the existence of potential spill-over effects within the Eurozone. Overall, the estimated specification (1) suffers from panel heteroscedasticity, spatial and temporal dependence for both rating agencies.

As the executed diagnostic testing result in a non-spherical error term, the estimated coefficients will have biased standard errors resulting in inaccurate confidence intervals. In such a case, the confidence intervals are misleading and may induce incremental underestimates of the true sample variability. To conduct proper statistical inference, the adopted model should not suffer from the misspecification problems mentioned earlier. To do so, I follow the (Dergiades et al., 2022) approach, which considers alternative estimators rather than relying wholly on traditional OLS estimates. The regimes formed after the identification of the estimated threshold depend on the threshold parameter γ through the indicator function $I(q_{it}) \leq \gamma$. Having identified the threshold for each rating agency, we proceed by constructing the underlying regime-dependent coefficients. The 'low regime' can be constructed by assigning it the value of the threshold variable if the estimated threshold is not surpassed and zero otherwise. The exact process applies to the 'high regime', which gets assigned the value of the threshold variable if the estimated threshold is exceeded. Since the adopted model specification for the two agencies under consideration suffers from all those misspecification problems, this thesis considers alternative estimates.

Contrary to the conventional variance estimator, I employ robust standard errors to tackle the misspecification problems of heteroscedasticity and serial correlation. Afterward, cross-sectional dependence is a common problematic aspect of panel data, especially in the field of macroeconomics, since the cross-sectional units are likely to be spatially correlated (Driscoll and Kraay, 1998), leading to inconsistent and biased standard errors. Consequently, since the formed regimes have already been identified, I consider the (Driscoll and Kraay, 1998) standard errors to yield robust estimates to heteroscedasticity, serial correlation, and cross-sectional dependence. However, the corrections for cross-sectional dependence can only be valid if the sample size has a large T dimension independently of the value of N dimension. A third approach considers the (Parks, 1967) application of Feasible Generalized Least Squares (FGLS) method, which is employed to remedy temporally and spatially correlated standard errors. The approach of Feasible Generalized Least squares assumes that the disturbance structure is known; however, "feasible" refers to *estimated* and not *known*, which is practically never the case. This is a dangerous assumption when dealing with panel data sets involving more parameters that are required to be estimated (Beck and Katz, 1995). In addition, (Beck and Katz, 1995) empirical research states that the Park approach results in an overconfidence of the true sample variability yielding inaccurate standard errors. Hence, this

underestimation leads to confidence intervals that are falsely augmented. To deal with the drawbacks of the Parks estimator, I consider the approach of (Beck and Katz, 1995), which generates standard errors that are accurate and remain robust to panel heteroscedasticity and contemporaneous correlation even in the case of complicated disturbances in a panel dataset. Corrections for cross-sectional correlations are much more perplexing due to the unobservable common factors that dominate the relationship between countries. The estimate variance covariance matrix based on the Beck's approach is consistent even in the case of spatially dependent data.

Consequently, the inference is conducted using Ordinary Least Square Estimates but with Panel Corrected Standard Errors (column PCSE) to tackle the misspecification issues of panel heteroscedasticity and contemporaneous correlation. Tables 1 and 2 report the coefficients along with their respective standard errors in brackets and the two regimes based on all the estimates mentioned above. Furthermore, it contains the diagnostic testing carried out for column 1 (Robust).

When Moody's concerned, all the explanatory variables, including the threshold variable, are statistically significant at all conventional levels apart from the interaction term, which is statistically significant at a 5% significant level. The PCSE estimates on which inference is based report the coefficients that severely impact the sovereign credit rating. Notice that both the bootstrap and the robust approach lead to akin standard errors. The 'low regime' estimated coefficient implies that an annual increase in the debt-to-GDP ratio by 38% percentage points $(\approx 38 * 0.0262)$ will instigate a downgrade of one notch. However, beyond the tipping point of the estimated threshold, debt-to-GDP has a more deleterious impact on the attributed sovereign credit rating. More specifically, the 'high-regime' coefficient suggests that an increase of 24% percentage points $(\approx 24 * 0.0415)$ will bring about one notch downgrade. Additionally, the regime dependant coefficient with the associated 95% confidence intervals are the following; -0.0234 [-0.04256, -0.00424] and 0.04006 [-0.06017,-0.01995] for the 'low' and 'high' regime, respectively.

Remarkably, Fitch accords greater significance in public debt since the estimated threshold is lower than Moody's (see Table **??**). However, based on the empirical results, the 'low regime' coefficient is not statistically significant, which signifies the tolerance in the lower debt levels of the underlying rating agency. Contrary to Moody's, based on the estimated coefficients, Fitch believes that the debt drag does not acutely impact the attributed sovereign credit rating. The 'high regime' coefficient admittedly exerts a less significant effect on credit rating. An increase of 40% $(\approx 40 * 0.0249)$ will prompt a downgrade of one notch. Furthermore, since the estimated specification for Fitch suggests that there is a threshold effect, but only the coefficient for the 'high' regime is statistically significant, I report the underlying regime-dependant coefficient and its associated confidence interval as follows: -0.02343[-.045318, -0.001558].

