TALLINN UNIVERSITY OF TECHNOLOGY
School of Business and Governance

Elerin Varek

PUBLIC DEBT SUSTAINABILITY AND FISCAL SPACE IN EUROPEAN UNION COUNTRIES

Master's thesis

Programme TAAM

Supervisor: Karsten Staehr, PhD

Tallinn 2026

I hereby declare that I have compiled the thesis independently
and all works, important standpoints and data by other authors
have been properly referenced and the same paper
has not been previously presented for grading.

The document length is 16484 words from the introduction to the end of the conclusion.

Elerin Varek 11.05.2026

TABLE OF CONTENTS

ABSTRACT

The thesis estimates country-specific debt limits and fiscal space for European Union member states. The empirical analysis draws on a unbalanced panel of 24 EU member states covering annual data from 1996 to 2024, with three country groupings: all countries, high-debt countries, and low-to-mid debt countries. The assumption of homogeneous fiscal behaviour across countries at any given debt level and the linear treatment of the interest payment schedule are the main limitations of the analysis. A cubic polynomial fiscal reaction function with country fixed effects and an AR(1) error structure is estimated to find fiscal fatigue thresholds. Then country-specific debt limits and fiscal space are derived under three interest rate-growth rate differential scenarios: historical, medium-term, and long-term projections. Fiscal fatigue is confirmed in the extended all-countries specification and in the high-debt subsample, where marginal fiscal response starts to weaken at debt level of 28 and 83 percent of GDP. The estimated average debt limit declines from 252 percent of GDP under historical differentials to 205 percent under long-term projections, with Italy retaining no finite debt limit under any scenario. Average fiscal space falls from 190 to 146 percentage points of GDP across the three scenarios. Denmark, Sweden and the Baltic states are consistently showing the largest buffers.

Keywords: debt sustainability, fiscal fatigue, fiscal space, debt limits, fiscal reaction function

INTRODUCTION

Public debt levels in European Union (EU) countries have increased significantly over the last decades with especially sharp increases following the global financial crisis and the COVID-19 pandemic. Many EU countries current debt levels are considerably above the levels at which questions of fiscal sustainability usually arise (Kose *et al.*, 2021) and further increases are projected in several countries (European Commission, 2026). These elevated debt levels have raised concerns whether governments can retain sufficient capacity to service their obligations and how much room is left before that capacity narrows out.

Governments may start experiencing fiscal fatigue as debt rises, meaning that responsiveness of primary balances to rising debt weakens or even turns to negative. If the debt levels continue to rise, fiscal space will be used up, and the finite debt limit is reached. This is the point beyond which the primary surplus a government can reasonably generate is no longer sufficient to stabilise the debt ratio and debt grows without bound. Fiscal space, defined as the difference between current debt and this limit, determines how much room governments have for fiscal manoeuvre before solvency is at risk. (Ghosh *et al.* 2013) Some countries may appear solvent for long periods, only to face rising borrowing costs or a sudden loss of market access once debt approaches this limit.

One empirical approach used to investigate the risk of fiscal fatigue and its implications for debt limits is the framework developed by Ghosh *et al.* (2013). They estimate a non-linear fiscal reaction function for 23 advanced economies using data from 1970 to 2007 and finds country-specific debt limits and fiscal space estimates. Their framework is unique because of the polynomial shape of the fiscal reaction function. However, the timeframe does not include both the European sovereign debt crisis and the COVID-19 pandemic. Additionally, the sample does not cover EU countries specifically. The EU represents a suitable group for such analysis given the shared fiscal governance framework and somewhat comparable macroeconomic conditions across member states.

The interest rate and growth rate conditions under which EU governments currently operate also differ considerably from those present in the Ghosh *et al.* (2013) sample. While that study covers a period during which interest rates were mostly higher than growth rates, EU countries have experienced highly favourable negative differentials in recent years, which means economic growth has exceeded the cost of borrowing and this has improved debt dynamics. However, projections of the differentials are less favourable and turn positive for several countries, which increases the burden of debt in the future. This provides a strong justification for reassessing the framework of Ghosh *et al.* (2013) with updated data and different samples of EU countries, providing an opportunity to evaluate whether the estimated non-linear fiscal response and implied debt limits remain relevant under current conditions.

The aim of the thesis is to estimate country specific debt limits and fiscal space for European Union countries by revisiting the debt sustainability framework of Ghosh *et al.* (2013). The following research questions are covered in this thesis:

1. Does the fiscal reaction function estimated for European Union countries present non-linear behaviour consistent with fiscal fatigue, and at what debt level does the primary balance response begin to weaken?
2. Which debt limits does the framework imply for EU countries under different interest rate-growth rate differentials, and how do these vary across countries?
3. How much fiscal space do the individual European Union countries retain, and which countries face the most constrained debt sustainability positions?

To answer these questions, a cubic polynomial fiscal reaction function is estimated on a panel of 24 EU member states using annual data from 1996 to 2024. The model includes country fixed effects and an AR(1) error structure. The marginal fiscal response derived from the estimated coefficients is used to identify presence and thresholds of fiscal fatigue. Country-specific debt limits are then calculated under three interest rate-growth rate differential scenarios: historical, medium-term and long-term projections. The fiscal space is measured as the difference between the estimated debt limit and each country's 2025 debt level.

The master's thesis is structured as follows. First chaptrer presents the theoretical and empirical background on debt sustainability, fiscal reaction function and fiscal fatigue, and then the debt limit and fiscal space. Second chapter describes the methodology and data in the analyses. Third chapter presents the empirical results with discussion and robustness checks. Final chapter concludes the paper.

1. THEORETICAL AND EMPIRICAL BACKGROUND

This chapter gives overview of the theoretical and empirical background of debt sustainability. First section defines what debt sustainability means and why it matters, which is followed by introduction of intertemporal budget constraint and debt dynamics. Second section explains the fiscal reaction function and how it is connected to fiscal fatigue. Third section introduces the ideas of debt limits and fiscal space.

1.1. Concept of public debt sustainability

1.1.1. Public debt sustainability

Public debt sustainability refers to the capacity of a government to meet its current and future financial obligations without needing to do significant policy adjustments, increasing debt levels significantly, or defaulting on its commitments. A future debt trajectory is considered sustainable when the government can service its obligations indefinitely while maintaining reasonable fiscal policies. (Bohn, 1998; Ghosh *et al.*, 2013) Beqiraj *et al.* (2018) states that fiscal sustainability requires that the government can repay its debt at some point in the future, making the primary budget balance an important factor in government debt dynamics.

The concept of debt sustainability has substantial economic and policy significance. When public debt approaches problematic levels, several consequences can arise. First, elevated debt constrains fiscal flexibility. This reduces governments capacity to respond to changes in economic situation through countercyclical policy or to finance necessary public investments (Kose *et al.*, 2022). Second, as debt rises, creditors may demand higher risk premia (Bi, 2012). This increases borrowing costs and potentially triggers a loop of rising interest payments and a degrading fiscal position. Salamaliki and Venetis (2023) highlight that although interest rates can remain low for extended periods even as debt rises, there exists a debt threshold beyond which sovereign default becomes possible and risk premia begins to rise rapidly, even in a previously low interest environment.

Checherita-Westphal and Rother (2012) provide empirical evidence of a non-linear relationship between debt and economic growth in euro area countries. Debt has negative effects on country's long-term growth when it goes above 90 percent of GDP, when confidence intervals suggest that negative growth effects may begin at debt levels as low as 70 percent of GDP. The channels through which high debt affects growth include private saving, public investment, and total factor productivity. (Checherita-Westphal and Rother, 2012) This ties with Reinhart and Rogoff (2010) earlier work, who associated debt levels above 90 percent of GDP with lower growth outcomes.

Additionally, market perceptions of sustainability can change in time. From 2008 to 2009 public debt ratios rose in multiple European countries by an average of 14 percentage points of GDP while bond yields increased by only two basis points. However, debt ratios rose by a further 13 percentage points from 2009 to 2010. At the same time, yields increased by almost 300 basis points. (Ghosh *et al.*, 2013) This shows that previously sustainable debt ratios can suddenly appear unsustainable, even though the change in debt levels was not something out of ordinary. As a result, costs of debt changed from close to risk-free rates to rather costly interest rates. Debt sustainability is affected by matter of confidence. As long as markets believe a government will repay, interest rates stay low. When that belief weakens, financing costs can change without a change in fundamentals.

Furthermore, the way debt builds up affects its economic impact and the prospects of stabilising or eliminating the debt. Peacetime debt accumulations may be more problematic for future growth than sudden debt explosions, as they tend to persist for longer periods (Reinhart and Rogoff, 2011). Additionally, banking crises, recessions and large negative shocks lead to persistent debt accumulation, rather than short term fluctuations in debt levels and these increases are rarely fully reversed (Kose *et al.*, 2022). Debt tends to continue rising for years after such episodes and that increase is regularly under-predicted (Kose *et al.*, 2021). This highlights that debt sustainability assessments must consider not only the level of debt but also the trajectory and composition of public debt.

1.1.2. The intertemporal budget constraint

The theoretical foundation for debt sustainability analysis is based on the governments intertemporal budget constraint. This constraint requires that the present discounted value of future primary surpluses equals the current stock of debt. This condition rules out the possibility for Ponzi financing, where debt is rolled over indefinitely and existing debt is serviced entirely by just issuing new debt. (Bohn, 1998) Intertemporal budget constraint states the opposite to Ponzi: debt at the start of a given period must be backed by the expectation of the present value of all future primary surpluses (Di Iorio and Fachin, 2022):

$$D_t = \sum_{i=0}^{\infty} E_t \left(\frac{PB_{t+i}}{(1+r)^i} \right) \tag{1}$$

where

D_t – the government gross debt as percent of GDP in period t

PB_{t+i} – the primary balance as percent of GDP in period $t+1$

E_t denotes the conditional expectation based on information available at time t

r – the real interest rate

$\frac{1}{(1+r)^i}$ – the discount factor applied to future primary balance

Early approaches of testing the intertemporal budget constraint focused mainly on stochastic properties of the fiscal data. Hamilton and Flavin (1986) tested it by examining whether the deficit inclusive of interest payments and government debt was stationary. With this approach, failure to reject stationarity was taken as evidence that fiscal policy was consistent with intertemporal budget constraint. It interpreted sustainability as a weak solvency condition, which allows debt to grow persistently if it does not grow faster than the rate at which it is discounted in present value terms.

Trehan and Walsh (1988) and Trehan and Walsh (1991) showed that sustainability does not require stationarity of debt itself, but rather stationarity of the deficit inclusive of interest payments, and cointegration between government expenditures, revenues, and seigniorage. Their results showed that intertemporal budget constraint holds even if the debt is non-stationary. Governments may satisfy the intertemporal budget constraint while still allowing debt ratios to rise.

Wilcox (1989) highlighted that the early tests of the intertemporal budget constraint were limited as the constraint itself is a theoretical condition and not something to be directly tested empirically. Instead, Wilcox (1989) examined whether the expected discounted value of future public debt converges to zero, as implied by the present value borrowing constraint. This allows debt to grow persistently as long as its discounted value will not explode. Wilcox (1989) concluded that satisfying the intertemporal budget constraint provides little information about if current fiscal policy is economically sustainable and can be maintained without requiring changes in the future.

Bohn (1998) demonstrates that tests based on the intertemporal budget constraint are mostly uninformative for practical debt sustainability analyses as the constraints on the debt stock are rather minimal: debt should not grow faster than the term it is discounted by. This results the constraint being almost always satisfied in data. Bohn (1998) proposed to evaluate sustainability by examining if governments systematically adjust primary balances in response to rising debt. In this approach, positive response of the primary balance to debt is sufficient to ensure satisfaction of the intertemporal budget constraint, regardless of the level of debt (Bohn, 1998).

1.1.3. Debt dynamics

The fundamental debt dynamics equation captures how public debt evolves over time. Next period debt is defined as current period debt minus the primary fiscal balance, all adjusted by the relationship between the real interest rate and the real economic growth rate (Ghosh *et al.*, 2013):

$$d_{t+1} = \frac{1 + r_t}{1 + g_t} d_t - pb_{t+1} \tag{2}$$

where

d_t – the government gross debt as percent of GDP in period t

d_{t+1} – the government gross debt as percent of GDP in period $t + 1$

r_t – the real interest rate

g_t – the real GDP growth rate

pb_{t+1} – the primary balance-to-GDP ratio in period $t + 1$

So debt increases when the government runs a primary deficit or when economic growth is lower than the interest rate. Kose *et al.* (2022) states that the primary balance sustainability gap measures the difference between the actual primary balance and the debt-stabilising primary balance. A negative sustainability gap indicates that debt is on a rising path if primary deficits, interest rates, and growth rates remain at current levels in perpetuity (Kose *et al.*, 2022).

The interest rate-growth rate differential plays a central role in debt dynamics as it has direct effect on the dynamics. If the interest rate is below the growth rate, the fiscal and welfare costs of debt may be smaller than assumed, as the government can potentially achieve decreasing debt-to-GDP ratios without raising taxes through debt rollovers (Blanchard, 2019). However, studies of debt sustainability have discussed how stable the interest rate-growth differential really is. Mathematically, interest rates must be higher than growth rates for the debt stock to be sustainable, however, the opposite has been satisfied in most countries and years since 1990 (Kose *et al.*, 2022).

Wyplosz (2020) provides data showing that the average interest rate-growth rate differential has been low across advanced economies, but the standard deviations are large, which strongly affects the debt accumulation process. Interest rates lower than growth rates have been common for the United States, but it cannot be considered a norm as interest rates response to monetary policy shifts and risk premia can change quickly (Blanchard, 2019). In countries where a favourable negative differential is present, governments must maintain sufficient primary balances to be able to stabilize the debt ratios as the differential itself does not guarantee sustainability. Often, it is not the case, and negative differentials are offset by primary deficits instead. (Fournier and Fall, 2017) However, further research has since shown that the interest rate-growth rate differential can quickly turn from negative to positive and its debt-reducing effects are often offset by other debt-increasing factors (Kose *et al.*, 2022).

A bubble premium concept is introduced by Reis (2021), which extends standard debt dynamic concepts that focuses on interest rates and growth and explains how governments can sustain debt when the marginal product of capital is higher than the interest rate on government bonds. Investors value the safety government bonds offer, so they accept a return that is lower than what they would get from private capital. This difference is the bubble premium that helps to increase future primary surpluses which again, support public debt and higher debt level can be sustained compared to interest rate-growth rate concepts. However, bubble premium responds to fiscal policy choices, as more government spending increases demand for safe assets but also increases the supply of debt, creating an upper limit on how much debt can be sustained. (Reis, 2021)

The endogeneity of interest rates to debt levels creates a feedback loop that directly affects the debt sustainability. As debt rises, markets may demand higher risk premia to compensate for rising default or rollover risk, which causes the interest rates to increase sharply rather than linearly. Higher interest rates raise countries interest payments and larger primary surplus is required to stabilize debt. Achieving these surpluses becomes increasingly more difficult, which elevates default risk even more and pushes interest rates even higher. Markets may review the risk and see an increase in possibility of large fiscal shocks, potentially reevaluating a sustainable debt position unsustainable without actual fiscal change. (Ghosh *et al.*, 2013) This intensifies during financial stress when interest rate-growth rate differentials move from negative to positive (Kose *et al.*, 2022). In such environment, feedback loops can create self-reinforcing dynamics, where negative market expectations lead to higher risk premia, which weakens fiscal outcomes and confirms initial negative expectation. This was present during the European sovereign debt crisis. (Aizenman *et al.*, 2013) This suggests that sustainability depends not only on current debt levels but also on market perceptions of future fiscal capacity and credibility of economic policy.

1.2. Fiscal fatigue

1.2.1. Fiscal reaction function

The fiscal reaction function describes how primary balance is adjusted by governments in response to changes in public debt. This relationship originates from the intertemporal budget constraint, which states that debt at the start of a period must be covered by the expectation of the present value of all future primary surpluses (Di Iorio and Fachin, 2022). Bohn (1998) showed that intertemporal budget constraint holds when primary balance-to-GDP ratio is in a positive relationship with lagged debt-to-GDP. This ensures that any increase in debt is eventually reversed through primary surpluses. Fiscal reaction function thus provides a framework for testing whether governments behaviour is consistent with long-run debt sustainability. The simplest specification of the concept is linear fiscal reaction function (Bohn, 1998):

$$pb_t = \beta \cdot d_{t-1} + \mu_t \tag{3}$$

where

pb_t – the primary balance as percent of GDP

d_{t-1} – lagged government gross debt as percent of GDP

β – the response coefficient

μ_t – captures other systematic determinants of the primary balance

A positive and statistically significant response coefficient β shows that the government continuously raises the primary surplus when debt increases, which means sustainability is guaranteed (Bohn, 1998). Approach of Bohn (1998), compared to earlier sustainability frameworks, differs as it relies mainly on primary balances and debt data, requiring just few control variables for GDP growth. It does not require detailed knowledge of fiscal policy rules or debt composition and applies regardless of whether debt is held by domestic or foreign residents (Mendoza and Ostry, 2008).

Fiscal reaction function estimations typically include other variables capturing cyclical and structural factors. The output gap controls for business cycle effects. (Abiad and Ostry, 2005; Mendoza and Ostry, 2008; Medeiros, 2012; Ghosh *et al.*, 2013; Lukkezen and Rojas-Romagosa, 2016) It is included because the government's budget balance usually improves automatically in good times and gets worse in bad times, even without any policy change. Tax revenues go up when people earn and spend more, and spending on things like unemployment benefits goes down. By controlling for this, actual governments response to debt movements can be isolated with fiscal reaction function.

The government expenditure gap measures how much government spending differs from its normal level (Abiad and Ostry, 2005; Mendoza and Ostry, 2008; Ghosh *et al.*, 2013; Lukkezen and Rojas-Romagosa, 2016). Sometimes spending increases for temporary reasons, for example during a war or a one-time crisis. Trade openness (Medeiros, 2012; Ghosh *et al.*, 2013) and inflation (Medeiros, 2012; Ghosh *et al.*, 2013; Lukkezen and Rojas-Romagosa, 2016) capture the effects of international integration and price dynamics on fiscal outcomes. Institutional variables include political stability metrics, fiscal rules indicators, and sometimes dummy variables, for instance for IMF-supported programmes (Medeiros, 2012; Ghosh *et al.*, 2013). Demographic variables are included to account for the effects of population structure as that can affect the spend and income structure (Ghosh *et al.*, 2013).

Bohn (1998) developed the theoretical foundation for fiscal reaction functions and used United States data from 1916 to 1995 in studies. Results showed a positive statistically significant response coefficient of 0.05. That means one percentage point increase in the debt-to-GDP ratio was associated with a 0.05 percentage point increase in the primary balance. Bohn (1998) also tested non-linear specifications using quadratic terms and found that for the United States, the primary surplus was even more responsive to increases in debt at higher debt levels. This suggests that fiscal policy in the United States became more disciplined as debt accumulated, which is contradictory to more recent findings.

Later studies used similar framework but focused more on non-linear models and applied the framework on cross-country datasets, panel data. Results showed different patterns compared to

Bohn (1998). Abiad and Ostry (2005) analysed 31 emerging market countries and used a spline at 50 percent of GDP as an additional variable, to check non-linear specification. Results showed that primary balance responded positively to increases in debt at low to moderate levels. However, when debt ratios exceeded 50 percent of GDP, the primary surplus became only marginally responsive to increases in debt, i.e. the response weakened at higher debt levels.

Mendoza and Ostry (2008) study covered 22 industrial countries over 1990-2005 and 34 emerging countries from 1990 to 2005. For industrial countries, a positive fiscal response to debt with response coefficient similar to Bohn (1998) was confirmed. However, when the sample was split into high-debt and low-debt countries, the estimate of response coefficient in the high-debt group was not statistically significant anymore and it had turned negative. Non-linear specifications were also tested by introducing splines, but the results were not statistically significant for the industrial country panel, which is opposite to what Bohn's found for the United States alone.