Numerous empirical studies have explored the debt-growth relationship since the seminal paper of (Reinhart and Rogoff, 2010). The debate between public debt and economic growth gave rise to those voices that opposed the austerity measures implemented in the debt-burdened economies following the Global Financial Crisis. Arguably, when there is a sharply rising public debt, economic growth prospects are diminished. While researchers tend to agree that the relationship between public debt and economic growth is not linear, plentiful research has revealed different thresholds. Broadening the spectrum, this thesis contributes to the literature by extending the scope of debt hang and economic growth to the attributed sovereign credit ratings. It advocates that the estimated thresholds exceed the threshold agreed upon in the Maastricht treaty and reveals the rating agencies' emphasis on public debt. The majority of empirical studies identify a threshold between 75% and 90% of GDP. My findings claim that public debt

Table 1: Panel Threshold Fixed-Effect estimation results for Moody's

Variable	Robust	Bootstrap	Driscoll-Kraay	FGLS	PCSE
Constant	19.8161^{***}	19.8161^{***}	19.8161^{***}	24.1360^{***}	24.1360^{***}
	(0.7758)	(1.1304)	(0.9098)	(1.0241)	(0.9289)
Unemployment	-0.1939^{***}	-0.1939^{***}	-0.1939^{***}	-0.1731^{***}	-0.1731^{***}
	(0.0530)	(0.0540)	(0.0365)	(0.0291)	(0.0351)
Regulatory Quality	3.3779^{***}	3.3770^{***}	3.3770^{***}	1.9458^{***}	1.9458^{***}
	(0.611)	(0.6517)	(0.8142)	(0.4722)	(0.5160)
Debt to revenue	-0.0224^{***}	-0.0224^{***}	-0.0224^{***}	-0.0226^{***}	-0.0226^{***}
	(0.0043)	(0.0049)	(0.0040)	(0.0025)	(0.0036)
Interaction term	0.0076^{*}	0.0076^{***}	0.0076^{**}	0.0066^{**}	0.0066^{**}
	(0.0038)	(0.0037)	(0.0029)	(0.0028)	(0.0033)
Regime slopes					
$GrossDebt_{R_1}$	-0.0234^{***}	-0.0234^{***}	-0.0234^{**}	-0.0262^{***}	-0.0262^{***}
	(0.0091)	(0.0090)	(0.0109)	(0.0066)	(0.0090)
$GrossDebt_{R_2}$	-0.0400^{***}	-0.0400^{***}	-0.0400^{***}	-0.0415^{***}	-0.0415^{***}
	(0.0095)	(0.0094)	(0.0117)	(0.0060)	(0.0085)
Summary statistics					
n	361	361	361	361	361
$R^2within$	0.809	0.809	0.809	-	-
F/Wald χ^2	0.000	0.000	0.000	0.000	0.000
Diagnostic testing for Robust specification					
Strict exogeneity test (p-value)	0.132		*Serial Correlation test (p-value)*	0.000	
Homoscedasticity test (p-value)	0.000		*CSD test (p-value)*	0.000	

Notes ***, ** and * denote statistical significance at the 0.01, 0.05 and 0.1 significance level, respectively. The reported values within the (.) are standard errors. The subscripts R1 and R2 are linked with Gross Debt lagged one year signify the two regimes formed after the identification of the significant threshold, (see Table 1). Columns 1 to 5 refer to panel threshold effect estimates.The columns titled as Robust, Bootstrapped, Driscoll-Kraay, FGLS and PCSE refer to the threshold panel fixed-effects estimates (i) with robust standard errors, (ii) with bootstrapped standard errors, (iii) with the (Driscoll and Kraay, 1998) corrected standard errors (robust to heteroskedastic error as well as to general forms of cross-sectional and temporal dependence), (iv) with the use of the of (Parks, 1967) Feasible Generalized Least Squares approach (allowing robust estimation while in presence of serial correlation, heteroskedasticity and cross-sectional dependence) and (v) with the Panel Corrected Standard Errors estimation approach (correcting for serial correlation, heteroskedasticity and cross-sectional dependence, respectively).