The results from these early studies were conflicting. Bohn's (1998) analysis on one country found strengthening responses at higher debt levels, but cross-country panel studies found mainly weakening responses (Mendoza and Ostry, 2008). Ghosh *et al.* (2013) addressed this by developing a more flexible non-linear specification of the fiscal reaction function, a specification that can capture varying responses across the debt distribution. This fiscal reaction function takes a cubic polynomial form:

$$pb_{ct} = \beta_1 d_{c,t-1} + \beta_2 d_{c,t-1}^2 + \beta_3 d_{c,t-1}^3 + \mathrm{Z}'_{ct}\gamma + \varepsilon_{c,t} \tag{4}$$

where

$d_{c,t-1}$ – lagged government gross debt as percent of GDP

Z'_{ct} – vector of controls

$\varepsilon_{c,t}$ – error term

subscript c stands for country

subscript t stands for year

This specification allows the marginal response of the primary balance to debt to vary continuously with the debt level. More specifically, it allows marginal fiscal response to take an inverted U-shape that is weak or negative at low debt levels, increases with debt and peaks at moderate debt levels. Then response declines, turning negative at very high debt levels. For this to happen, sign structure of $\beta_1 < 0$, $\beta_2 > 0$, and $\beta_3 < 0$ is expected. (Ghosh *et al.* 2013)

Fournier and Fall (2017) proposed an alternative framework using threshold specifications with discrete breaks at specific debt levels, rather than smooth polynomial transitions. Di Iorio and Fachin (2022) highlight the importance of considering stochastic properties of fiscal data and that powers of integrated variables are not difference stationary, which implies that standard cointegration tests may not apply to polynomial specifications.

Panel data estimation of fiscal reaction functions has some methodological challenges. It requires the assumption that all countries behave in a similar way across different debt ranges, even though countries' primary balance ratios are usually observed in limited number of debt levels across the whole debt distribution. Some of the countries might never reach the higher debt ratios where primary balance response starts to weaken or turn negative, but the same behaviour is still attributed to them. Ghosh *et al.* (2013) addresses this by testing if countries observed in same debt range have approximately the same response coefficient. Results show that the hypothesis of equal slope coefficients cannot be rejected over low-to-moderate and moderate-to-high debt ranges separately, which provides evidence that countries are behaving similarly. However, the overall results of the model are still relying on rather small number of high-debt observations.

There are also endogeneity concerns in fiscal reaction functions. Based on the debt dynamics equation, lagged debt depends on previous values of primary balance, and this creates correlation between the regressor and unobserved country-specific determinants. Countries able to generate higher primary balances have also higher fixed effects and lower debt ratios. There might be a downward bias in the estimated debt coefficient, if this effect is not accounted for (Ghosh *et al.*, 2013). Medeiros (2012) addresses this through using instrumental variables with lagged values of primary balance, debt ratio and output gat as instruments. Ghosh *et al.* (2013) uses country fixed effects and models serial correlation in the error term. Fournier and Fall (2017) acknowledge the presence of potential endogeneity issues but expects the endogeneity bias to be small.

1.2.2. Fiscal fatigue

Fiscal fatigue is the phenomenon where the marginal response of the primary balance to rising public debt weakens and becomes negative at high debt levels (Ghosh *et al.*, 2013). Bohn's (1998) results showed that a positive fiscal response to debt is enough for ensuring debt sustainability, but this would mean that primary balance would always increase enough to offset the interest bill. In theory, this would imply that the primary balance could exceed GDP if governments consistently increased it in response to rising debt, which is not possible. Fiscal fatigue shows that governments have practical limits to their adjustment capacity (Ghosh *et al.*, 2013).

Economic and political mechanisms explain why fiscal fatigue occurs. On the revenue side, governments face constraints consistent with Laffer curve dynamics, where higher tax rates start to eventually generate lower revenues as economic activity decreases or moves to the informal sector (Trabandt and Uhlig, 2011). Tax bases may also decrease as mobile factors of production relocate to lower-tax jurisdictions. On the expenditure side, some spending categories are difficult to decrease. Interest payments on existing debt are contractual obligations which cannot be easily decreased. Entitlement programs like publicly funded pensions and healthcare create expectations among beneficiaries which are difficult to disappoint. As debt rises and more of the budget is absorbed by interest payments and mandatory spending, the scope for discretionary adjustment narrows. (Heller, 2005)

Political factors worsen these economic constraints. Fiscal adjustment can cause a war of attrition where competing groups attempt to avoid consolidation costs affecting them by shifting them onto others, causing delays even when everyone acknowledges that adjustment is necessary. Everyone wants someone else to be affected by the cost of adjustment. At higher debt levels, the required fiscal measures become more severe, strengthening political opposition and making it harder to build coalitions supporting consolidation. Election timing may also matter, as governments approaching elections postpone unpopular fiscal measures even when debt levels are elevated. (Alesina and Drazen, 1991)

A decline in governments credibility adds additional constraints to the capacity of fiscal adjustment. As debt rises and adjustment efforts repeatedly fail to stabilise the debt ratio, even if government has promised a consolidation, markets and citizens may lose confidence in the government. Estefania-Flores *et al.* (2023) show that official forecasts have continuously underestimated the persistence of debt accumulation, with actual government debt ending up approximately 10 percentage points of GDP higher after five years compared to the initial projections. Similarly, Abiad and Ostry (2005) found that fiscal projections for emerging markets in the early 2000s predicted debt decreases, while actual public debt increased over the same period.

The fiscal situation is likely to worsen from such repeated forecast errors (Kose *et al.*, 2021). People start expecting that the government will eventually default or that it will monetise debt through inflation, so they start taking protective actions which can worsen the government's fiscal position even further (Aizenman *et al.*, 2013). Capital starts flowing abroad which reduces the domestic tax base and government revenues. Investments decline, which lowers potential growth and future revenue capacity. High-debt economies face spillover effects where rising sovereign risk premia push up private sector borrowing costs, which crowds out private investment, which further weakens growth and undermines the government's fiscal capacity (Burriel *et al.*, 2020).

The concept of fiscal fatigues comes from fiscal reaction functions that allow non-linear responses and the empirical literature has produced varying fiscal fatigue threshold estimates. Ghosh *et al.* (2013) uses data of 23 advanced economies from 1970 to 2007 and estimate that the marginal response of the primary balance to debt starts to decline around 90-100 percent of GDP and becomes negative at around150 percent. Specification shows a negative coefficient on the linear term, a positive coefficient on the squared term, and a negative coefficient on the cubic term, all statistically significant. This pattern confirms that at low debt levels, there is a weak or negative response, the response strengthens as debt increases, but as debt continues to rise to high levels, the response weakens again and eventually becomes negative. Ghosh *et al.* (2013) emphasize that the downward sloping portion is strongly affected by a small number of observations. Medeiros (2012) applies a similar methodology to 21 European Union countries over 1976 to 2011 and finds that fiscal fatigue occurs at a similar, but slightly lower, debt range of 80 to 90 percent of GDP.

Fournier and Fall (2017) use threshold-based specifications, where thresholds are set at 120% and 170% of GDP. They use data for 31 OECD countries from 1985 to 2013 and find that countries increase primary balances in response to debt below 120 percent of GDP, react more strongly between 120 and 170 percent, and respond negatively when debt reaches above 170 percent. However, similarly to Ghosh *et al.* (2013), Fournier and Fall (2017) results are affected by few observations: leaving Japan out of the sample turns negative response above 170 percent statistically insignificant.

Di Iorio and Fachin (2022) are questioning the methods used in previous fiscal fatigue empirical papers as they highlight the importance of considering stochastic properties of fiscal data. They used cointegrating polynomial regression tests for 22 advanced economies from 1961 to 2019 and found that cubic specification is supported in only five of the advanced economies. Just Germany showing statistically significant fiscal fatigue, by increasing primary surpluses at debt levels between 35 to 70 percent of GDP and having weakening response from debt level of 70 percent of GDP. Di Iorio and Fachin (2022) argue that the widespread findings of fiscal fatigue in panel studies may reflect methodological shortcomings instead of actual fiscal behaviour.

Di Iorio and Fachin (2022) and Fournier and Fall (2017) are raising an important questions about the robustness and generality of fiscal fatigue. The fiscal fatigue has appeared in panel estimations that put together diverse countries and rely on results of few high-debt observations. With panel data, it is expected that the countries behave similarly, while individual country estimations have shown more diverse results: some showing strengthening responses (Bohn, 1998) and some showing no clear pattern (Di Iorio and Fachin, 2022). This suggests that fiscal fatigue may not be a universal phenomenon but depends on country-specific characteristics.

The consequences of fiscal fatigue extend beyond direct impacts on primary balances. When adjustment capacity is exhausted, debt dynamics become explosive. If the primary balance can not increase enough to offset interest payments anymore, the debt ratio rises without bound. This threshold defines the debt limit beyond which standard fiscal behaviour cannot stabilise the debt.

1.3. Debt limit and fiscal space

The debt limit represents the maximum level of debt a country can sustain. At this threshold, the government can no longer service its obligations through standard fiscal behaviour and must take extraordinary adjustment beyond its historical response to rising debt or default. Ghosh *et al.* (2013) define the debt limit as the debt level at which debt dynamics become explosive. If debt were to exceed this point, it would rise indefinitely because the primary surplus would never be large enough to offset the growing debt anymore. Fiscal space is defined as the difference between the current level of public debt and this debt limit. It describes how much room is left for fiscal manoeuvre before sustainability is lost. (Ghosh *et al.*, 2013) A country with large fiscal space can absorb unexpected shocks and if needed, practice countercyclical policy without threatening debt sustainability. A country with limited fiscal space has immediate constraints on its policy options.

Fiscal space definition varies slightly across literature. Heller (2005) defines it as the budgetary room that allows government to allocate resources for a desired purpose without threatening fiscal sustainability. Perotti (2007) sees fiscal space as an alternative interpretation of intertemporal budget constraint. Wyplosz (2020) defines fiscal space as governments ability to carry out expansionary fiscal policy without negative effects on fiscal position. Ghosh *et al.* (2013) is more specific with the definition, by defining fiscal space as the space between current debt level and debt limit, that is put in place based on countries historical fiscal behaviour. Fiscal space can also be defined as fiscal position that keeps borrowing costs low, that preserves financial stability or that allows unconstrained fiscal policy responses to the crises (Kose *et al.* 2022). Kose *et al.* (2022) conclude that even though there is no single agreed definition for fiscal space, the core aspect is the ability of a government to service its debt and continue to do so, while emphasizing that it is important to choose suitable fiscal space measure based on the purpose of the analyses.

Debt limits depend directly on fiscal fatigue and the limits are finite. If governments could always increase primary surpluses in the proportion to increases in debt, debt level would always be sustainable, as any debt ratio could be stabilised by fiscal adjustment. Fiscal fatigue concept states that the marginal response of primary balances to debt weakens and eventually becomes negative at high debt levels, which limits the adjustment capacity countries have and makes debt limits finite (Ghosh *et al.*, 2013).