Table 2: Panel Threshold Fixed-Effect estimation results for Fitch

Variable	Robust	Bootstrap	Driscoll-Kraay	FGLS	PCSE
Constant	18.4471^{***}	18.4471^{***}	18.3958^{***}	21.6589^{***}	21.6589^{***}
	(1.2575)	(1.2575)	(0.6714)	(0.9586)	(0.9799)
Unemployment	-0.2374^{***}	-0.2374^{***}	-0.2416^{***}	-0.2228^{***}	-0.2228^{***}
	(0.0447)	(0.0466)	(0.0350)	(0.0265)	(0.0478)
Regulatory Quality	3.4187^{***}	3.4187^{***}	3.4586^{***}	2.3293^{***}	2.3293^{***}
	(0.6263)	(0.6802)	(0.4329)	(0.4288)	(0.5144)
Debt to revenue	-0.0139^{***}	-0.0139^{**}	-0.0141^{***}	-0.0141^{***}	-0.0141^{***}
	(0.0048)	(0.0035)	(0.0035)	(0.0025)	(0.0042)
Interaction term	0.0040	0.0040	0.0037	0.0017	0.0017
	(0.0044)	(0.0044)	(0.0028)	(0.0025)	(0.0039)
			Regime slopes		
$GrossDebt_{R_1}$	-0.0108	-0.0108	-0.0096	-0.0147^{**}	-0.0147
	(0.0141)	(0.0101)	(0.0101)	(0.0069)	(0.0111)
$GrossDebt_{R_2}$	-0.0264^{**}	-0.0264^{**}	-0.0256^{**}	-0.0249^{***}	-0.0249^{**}
	(0.0122)	(0.0133)	(0.0106)	(0.0057)	(0.0104)
			Summary statistics		
n	361	361	361	361	361
$R^2within$	0.772	0.7706	0.774	-	-
F/Wald χ^2	0.000	0.000	0.000	0.000	0.000
			Diagnostic testing for Robust specification		
Strict exogeneity test (p-value)		0.376	*Serial Correlation test (p-value)*		0.000
Homoscedasticity test (p-value)		0.000	*CSD test (p-value)*		0.000

Notes ***, ** and * denote statistical significance at the 0.01, 0.05 and 0.1 significance level, respectively. The reported values within the (.) are standard errors. The subscripts R1 and R2 are linked with Gross Debt lagged one year signify the two regimes formed after the identification of the significant threshold, (see Table 2). Columns 1 to 5 refer to panel threshold effect estimates.The columns titled as Robust, Bootstrapped, Driscoll-Kraay, FGLS and PCSE refer to the threshold panel fixed-effects estimates (i) with robust standard errors, (ii) with bootstrapped standard errors, (iii) with the (Driscoll and Kraay, 1998) corrected standard errors (robust to heteroskedastic error as well as to general forms of cross-sectional and temporal dependence), (iv) with the use of the of (Parks, 1967) Feasible Generalized Least Squares approach (allowing robust estimation while in presence of serial correlation, heteroskedasticity and cross-sectional dependence) and (v) with the Panel Corrected Standard Errors estimation approach (correcting for serial correlation, heteroskedasticity and cross-sectional dependence, respectively).

on those levels is still sustainable, and it only commences to pose a threat to a country's solvency when it exceeds 95% percent. Previous empirical evidence (see (Boumparis et al., 2015)) attempted to back (Reinhart and Rogoff, 2010) claims by capturing this non-linear threshold by employing a dummy variable that was allowed to take the value 1 if the 90% was exceeded. This endeavor failed to provide any relevant statistical proof that *CRAs* might change their behavior and downgrade more aggressively. Finally, my findings suggest that the rating methodology of the *CRAs* is not identical and consider different debt levels when it comes to debt sustainability. Notice also that the estimated coefficients remained statistically significant for all estimates, especially for Moody's.

Moreover, based on the PCSE estimates, all the explanatory variables have the expected signs. Remarkably, an improvement in the regulatory index by 1 point entails an upgrade by almost two notches for Moody's, signifying the importance for countries to have strong institutions that can promote the advancement of the private sector. For Fitch, the estimated coefficient is slightly more significant, implying that Fitch might put more emphasis on the quality of governance. Unemployment is perceived as an indicator of the under-utilization of resources, and the initial expectation is to enter the model specification with a negative sign. Based on the empirical results, an increase in the unemployment rate would entail a downgrade of the attributed sovereign credit rating. Notice also that the interaction term is statistically significant when it enters the modeling framework; based on this finding, we can support (Gros, 2011) claim that the accumulated current account is of the essence for a monetary union and especially during the years of crisis. In fact, according to (Baghai et al., 2014), the rating agencies became more conservative during the Global Financial Crisis and were reluctant to assign higher credit scores. However, the interaction term is not statistically significant for Fitch implying that during the years crisis, Fitch did not change its perceptions on the importance of the fiscal sector.The underlying coefficient remained statistically insignificant when estimating equation (1) with all the estimates under consideration. Decisively, the reported coefficient for the rating agencies under consideration are of similar magnitude. While their rating methodology is not identical, it is not far apart. Figures **??** and **??** plot the fitted values based on the PCSE estimation along with 95% and 90% confidence intervals.