The debt limit is determined by the intersection of fiscal reaction function and interest payment curves. The fiscal reaction function describes how the primary balance responds to the level of public debt and this response tends to be modest at low debt levels, increase as debt rises, and eventually weakens again high debt levels as fiscal fatigue becomes visible. The interest payment curve describes the primary balance surplus needed to stabilize debt. At low debt levels, the primary balance exceeds the interest payment, so debt declines toward a stable long run equilibrium. As debt rises, both the primary balance and interest payments increase, but fiscal fatigue causes the primary balance response to weaken while interest payments continue to grow. The debt limit is the point where these curves intersect, where primary balance equals the interest payment. Beyond this point, debt related obligations exceed what the government can generate through fiscal adjustment and debt continues to grow without bound. (Ghosh *et al.*, 2013) Ghosh *et al.* (2013) formalises this as solving for the debt level $\bar{d}$ that satisfies

$$\mu_i + f(\bar{d}) = (r - g)\bar{d} \quad (5)$$

where

μ_t – country-specific intercept

f(d) – the debt-dependent component of the fiscal reaction function

r – the nominal interest rate

g – the nominal growth rate

This equation has two solutions. A lower intersection represents the stable long-run debt ratio to which the economy converges. Upper intersection represents the debt limit beyond which debt sustainability fails. A countries fiscal space is simply $\bar{d}$ minus current level of debt.

Bi (2012) propose an alternative framework to calculate debt limits using a Laffer curve. In that paper, the debt limit is called the fiscal limit, but it refers to the same concept as debt limit. In the Laffer curve model, taxes on labour income reduce the after-tax wage, which leads households to work less and as a result, the tax base shrinks. At low tax rates, increase in tax rates increases revenue, but at high rates, further increases actually reduce revenue because the tax base decreases. For any given state of the economy, there exists a tax rate at the peak of the Laffer curve that maximises revenue. The fiscal limit is then calculated as the discounted sum of the maximum primary surpluses the government could generate if taxes were always set at this revenue-maximising rate.

In the Laffer curve-based framework, the fiscal limit is not a single number, it is a distribution of results instead. The shape of the dynamic Laffer curve depends on the state of the economy, particularly productivity and government spending. Because these evolve randomly, the maximum sustainable debt varies over time. Default becomes possible when current debt exceeds a draw from this distribution. Even if the current tax rate is well below the peak of the Laffer curve, the possibility that the economy may reach that peak in the future is enough for households to start pricing in default risk and demand higher returns on government bonds today. (Bi, 2012; Bi and Leeper, 2013)

The benefit of Laffer curve-based approach is that structural Laffer curve responds to policy changes while debt limits calculated based on fiscal reaction function and interest rate-growth rate differential rely on countries historical behaviour that is assumed to continue. It does not capture changes in policy rules. On the other hand, Laffer curve-based approach requires setting up full general equilibrium model, which makes cross-country application difficult. (Bi and Leeper, 2013)

Both frameworks highlight that interest rates are endogenous to default risk (Ghosh *et al.*, 2013; Bi, 2012). At low debt levels, governments borrow near the risk-free rate. As debt approaches the limit, creditors demand higher risk premia to compensate for rising default probability. This creates a feedback loop. Higher debt raises default risk, which raises risk premia, which raises interest costs, which raises debt further. Debt limit is the point where no interest rate exists that can satisfy the creditors required return and keep debt on a sustainable path (Ghosh *et al.*, 2013). Creditors need higher interest rates to be compensated for the high risk of default, but that high interest rate would make debt service very costly. At that point, the market shuts the government out. Because interest rates start rising before the debt limit is reached, the estimated debt limit is overestimated, and actual limit is lower than a calculation based on the risk-free rate alone would suggest (Ghosh *et al.*, 2013).

Ghosh *et al.* (2013) estimates debt limits for 23 advanced economies using 1970-2007 data. Debt limits range from 150 to 260 percent of GDP. Variances between countries are mainly caused by differences in historic fiscal behaviour and interest rate-growth differentials. Australia, Korea and Norway have the highest limits at over 200 percent of GDP, while most European countries fall in the 170 to 190 percent range. For some countries, no finite debt limit exists under projected market interest rates as fiscal reaction function is always below the interest payment curve and no intersection exists. Italy and Japan show no convergent debt path even under historical interest and growth rates as their debt was not on a sustainable path even before the global financial crisis. In terms of fiscal space, Australia, Korea, and the Nordic countries have the most room, while Greece, Italy, Japan, and Portugal have little or none. (Ghosh *et al.*, 2013)

Fournier and Fall (2017) expand the analysis to 31 OECD countries using data from 1985 to 2013. Their threshold specification results in somewhat higher debt limits, which they attribute to post-crisis period, during which many countries undertook significant fiscal consolidation at elevated debt levels. This pushed up estimated fiscal response in higher debt range, raising calculated debt limit. For several countries including Greece, Japan, Portugal, and Spain, no finite debt limit exists, which shows that these countries past fiscal behaviour does not stabilise debt under current conditions. Both Ghosh *et al.* (2013) and Fournier and Fall (2017) work shows that the interest rate assumption affects both the level of the debt limit and whether a finite limit exists at all and using projected market rates give fiscal space 10-30 percentage points lower estimates than with historical averages.

Kose *et al.* (2022) created a fiscal space database by consolidating data of 202 countries from 1990 to 2020. Estimates show that fiscal space fell more in 2020 than in any year since 1990 and that financial crises tend to cause lasting declines that are rarely reversed. As a result, many advanced economies now operate with considerably smaller fiscal buffers than during the period studied by Ghosh *et al.* (2013) and Fournier and Fall (2017)

2. METHODOLOGY AND DATA

This chapter of the thesis describes the methodology and the data used in this thesis to estimate fiscal reaction function function, evaluate fiscal fatigue and calculate countries debt limits. Section 2.1. discusses the methodologies used, while section 2.2. introduces the data used in the empirical analysis and its limitations.

2.1. Methodology

This section explains the methodologies used in the empirical analysis. The methodology follows the previous studies completed on the topic, mainly the analysis in Ghosh *et al.* (2013) on fiscal fatigue, debt limits and fiscal space. The section is divided into three subsections, first covering specifications of fiscal reaction function, then the methodology for fiscal fatigue, and finally the calculations of debt limits and fiscal space.

2.1.1. Fiscal reaction function

The general cubic polynomial specification that was used by Ghosh *et al.* (2013) and Fournier and Fall (2017) to evaluate fiscal reaction function is described in formula 4 and discussed in subsection 1.2.1. It is expected that the coefficients of this cubic fiscal reaction function follow a certain sign structure: $\beta_1 < 0$, $\beta_2 > 0$, and $\beta_3 < 0$ (Ghosh *et al.*, 2013). This structure confirms the S-shape of fiscal reaction function where the primary balance falls slightly with low debt levels, rises with debt up to a certain point and then turns over and falls again. This does not, however, prove presence of fiscal fatigue.

There are endogeneity related problems in this fiscal reaction function, which are caused by the dependence of lagged debt on past values of primary balance. Some countries are constantly better at generating primary surpluses. These unobserved country specific characteristics are captured by the country fixed effects which make sure that the effect of this endogeneity is not absorbed into the coefficient of lagged debt, biasing it downward as a result.

It is assumed that the error term follows an AR(1) process to account for serial correlation. Ghosh *et al.* (2013) confirmed that there is serial correlation present, showing that shocks to fiscal balances are persistent and that the current error term is correlated with its past values. Taking this into account and applying the AR(1) process to the error term helps to produce more accurate standard errors. In this thesis, first-order autocorrelation is tested with Wooldridge test. A join significance test is also run to evaluate joint significance of debt terms combined. Wald test is used for this.

In this thesis, two specifications are estimated: a baseline and an extended specification. Estimating both specifications allows testing whether the estimated non-linear fiscal response to debt is robust to the inclusion of additional determinants. Similarly to Ghosh *et al.* (2013), country fixed effects are included in both models as well AR(1) process for error term. The baseline specification includes only the core variables required to capture the relationship between public debt and the primary balance. In addition to general cubic polynomial model, output gap and government expenditure gap are included to control for business cycles and temporary fluctuations in government spending:

$$pb_{ct} = \mu_c + \beta_1 d_{c,t-1} + \beta_2 d_{c,t-1}^2 + \beta_3 d_{c,t-1}^3 + \gamma_1 outputgap_{c,t} + \gamma_2 govexgap_{c,t} + \varepsilon_{c,t} \quad (6)$$

where

μ_c – country fixed effects

$d_{c,t-1}$ – lagged government gross debt as percent of GDP

$outputgap_{c,t}$ – output gap as percent of potential GDP

$govexpgap_{c,t}$– government expenditure gap as percent of potential government expenditure

$\varepsilon_{c,t}$ – follows AR(1) process $\varepsilon_{c,t} = \rho\varepsilon_{c,t-1} + u_{ct}$, where ρ is the autocorrelation coefficient and $u_{c,t}$ is the truly random error after accounting for autocorrelation

subscript c stands for country

subscript t stands for year

The baseline specification follows the specification in Ghosh *et al.* (2013), but the output gap and government expenditure are also commonly included as control variables in other fiscal reaction function frameworks (Bohn, 1998; Mendoza and Ostry, 2008; Fournier and Fall, 2017; Lukkezen and Rojas-Romagosa, 2016).