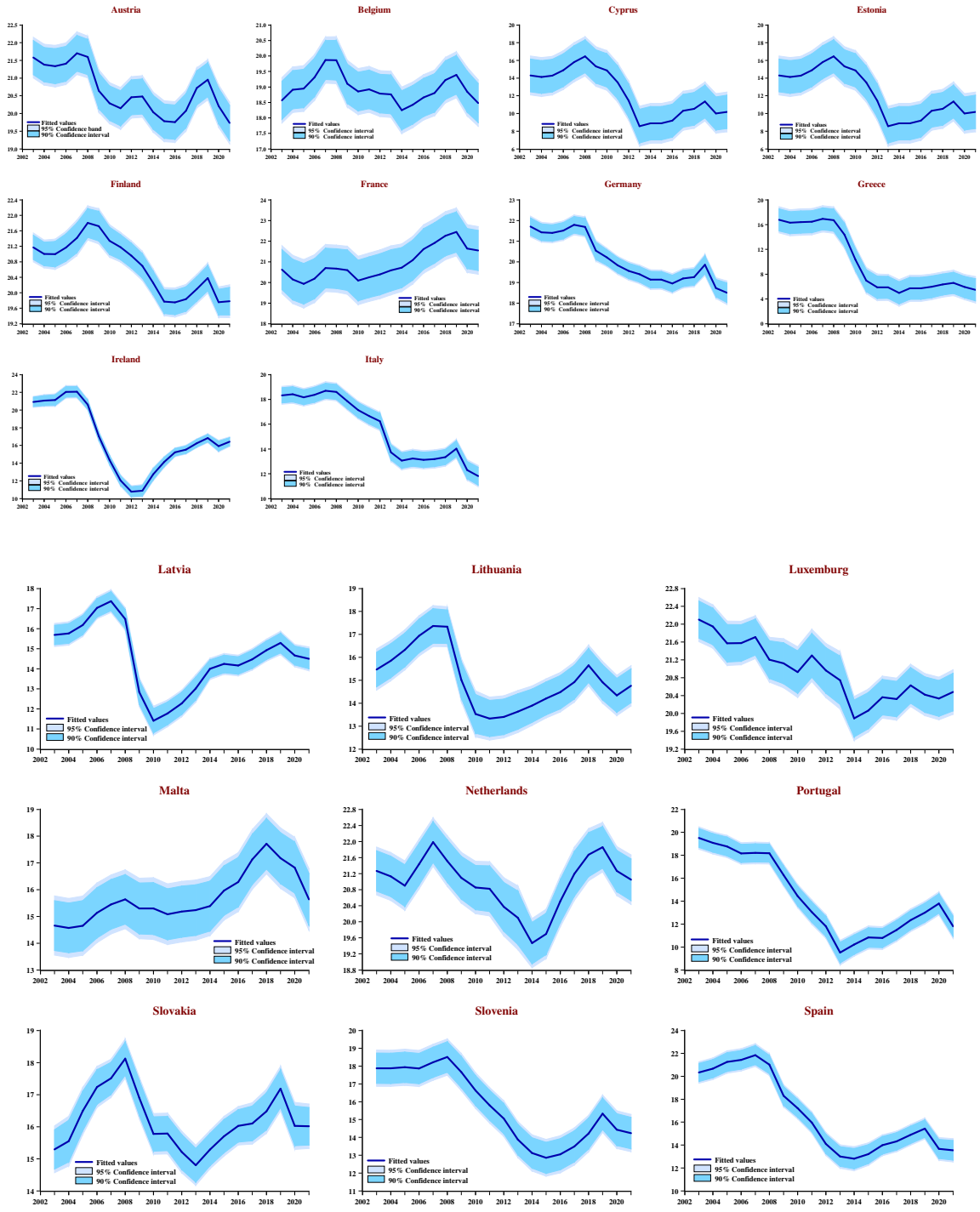


Figure 1: Moody's Sovereign Credit Rating per Member State: fitted values along with 95% confidence interval

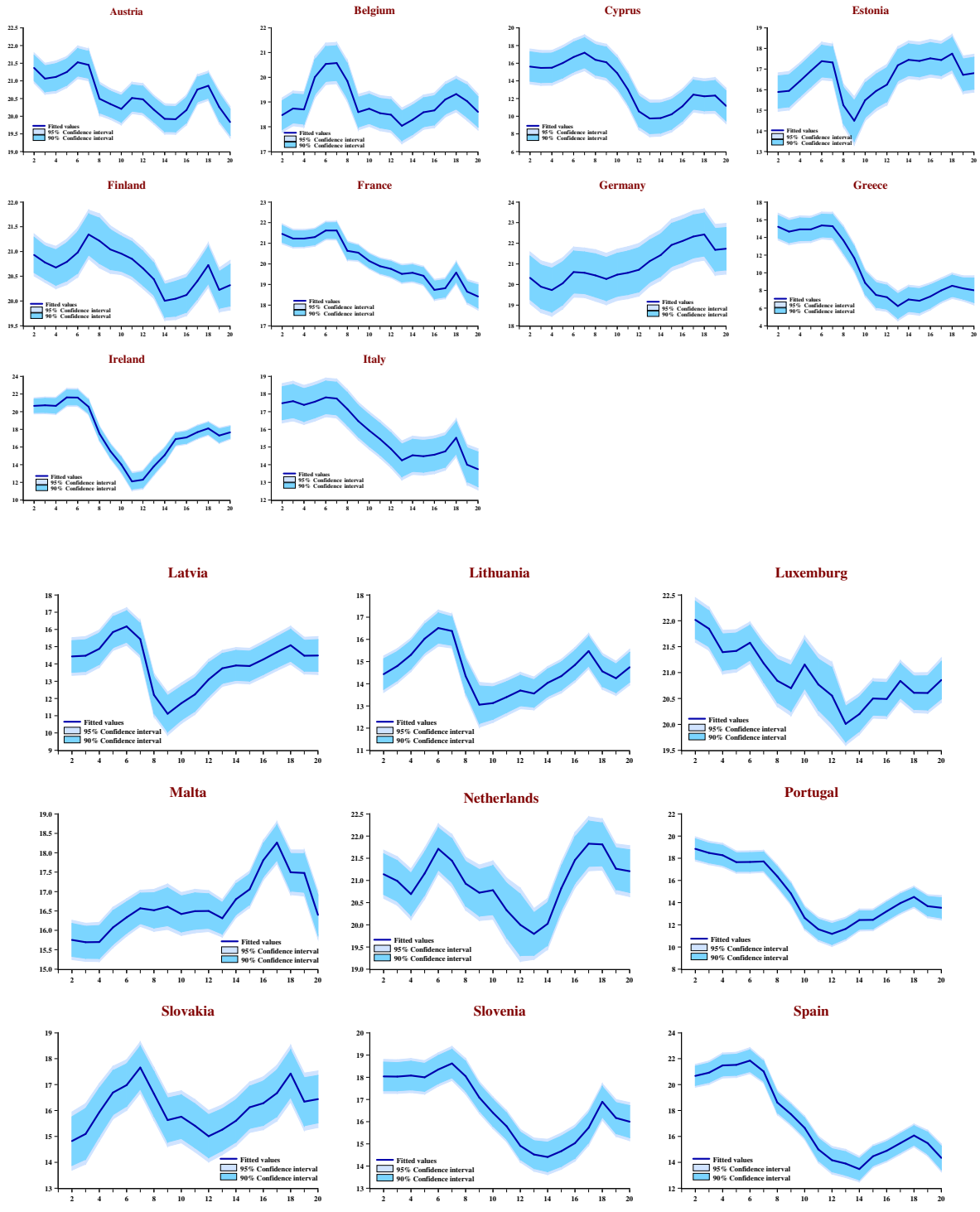


Figure 2: Fitch Sovereign Credit Rating per Member State: fitted values along with 95% confidence interval

6. Conclusions

We examine, for the Eurozone of 19, the nonlinear relationship between the debt-to-GDP ratio and the attributed sovereign credit rating for two of the 3 leading rating agencies, namely Moody's and Fitch over the period 2002-2021 in a panel data framework. Since the attributed sovereign credit ratings are in an ordinal scale we consider transforming them into a quantitative variable. In line with a major strand of literature, we adopt a linear transformation for the rating scale, ranging from 1-21. By employing a Panel Fixed Effects Threshold methodology we consider the varying magnitude of debt-to-GDP ratio on the attributed sovereign credit rating. Our results suggest that the rating agencies under investigation have different levels of debt tolerance since a common threshold has not been identified. The estimated threshold for Moody's is greater than Fitch and it results to two regime dependent coefficients, while the adopted specification implies for Fitch, the public debt has a deleterious impact on sovereign credit rating once the estimated threshold is surpassed. Moreover, since our model suffers from misspecification problems, this thesis considers different variance covariance estimates to tackle panel heteroscedasticity, serial correlation and cross-sectional dependence. To deal with potential endogeneity, the threshold variable enters the model specification lagged one year. The adopted model specification considers a set of regime independent variables that were consistently entering the modelling framework in the researched literature.The model specification was enhanced with an interaction term that assesses the importance of the accumulated current account during the European Debt Crisis. Finally, we consider the ratio of debt-to-revenue as an additional regressor since it conveys information for a sovereign's ability to generate sufficient revenue to service debt outstanding as well as an indicator of risk of default.

Based on our findings, we can argue that public debt increases the probability of default of a sovereign in a nonlinear manner. While on low levels it might not affect at all the ability of a country to remain solvent and it might be even tempting to suggest that it may also boost aggregate demand, on high levels it can become unsustainable. While a tipping point has yet to be agreed in the academia, this thesis contributes to the existing literature by providing an alternative approach of measuring the effect of public debt to sovereign credit ratings. Debt sustainability will always be at the forefront of developments for exceedingly indebted countries especially for the member states of Eurozone that have already experience a disastrous debt crisis that give birth to the ESM. The risk of default while less severe for sovereigns than companies still remains and is reflected through the attributed credit ratings, public debt is a foreseeable fiscal challenge for all member states as well as for the monetary union as a whole. Thus, it remains to be seen whether the debt tolerance of the rating agencies will remain at the same levels or will they be less conducive against nations with higher debt burden. Arguably, our empirical findings shed some light on the rating behaviour of the *CRAs*.