The extended specification adds to the model additional economic, demographic and institutional controls that may influence fiscal policy:

$$pb_{ct} = \mu_c + \beta_1 d_{c,t-1} + \beta_2 d_{c,t-1}^2 + \beta_3 d_{c,t-1}^3 + \gamma_1 outputgap_{c,t} + \gamma_2 govexpgap_{c,t} + \gamma_3 tradeopen_{c,t} + \gamma_4 inflation_{c,t} + \gamma_5 agedep_{c,t} + \gamma_6 futureagedep_{c,t} + \gamma_7 polstab_{c,t} + \gamma_8 imfprog_{c,t} + \gamma_9 fiscalrule + \varepsilon_{c,t} \quad (7)$$

where

μ_c – country fixed effects

$d_{c,t-1}$ – lagged government gross debt as percent of GDP

$outputgap_{c,t}$ – output gap as percent of potential GDP

$govexpgap_{c,t}$– government expenditure gap as percent of potential government expenditure

$tradeopen_{c,t}$ – sum of total exports and imports as a percent of GDP

$inflation_{c,t}$ – three-year back moving average of CPI inflation, lagged

$agedep_{c,t}$ – ratio of the dependent population to the working age population

$futureagedep_{c,t}$– projected age dependency 20 years ahead

$polstab_{c,t}$ – political stability and absence of violence/terrorism estimate

$imfprog_{c,t}$ – dummy equal to one if country has an active IMF lending arrangement in that year

$fiscalrule_{c,t}$ – dummy equal to one if any type of fiscal rule is in force

$\varepsilon_{c,t}$ – follows AR(1) process $\varepsilon_{c,t} = \rho\varepsilon_{c,t-1} + u_{ct}$, where ρ is the autocorrelation coefficient and $u_{c,t}$ is the truly random error after accounting for autocorrelation

subscript c stands for country

subscript t stands for year

The specification broadly follows Ghosh *et al.* (2013) by including trade openness, inflation, age dependency, future age dependency, political stability, ongoing IMF arrangement and existence of any fiscal rules. However, instead of the political stability index from International Country

Risk Guide, political stability and absence of violence and terrorism variables from World Bank was used because of the availability of the metric. Oil and non-fuel commodity prices were included in Ghosh *et al.* (2013) model, but not in this thesis as none of the European Union countries are categorised as energy or non-oil commodity export dependent. A country is dependent on a specific commodity when that commodity's exports generate more than 60% of countries total exports (UN Trade and Development, 2023).

The model is estimated using a fixed effects panel approach where the country fixed effects control for unobserved, time-invariant differences across countries. This is done by removing country-specific effects that do not change over time, so that the estimation relies only on variation within each country. The estimation also accounts for first-order serial correlation in the error term within each country by allowing the errors to follow an autoregressive process. This is addressed through a transformation of the data prior to estimation, so that both the coefficient estimates and their standard errors reflect the presence of serial correlation.

2.1.2. Fiscal fatigue

To evaluate existence of fiscal fatigue, marginal fiscal response (MFR) is calculated for each model, which tells at any given debt level, how much the primary balance responds to additional percentage point of debt. This is done by first taking first difference from estimated fiscal reaction function with respect to the debt ratio. This isolates only the debt dependent polynomial terms:

$$MFR(d) = \frac{\partial pb}{\partial d} = \beta_1 + 2\beta_2 d + 3\beta_3 d^2 \tag{8}$$

To find the threshold where fiscal fatigue becomes present, meaning that the primary balance still responds positively to rising debt but at a decreasing rate, the maximum of the MFR must be found. It is the point with the strongest primary balance response to an increase in debt. This is found by taking the derivative from MFR, setting it equal to zero and solving for the level of debt:

$$\frac{\partial MFR}{\partial d} = 2\beta_2 + 6\beta_3 d \;\Rightarrow\; d^{peak} = -\frac{\beta_2}{3\beta_3} \tag{9}$$

To understand if d^{peak} is truly a maximum after which fiscal fatigue starts, second derivative must be taken from MFR. If result of the derivative is below zero, d^{peak} is true maximum. If result is above zero, it opens upward and d^{peak} is minimum and not expressing start of fiscal fatigue. Second derivative is as follows:

$$\frac{\partial^2 MFR}{\partial^2 d} = 6\beta_3 \tag{10}$$

Fiscal fatigue deepens when the MFR turns negative, which means from this point onward, primary balance starts to decline in response to rising debt. This threshold can be found by setting MRF(d) equal to zero and solving for the level of debt. This results in two roots where the relevant one is the higher root. Formula is following:

$$\beta_1 + 2\beta_2 d + 3\beta_3 d^2 = 0 \;\; \Rightarrow \;\; d^{neg} = \frac{-2\beta_2 \pm \sqrt{4\beta_2^2 - 12\beta_3\beta_1}}{6\beta_3} \tag{11}$$

2.1.3. Debt limits and fiscal space

The debt limit is calculated based on the extended specification model. The debt limit $\bar{d}_c$ is defined as the higher solution to the condition where the country's primary balance exactly covers its interest payment obligation:

$$f_c(d) = (r - g) \cdot d \tag{12}$$

where

$f_c(d)$ – country specific extended fiscal reaction function

r – nominal interest rate

g – nominal GDP growth rate

This condition produces two intersections. The lower intersection d_c^* is the stable long-run debt ratio to which the countrys debt converges under normal fiscal behaviour. The upper intersection is the debt limit $\bar{d}_c$ beyond which the primary balance can not cover the growing debt and debt ratio rises without bound. For countries where condition $f_c(d) < (r - g) \cdot d$ is always true, no finite intersection exists, which means country is not on a convergent path, considering countries previous fiscal behaviour and interest rate-growth rate gap. The left-hand side, $f_c(d)$, is the country specific fiscal reaction function derived from the estimated extended specification of the fiscal reaction function. It is defined as:

$$f_c(d) = \mu_c + \beta_1 d + \beta_2 d^2 + \beta_3 d^3 + \bar{Z}_c' \hat{\gamma} \tag{13}$$

where

μ_c – the estimated country fixed effect

$\bar{Z}_c'$ – combined values of control variables

The function varies across countries only through the fixed effects and the control variables, which together reflect country-specific fiscal behaviour. The debt-polynomial component is common across all countries. The cyclical variables output gap and government expenditure gap are set to zero, as the debt limit should reflect countrys structural fiscal capacity (Ghosh *et al.*, 2013). The remaining structural controls are taken as follows:

- The 2020-2024 average per country is taken for inflation, political stability, trade openness, age dependency and future age dependency variables.
- The IMF program variable is set to zero for all countries as no country has had an active IMF program in last five years.
- Fiscal rules variable is set to one as all countries in EU have active fiscal rules in place and it is expected not to change..

The right-hand side, $(r - g) \cdot d$, represents the interest payment schedule, which is the minimum primary balance government must generate to prevent the debt ratio from rising. GDP growth reduces the debt-to-GDP ratio even without any primary adjustment, so just the situation when interest rate is higher than growth rate creates additional debt burden on countries. The interest payment schedule is treated as linear through all debt levels, similarly to the assumption used in Ghosh *et al.* (2013).

Three separate interest rate-growth rate differentials are used:

1. Historical is based on the average implied nominal interest rate on government debt and the average nominal GDP growth rate over 2015-2024.
2. Medium-term projection-based uses the projected average implied nominal interest rate for 2025–2027, and the corresponding projected average nominal GDP growth differential.
3. Long-term projection-based uses the projected average long-term interest rate on government bonds for 2026–2030, and the projected average nominal GDP growth over the same period. Note that long-term bond interest rate projections are not available for all EU countries.

The historical differential is consistent with the estimation period of the fiscal reaction function, while the projected differentials are forward-looking and more relevant to evaluate current debt limits. Additionally, historic rates tend to overestimate the debt limit, compared to using the projected rates. (Ghosh *et al.*, 2013)

The fiscal space is then defined as the difference between the estimated debt limit and the observed debt ratio at the end of the sample period:

$$FS_c = \bar{d}_c - d_{c,t} \quad (14)$$

where

FS_c – fiscal space for a specific country

$\bar{d}_c$ – country specific debt limit

$d_{c,t}$ – countrys observed debt-to-GDP ratio at specific year

A positive value of fiscal space means that there is still room remaining before the debt limit is reached. A negative value means that the countries current debt level is already above the sustainable level under its historical fiscal behaviour.

The room to lower convergence point provides additional context for interpreting fiscal space. It is defined as the difference between the stable long-run debt ratio and the observed debt ratio at the end of the sample period:

$$LG_c = d_c^* - d_{c,t} \quad (15)$$

where

LG_c – room to lower convergence point for a specific country

d_c^*– country specific stable long-run debt ratio

$d_{c,t}$ – countrys observed debt-to-GDP ratio at specific year

A positive value means that debt is currently below its long-run equilibrium, meaning the country's debt will continue to increase until it reaches the equilibrium level. A negative value indicates that debt is above its long-run equilibrium and if the country continues to behave as historically, debt will be pushed downward over time.

2.2. Data

2.2.1. Sample of countries

The empirical analysis is based on an unbalanced panel dataset of European Union (EU) member states using annual observations from 1996 to 2024. Recent increases in public debt in many EU countries make the region a suitable case for evaluating fiscal fatigue and fiscal space. Much of the empirical literature on fiscal fatigue has focused on advanced economies or core members of the Organisation for Economic Co-operation and Development (OECD) and therefore does not typically cover the full set of EU countries. Medeiros (2012) covers all 27 EU member states and Kose *et al.* (2022) includes EU countries in their fiscal space database. EU economies have broadly common fiscal framework, and they share similar macroeconomic policy constraints, which makes countries fiscal behaviour more comparable.

In this thesis, Greece, Luxembourg and Ireland are excluded from the sample. Greece has experienced a sovereign debt crisis and as a result, their fiscal policy has been externally constrained. Primary surpluses were required from Greece as a condition for accessing EU and IMF financing (European Commission, 2015; International Monetary Fund, 2012). This means that the observed primary balance is affected by externally introduced targets instead of countries' autonomous fiscal response to rising debt. Luxembourg's fiscal position is strongly influenced by its role as a financial centre and a domicile for investment funds. This makes indicators such as the output gap and trade openness harder to interpret (International Monetary Fund, 2023). Irelands GDP is heavily influenced by multinational enterprises activities and intellectual property relocations (International Monetary Fund, 2018). This also distorts debt-to-GDP and primary balance ratios and makes the country not comparable with other countries. Including these observations would bias the estimated fiscal reaction function.

To evaluate, if there are any differences in results between countries that experience high debt levels and those who do not, countries are divided into two segments – high debt countries and low-mid debt countries. Low to mid debt level countries are those whose highest debt level is below 100% of GDP. High debt countries those who have experience higher debt than 100% of GDP. This grouping follows Ghosh *et al.* (2013) approach. There are six countries categorized as high debt countries: Belgium, Cyprus, France, Italy, Portugal and Spain. All other countries are categorized as low to mid debt level countries.

2.2.2. Data for evaluating fiscal fatigue

Fiscal reaction function relies on fiscal and macroeconomic, demographic and policy related variables. Fiscal and macroeconomic variables are taken from Eurostat to ensure metrics are defined in unified way and comparable across countries. Demographic variables include current and future age dependency estimates which are taken from United Nations Population Divisions World Population Prospects. For future age dependency, medium variant projections are used. Institutional variables include binary variables for fiscal rules and active IMF programmes, which take value one when country had an active corresponding programme in a that year. Fiscal rules are taken from International Monetary Fund fiscal rules dataset and historical data of IMF programmes is taken from IMF history of lending arrangements database. Political stability variable comes from World Bank database.

Not all required metrics are readily available via databases. The following calculations are done to preprocess the data and derive the metrics:

- primary balance is calculated by adding together overall fiscal balance as percentage of GDP and interest expenditure as percentage of GDP,
- trade openness is calculated by adding together imports and exports of goods and services as a percentage of GDP,
- debt is taken as percentage of GDP and lagged by one year and then, depending on the metric, squared of cubed,
- inflation is calculated as three years lagged moving average of HCIP inflation to reduce the effect of fluctuations,
- output gap is calculated from real GDP in national currency by using Hodrick-Prescott (HP) filter. The output gap is shown in per cent of potential GDP,
- government expenditure gap is calculated from general governments final consumption expenditure in national currency by using HP filter. Metric is shown as percentage of potential government expenditure.

Debt-to-GDP and inflation are lagged to help to deal with endogeneity. Current period debt endogeneity originates from the debt dynamics equation. Debt in certain period is determined in part by the primary balance in the same period (Formula 2), which is the dependent variable in the fiscal reaction function. There is also reverse causality running from the fiscal position to inflation as primary deficits financed through money creation can produce inflation as a result (Catão and

Terrones, 2005). This means the primary balance and inflation are determined jointly in the same period. Lagging these regressors lowers the risk that the variables are influenced by the primary balance and reverse causality biases the estimated coefficients, and it is therefore the approach taken in this thesis.

Both output gap and government expenditure gap are constructed using the HP filter. HP filter separates a time series into a trend and cyclical component by separating the smooth long-run trend from short-run fluctuations. Degree of smoothing is controlled by parameter λ set equal to 100, which is the standard recommendation for annual frequency data (Hodrick and Prescott, 1997). The smoothened trend component may be interpreted as the potential level of the variable. The gap variable is then defined as the difference between the observed and potential level, calculated as percentage of potential level.

Descriptive statistics of the variables are presented in table 1. The primary balance is close to zero on average while showing considerable dispersion, which reflects presence of both large deficits and surpluses across countries and time. Public debt averages at approximately 58 percent of GDP, but ranges from very low levels below 10 percent to above 150 per cent, so the sample includes both low debt and very high debt economies.

Table 1. Descriptive statistics of main variables

Variable	Mean	Std. Dev.	Min	Max
Primary Balance (% GDP)	-0.36	3.08	-11.90	9.60
Debt-to-GDP (%)	57.58	30.29	3.90	154.40
Output Gap	-0.04	3.32	-10.49	21.04
Gov. Expenditure Gap	-0.09	2.58	-10.19	12.71
Trade Openness	108.15	40.29	42.80	244.60
Inflation	3.20	3.70	-1.33	34.23
Age Dependency Ratio	50.20	5.13	38.54	63.00
Future Age Dependency	59.87	7.15	40.20	86.82
Political Stability	0.78	0.38	-0.47	1.76
IMF Programme	0.11	0.32	0	1
Fiscal Rule	0.88	0.32	0	1

Source: Author's calculations

Cyclical variables such as the output gap and government expenditure gap average around zero, as expected, but both show relatively high variability. This shows that both economic expansions and recessions are covered in the sample. At the same time, metrics are constructed with HP filter, which introduces potential measurement issues at the ends of the time series and estimated gaps depend on the choice of smoothing parameter. Trade openness varies significantly across countries, mainly due to differences in economic size and how strongly country is connected to global economy. Inflation remains relatively moderate, while demographic variables show increasing age dependency, indicating ageing populations. Institutional variables are relatively stable. Four of the countries in sample have had an active IMF program in the timeframe of the data, while none of the countries have it active now. All EU member countries have active fiscal rules at least from the time they joined EU, which explains the high mean for fiscal rules.

The time series of the primary balance shows cyclical behaviour with substantial drops during economic downturns, especially during global financial crisis and COVID-19 period (Figure 1). High-debt countries have more volatile primary balance, which also means deeper deficits during crisis period, compared to low-mid debt countries. Debt-to-GDP tends to increase sharply following a crisis period and remain persistently elevated, especially in high-debt countries (Figure 1). In contrast, low-mid debt level countries tend to maintain a more stable debt level. This highlights the importance of separating high and low to mid debt level countries in fiscal reaction function.

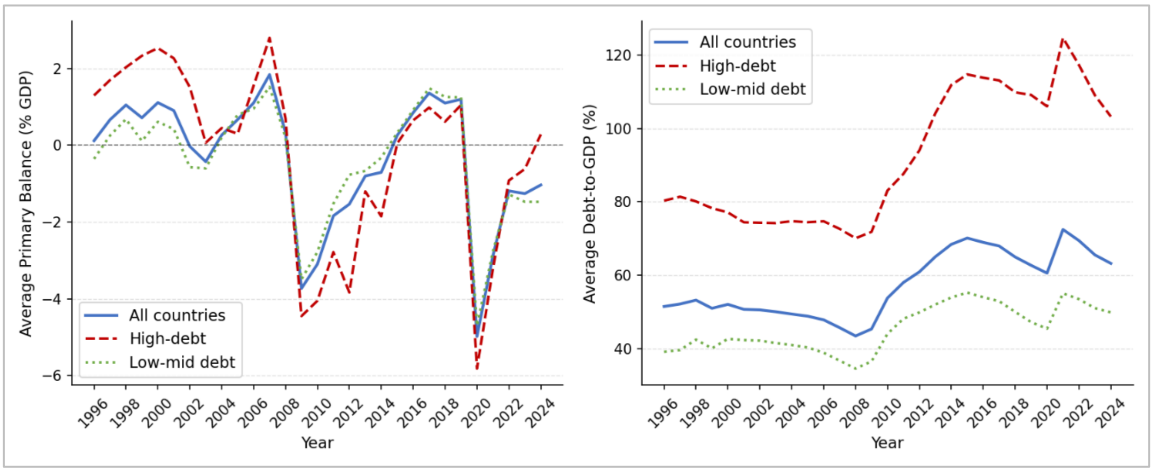

Figure 1. Average primary balance debt-to-GDP percentage over time
Source: Author's calculations

The distribution of observations across debt levels shows that most of the data points are concentrated on lower debt levels, while relatively small number of observations are captured at very high debt levels (Figure 2). Even though overall EU countries debt levels have increased in time, not many countries are observed on upper range of debt levels which means that low number of countries are a base for estimating countries behaviour at high debt levels. This issue has previously been highlighted by Ghosh *et al.* (2013).

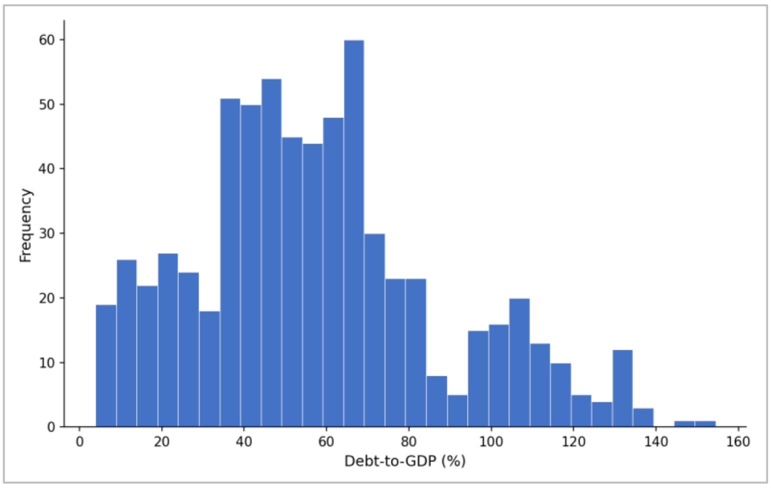

Figure 2. Distribution of observations on across debt levels
Source: Author's calculations

Looking at the relationship between debt and primary balance across different debt levels suggests a non-linear pattern. On figure 3, horizontal axis displays debt-to-GDP levels in 10pp bins and vertical axis displays primary balance as a percentage of GDP. Primary balance tends to be in negative at low debt levels and seems to increase as debt increases. At higher debt levels, the primary balance starts to decrease again.

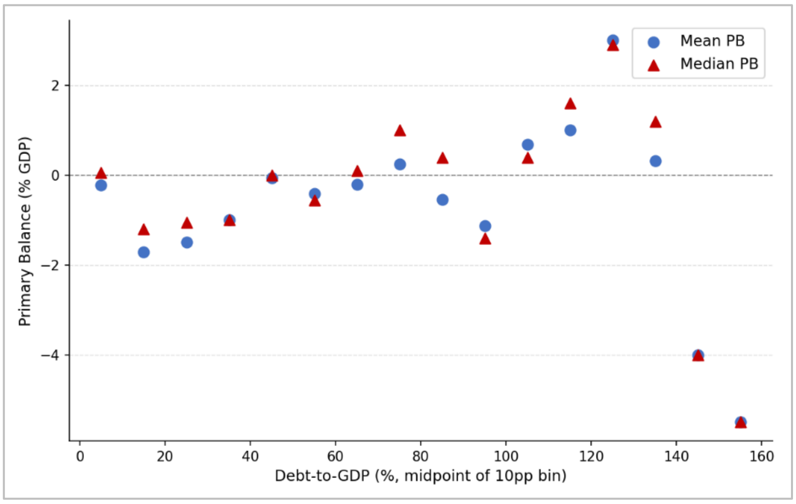

Figure 3. Median and mean primary balance on different debt levels.
Source: Author's calculations

This pattern is consistent with concept of fiscal fatigue, even though the higher debt level means and medians are driven by small number of observations.

2.2.3. Data for debt limits

Calculation of debt limits requires growth rate of nominal GDP and the nominal interest rate to construct the interest rate-growth rate difference. For the interest rate, all three scenarios require a different approach. Historical scenario calculates the interest rate with Eurostat data, by dividing general governments interest payments with gross public debt year before. Average of annual values for 2015-2024 is taken. Medium-term uses government debts implied interest rate projections for 2025-2027 from European Commission's annual macro-economic database. To reduce the fluctuations, an average is taken over these three years. Long-term scenario uses OECD projections of long-term bond interest rates for 2026-2030. Similarly to medium-term model, average over projected period is taken.

Nominal GDP for the historical scenario is taken from Eurostat database while medium and long-term scenarios use nominal GDP projections from IMF database. The growth rate is calculated as year-over-year percent change. Similarly to interest rate, growth rate is then averaged per year.