7. Appendix A

Table 1: Data Definition

Variable	Description	Source
Moody's Rating	Sovereign rating attributed at 31st December of each year	Moody's
Fitch Rating	Sovereign rating attributed at 31st December of each year	Fitch
Unemployment rate	Unemployment rate as a percentage of labor force	IMF WEO
Regulatory quality	Reflects governance quality on private sector development	World Bank
Gross debt	General government gross debt as a percentage of GDP	IMF WEO
Debt to revenue	Gross debt as a percentage of revenue	IMF WEO
Accumulated current account	Sum of current account as a percentage of GDP	WEO

Table 2: Descriptive Statistics

Variable		Mean	Standard Deviation	Min	Max
Unemployment	Overall	8.912	4.418	2.5	27.47
	Between		3.159	5.222	13.2
	Within		3.168	0.543	20.268
Regulatory Quality	Overall	1.258	0.374	0.148	2.05
	Between		0.357	0.632	1.802
	Within		0.137	0.774	10646
Debt to Revenue	Overall	157.9	86.781	10.329	433.044
	Between		78.108	21.571	338.171
	Within		41.666	13.574	300.27
Gross Debt	Overall	67.33	39.595	3.765	211.897
	Between		59.988	8.388	152.551
	Within		18.372	17.089	126.667

Notes: Employed dataset contains 360 observations, where $n=19$ and $t=20$

Table 3: Number of upgrades and downgrades per year

Year	Moodys		Fitch	
	Downgrades	Upgrades	Downgrades	Upgrades
2003	0	1	0	5
2004	0	0	1	5
2005	0	1	0	1
2006	0	3	1	3
2007	0	1	1	2
2008	1	2	3	1
2009	**4**	0	**5**	0
2010	**4**	0	**4**	1
2011	**9**	0	**6**	2
2012	**8**	0	**5**	1
2013	**2**	2	**5**	3
2014	0	6	1	5
2015	2	4	2	1
2016	2	1	2	3
2017	0	4	1	5
2018	0	4	0	4
2019	0	2	0	1
2020	1	2	2	2
2021	0	3	0	1

Notes: An important notice that should be taken into account is the fact that the attributed sovereign credit rating are on a yearly basis and thus it does not account for more than one downgrade during a year. However, there are countries such as Greece and Cyprus that experienced downgrades even more than two times during the same year.