The descriptive statistics of interest rate-growth rate differential are in table 2. Average of interest rate-growth rate is negative across all three scenarios, which shows that economic growth has generally exceeded interest rate during the sample period and projections. However, there is notable variation across scenarios. In the historical scenario, the difference is negative for all the countries, ranging from -9.1% to -0.3%. In the medium- and long-term projection-based scenarios it becomes less negative and, in some cases, even exceeds zero. This variation is important for debt limit estimation, as higher differentials imply a larger interest burden on countries and therefore lower sustainable debt levels.

Table 2. Descriptive statistics of interest rate-growth rate differential

Variable	Mean	Std. Dev.	Min	Max	Median	Countries
Historical (2015–2024)	27	-3.776	2.037	-9.061	-4.894	24
Medium-term (2025–2027)	27	-1.854	1.147	-4.316	-2.502	24
Long-term (2026–2030)	21	-0.34	0.77	-1.723	-0.868	18

Source: Author's calculations

Country level interest-growth rate differentials are in figure 4. The differential varies across countries significantly as does the difference between historic and projected scenarios. The clear trend is that the historical differential has been negative for all the countries in the sample and it has been a rather favourable situation for the countries. Medium-term projections are noticeably less favourable for all countries, more so for the countries that have enjoyed the lowest historical differentials. Long-term projections are again, even less favourable for all the countries, which mirrors that the countries can not expect that the favourable differential situation they have been in continues forever.

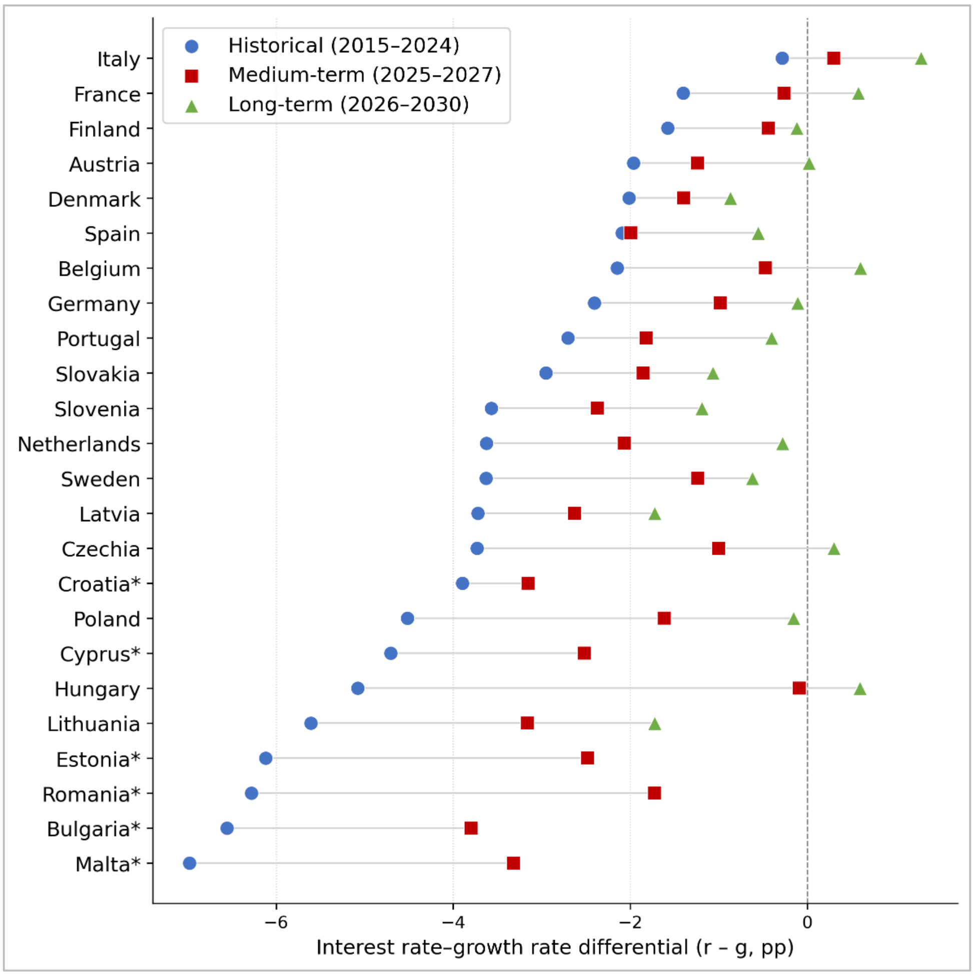

Figure 4. Interest rate-growth rate differentials by country
Source: Created by author
Notes: Countries marked with an asterisk do not have a projected long-term scenario available

This mirrors differences in countries macroeconomic conditions and borrowing costs within EU. It also emphasizes the importance of using alternative scenarios while estimating debt limits, as relying on just historical averages may overestimate debt limits if future conditions are less favourable. If the differential is negative, debt can be rolled over with relative ease and the debt limit calculated with differential is higher. If it rises toward zero or even becomes positive, the interest cost grows more quickly than the economy and the debt limit contracts. Detailed table of country level interest rate-growth rate differentials per scenario is included in appendix 1.

3. EMPIRICAL ANALYSIS

This chapter presents the main results of the empirical analysis. First section covers results of fiscal reaction function, fiscal fatigue and debt limits. Second section provides an overview of the robustness checks that help to confirm validity of the results. Final section of the chapter contains discussion about limitations of current analysis.

3.1. Main results

3.1.1. Fiscal reaction function results

Fiscal reaction function results are presented in table 3. Both baseline and extended specifications are estimated for three country groups: all countries, high debt countries and low-to-mid debt countries. None of the debt variables is statistically significant, most likely due to multicollinearity among the polynomial terms. Since debt variables are highly correlated (Table 4), they capture very similar variation in the data. This makes it difficult for the model to separate their individual effects, which leads to large standard errors and insignificant coefficients.

A joint Wald test rejects the null hypothesis that all debt coefficients are equal to zero in most of the samples and specifications, which means that the debt terms are jointly significant (Table 5) in all countries and low-mid countries samples. This suggests that debt does have a significant relationship with the primary balance, but its impact cannot be precisely identified for each polynomial term separately. Wald test does not reject the null hypothesis in high debt samples extended model and marginally passes in baseline model. In these models, the sample size is rather small, just 6 countries and 161 observations, which can mean the explanatory power of that sample is just too low.

Table 3. Estimated fiscal reaction functions by country segment

sample	all countries		high debt		low-mid debt	
variable	(1)	(2)	(3)	(4)	(5)	(6)
debt	0.1088	0.0682	-0.2250	-0.2339	0.1940*	0.2699**
	(0.0636)	(0.0642)	(0.2814)	(0.2829)	(0.1095)	(0.1153)
d_squared	-0.0004	0.0002	0.0036	0.0033	-0.0023	-0.0044*
	(0.0009)	(0.0009)	(0.0030)	(0.0030)	(0.0023)	(0.0025)
d_cubed	-0.0000	-2.0e-06	-1.5e-05	-1.3e-05	1.2e-05	2.9e-05
	(4.0e-06)	(4.0e-06)	(1.0e-05)	(1.0e-05)	(1.5e-05)	(1.7e-05)
outputgap	0.4354***	0.3983***	0.6101***	0.5803***	0.3917***	0.3573***
	(0.0270)	(0.0295)	(0.0643)	(0.0729)	(0.0294)	(0.0315)
govexpgap	-0.2670***	-0.2530***	-0.3046**	-0.2722**	-0.2478***	-0.2295***
	(0.0375)	(0.0381)	(0.0834)	(0.0915)	(0.0418)	(0.0410)
tradeopen		0.0328***		0.0486		0.0273**
		(0.0092)		(0.0256)		(0.0098)
inflation		0.0582		-0.0745		0.0537
		(0.0597)		(0.2323)		(0.0587)
agedep		-0.0958		0.2100		-0.1156
		(0.0732)		(0.3207)		(0.0765)
futureagedep		-0.1517**		-0.1551		-0.1698**
		(0.0556)		(0.1228)		(0.0739)
polstab		0.4455		0.8919		0.1130
		(0.5735)		(1.1337)		(0.6617)
imfprog		0.1670		3.1272**		-0.3778
		(0.4284)		(1.0928)		(0.4494)
fiscalrule		0.1291		0.1719		0.0729
		(0.5731)		(2.1225)		(0.5775)
_cons	-4.7393	5.3672	1.9885	-2.3835	-5.2487	6.2567
	(0.4184)	(1.0397)	(2.0330)	(3.4748)	(0.5210)	(1.2372)
N obs	649	623	168	161	481	462
N countries	24	24	6	6	18	18
rho	0.7034	0.6606	0.7638	0.7490	0.6765	0.6448
R^2 within	0.3187	0.3589	0.3904	0.4560	0.3069	0.3605
F test	1.84***	2.83***	1.77*	1.62	2.00**	3.51***

Source: Author’s calculations

Notes:

1. Significance level values *, **, *** indicate significance at 10%, 5% and 1% level.
2. Results including Ireland, Greece and Luxembourg are reported in Appendix 2.

The cyclical control variables behave relatively constantly across all specifications and models. The output gap has positive, statistically significant relationship with primary balance in all models, while the coefficient varies from 0.36 in low-mid debt countries extended model to 0.61 in high debt baseline model. This can be explained through automatic stabilisers that improve primary balance when countries economy is above trend level. The government expenditure gap has a negative relationship with primary balance, which is statistically significant in all the models. This is consistent with temporary expansionary spending episodes that reduce the primary balance, without a permanent change. These results align with previous findings in the fiscal reaction function literature (Bohn, 1998; Mendoza and Ostry, 2008; Ghosh *et al.*, 2013).

Table 4. Debt, squared debt and cubed debt correlation coefficients.

Variable	debt	d_squared	d_cubed
debt	1		
d_squared	0.96***	1	
d_cubed	0.89***	0.98***	1

Source: Author's calculations

It is expected that the coefficients follow a sign structure of $\beta_1 < 0$, $\beta_2 > 0$, and $\beta_3 < 0$ for model to take polynomial shape described by Ghosh *et al.* (2013), as discussed in subsection 1.2.1. This expectation is filled only by high debt countries models. All countries baseline model follows sign structure of $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 < 0$, while β_3 coefficient is very close to 0. Extended model follows $\beta_1 > 0$, $\beta_2 > 0$, and $\beta_3 < 0$. Both low-mid countries specifications follow sign structure of $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 > 0$. This means that the estimated fiscal reaction function follows non-linear behaviour in all models, but the exact polynomial shape as previous Ghosh *et al.* (2013) findings stated is present only in high debt country segment.