8. Appendix B

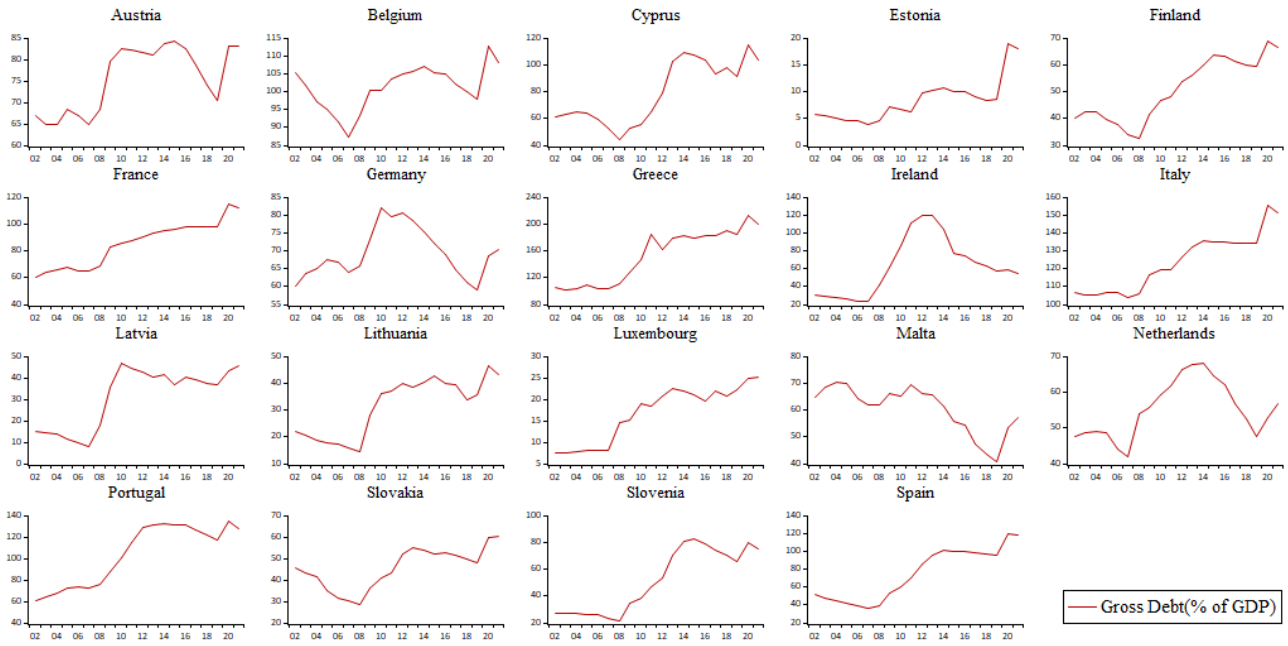


Figure 3: Gross Debt

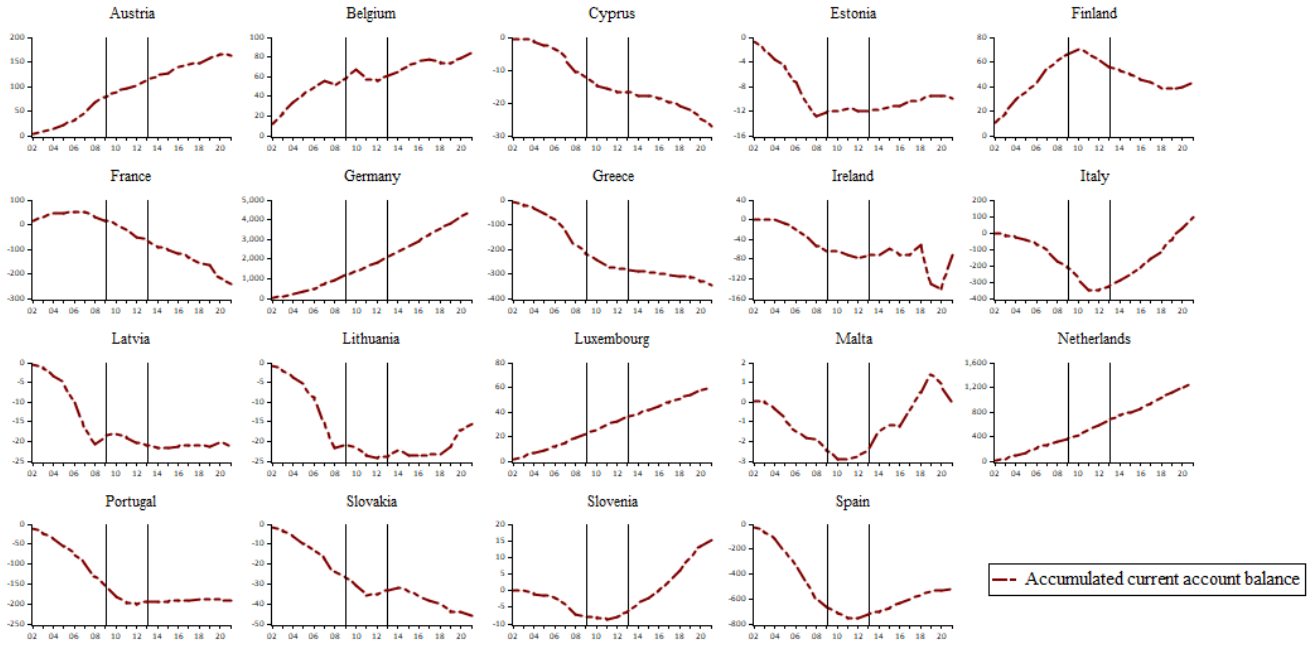
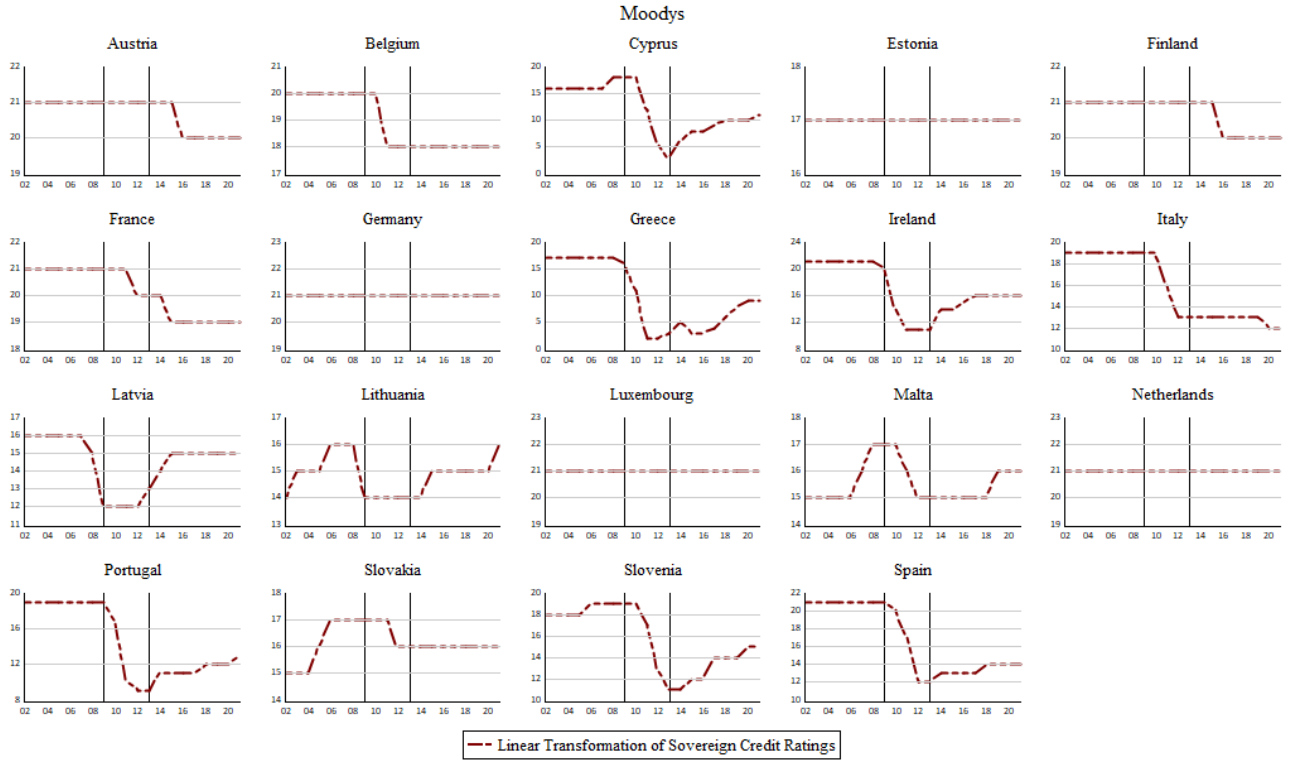
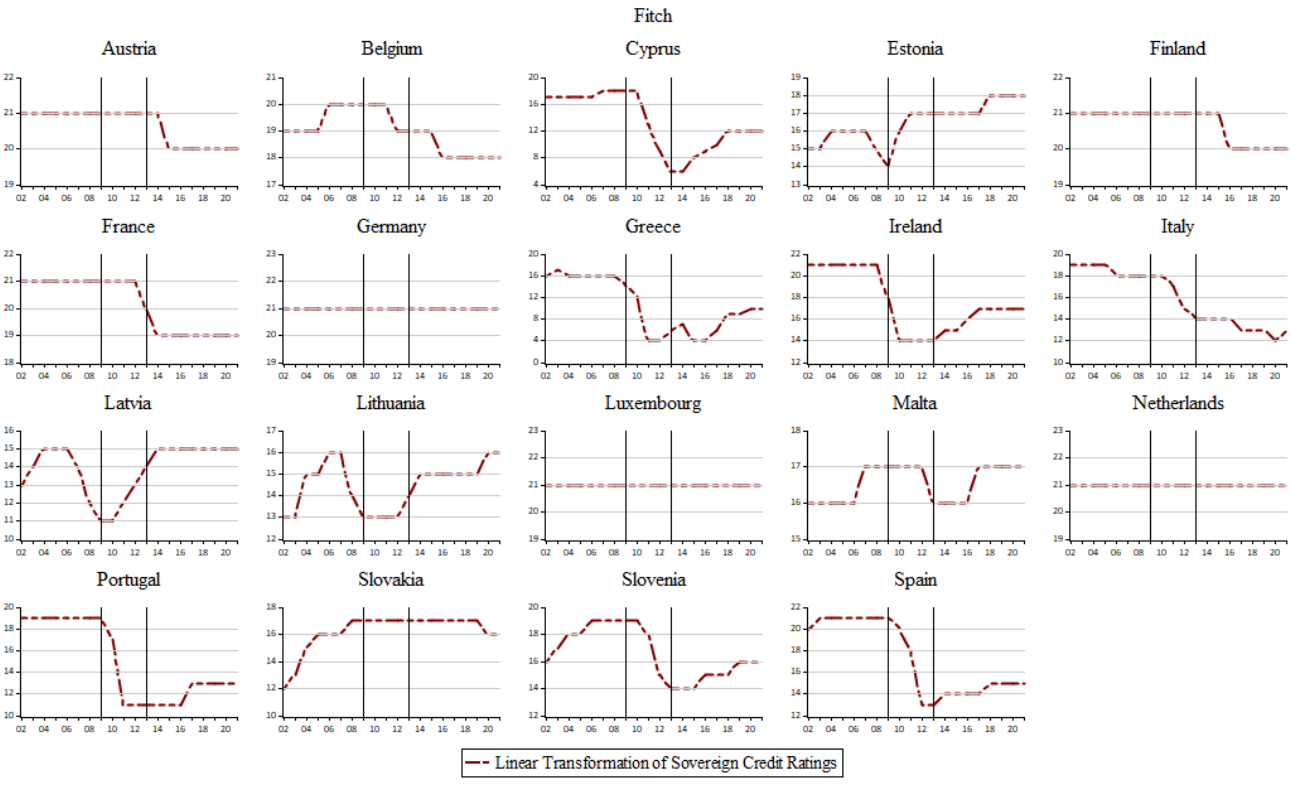


Figure 4: Accumulated current account



(a) Moody's



(b) Fitch

Figure 5: Comparing the Sovereign Credit Ratings between the two agencies

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