Table 5. Joint significance of debt terms evaluated with Wald test

Sample	all countries		high debt		low-mid debt	
Model nr	(1)	(2)	(3)	(4)	(5)	(6)
F-statistic	6.02	7.13	2.29	1.09	6.04	8.66
p-value	0.00	0.00	0.08	0.35	0.00	0.00

Source: Author's calculations

In extended model, trade openness has a positive relationship with primary balance, which is statistically significant on at least ten percent level in all models. This suggests that more open economies manage to maintain higher primary balances. Focusing on extended all countries model, signs of almost all coefficients are consistent with Ghosh *et al.* (2013) extended model. While active IMF program dummy had a negative relationship in Ghosh *et al.* (2013) model, it had a positive relationship in current model.

Using AR(1) correction for serial correlation is justified as the Wooldridge test rejects the null of no first-order autocorrelation in both baseline and extended specifications, in all countries sample (Table 6). The estimated autocorrelation coefficient rho ranges between 0.65 and 0.76 (Table 3), further indicating high persistence in the error term. This confirms that shocks to primary balances are persistent over time and that ignoring serial correlation would result in unreliable standard errors, consistent with the finding in Ghosh *et al.* (2013).

Table 6. Wooldridge test for autocorrelation results

Specification	F-statistic	p-value	Serial correlation
Extended	44.45	0.0000	Yes
Baseline	47.83	0.0000	Yes

Source: Author's calculations

A linear specification is also estimated to check whether the data supports a basic positive fiscal response to debt at all. Results are displayed in appendix 3. The debt coefficient is positive and statistically significant at the 1 percent level in both all-countries and low-to-mid debt countries models. For high-debt countries, coefficient is still positive but smaller and not statistically significant. This is in line with Bohn (1998) and Mendoza and Ostry (2008), who find a positive linear response in their samples. Mendoza and Ostry (2008) also saw lower and not-significant coefficient for high-debt country sample. These results also confirm that the insignificant cubic terms in the main specification are not because countries do not respond to increases in debt.

Overall, the fiscal reaction function estimates show a positive average fiscal response to debt across EU countries. However, the specific non-linear cubic pattern suggested by Ghosh *et al.* (2013) is not visible in any models. This, however, does not mean fiscal fatigue is not present.

3.1.2. Fiscal fatigue results

Fiscal fatigue is present in three models: the extended specification for all countries and both specifications for high-debt countries (Table 7). In all cases, the marginal fiscal response follows an inverted-U shape (Figure 5), consistent with the theoretical expectation for fiscal fatigue described by Ghosh *et al.* (2013). For the extended all-countries model, the primary balance response to rising debt begins to weaken at a debt level of 28 percent of GDP, which means fiscal fatigue begins at a relatively low debt level. The response turns negative at 140 percent of GDP, beyond which on average, EU governments no longer increase their primary balance in response to further debt accumulation. Fiscal fatigue threshold of 28 percent for EU countries is considerably lower than the 90-100 percent of GDP estimated by Ghosh *et al.* (2013) for advanced economies, though the threshold at which the response turns negative is close to their estimate of approximately 150 percent of GDP.

Table 7. Estimated fiscal fatigue thresholds by country segment

sample	all countries		high debt		low-mid debt	
	(1)	(2)	(3)	(4)	(5)	(6)
d^{peak}	-1327.3	28.1	81.2	84.7	66.9	50.7
$6\beta_3$	-1.1e-07	-1.9e-06	-1.5e-05	-1.3e-05	1.2e-05	2.9e-05
d^{neg}	118.7	139.7	119.8	117.9	––	––
fatigue confirmed	No	Yes	Yes	Yes	No	No

Source: Author's calculations

For high-debt countries, the pattern is similar with all countries sample, but the thresholds differ. The marginal fiscal response peaks and fiscal fatigue becomes present around 83 percent of GDP and turns negative at 118 percent of GDP in both baseline and extended specification. This means that high debt countries have relatively narrow debt range within which they still increase their primary balance, before fiscal adjustment capacity becomes exhausted.

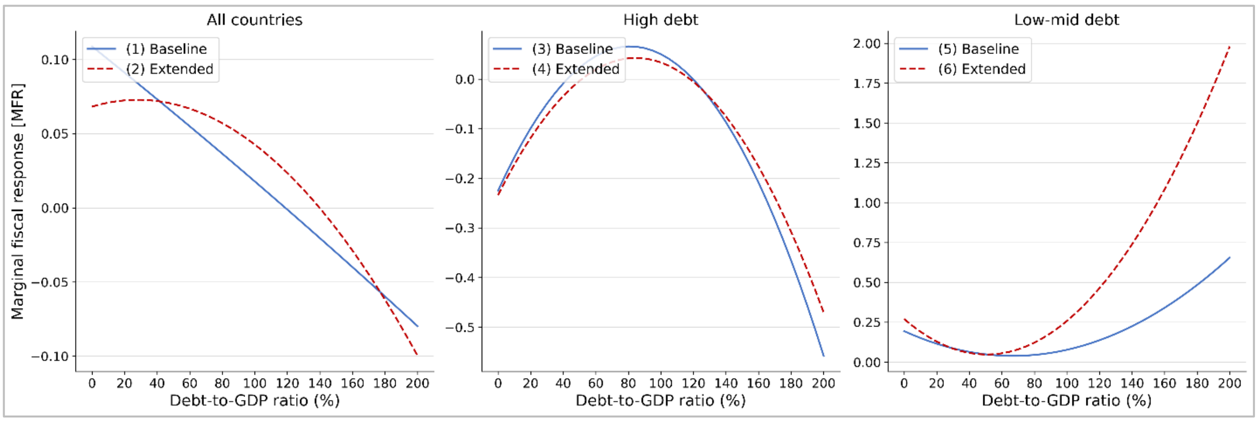

Figure 5. Marginal fiscal response across debt-to-GDP levels
Source: Created by author

The all-countries baseline model does not confirm fiscal fatigue in the strict sense, as the marginal fiscal response does not follow the expected inverted-U shape. The response is weakening from the start and turns negative at 119 percent of GDP, but without a clear peak it does not satisfy the theoretical definition of fatigue.

There is clear difference between the high debt and low-to-mid debt sample. For the group of low-mid debt countries, fiscal fatigue is not present in either specification. The marginal fiscal response is always positive and strengthens as debt rises, meaning these countries consistently increase their primary balance as debt grows, without signs of exhaustion. This is consistent with Ghosh *et al.* (2013) and the observation that countries not observed at high debt levels cannot be expected to exhibit the behaviour that is associated with high debt.

The evidence for non-linear fiscal behaviour consistent with fiscal fatigue is present, but it is concentrated mainly to high-debt countries and is sensitive to whether additional structural controls are included. In specifications where fiscal fatigue is confirmed, the threshold at which the fiscal response begins to weaken ranges from 28 to 85 percent of GDP depending on the sample, and the threshold beyond which the response turns negative ranges from approximately 118 to 140 percent of GDP.

3.1.3. Debt limit and fiscal space results

The country-specific debt limits and convergence levels are presented in table 8. The table presents the stable long-run debt ratio to which each country's debt converges, if the limit is not breached, and the debt limit beyond which debt grows without bound. Results are presented for all three interest-growth rate differential scenarios. Results marked with (—) have no finite debt limit or convergence point under that scenario given their estimated fiscal reaction function and the assumed interest rate-growth rate differential. The country specific fiscal space and room to lower convergence point results are presented in table 9.

As the difference increases across the interest rates and GDP growth projection scenarios, debt limits decrease across the board. The average estimated debt limit falls from 252 percent of GDP under historical rates to 225 percent under medium-term and 205 percent under long-term projections. The average fiscal space follows the same pattern, declining from 190 percentage points under historical rates to 166 under medium-term and 146 under long-term projections. More importantly, several countries lose their finite debt limit entirely as the differential narrows, meaning their historical fiscal behaviour is no longer sufficient to stabilise debt under projected interest rate conditions. For those countries, fiscal space drops to zero regardless of how large the fiscal space buffer was under historical conditions.

Table 8. Estimated debt limits and long-term convergence points by country and interest rate-growth rate scenario

		historical		medium-term		long-term	
country	2025 debt	d^*	$\bar{d}$	d^*	$\bar{d}$	d^*	$\bar{d}$
Austria	81	73	220	81	206	102	174
Belgium	107	64	228	81	196	100	167
Bulgaria*	29	22	298	28	267	N/A	N/A
Croatia*	56	59	251	64	240	N/A	N/A
Cyprus*	56	36	272	44	244	N/A	N/A
Czechia	43	52	253	71	210	88	180
Denmark	29	6	257	7	249	7	242
Estonia*	23	15	297	21	256	N/A	N/A
Finland	88	39	236	45	219	47	213
France	116	114	183	––	––	––	––
Germany	63	59	234	71	210	81	191
Hungary	74	58	264	114	165	––	––
Italy	136	––	––	––	––	––	––
Latvia	48	38	261	42	247	46	234
Lithuania	40	29	285	36	256	42	236
Malta*	47	32	297	43	254	N/A	N/A
Netherlands	45	39	259	45	238	56	210
Poland	60	53	261	71	217	89	186
Portugal	91	99	210	115	187	––	––
Romania*	59	54	278	84	210	N/A	N/A
Slovakia	62	71	233	81	214	91	197
Slovenia	65	58	248	65	230	76	209
Spain	100	105	199	107	196	––	––
Sweden	35	18	270	23	240	25	231
Average	65	52	252	61	225	65	205
Median	59	53	257	65	224	76	209

Source: Author's calculations
Notes:

1. Countries marked with an asterisk have no a projected long-term scenario available.
2. Results marked with (N/A) have no long-term scenario is available.
3. Results marked with (––) have no finite debt limit or convergence point under that scenario.

The estimated debt limits are considerably higher than those estimated by Ghosh *et al.* (2013), whose mean debt limit under historical conditions was around 196 and projected conditions 186 percent of GDP. One main driver of this difference is the interest rate-growth rate differential, which was positive or near zero for almost all the countries in Ghosh *et al.* (2013) sample, but in current sample, all countries have experienced negative differentials (Figure 4). This results in more favourable borrowing conditions and higher debt limits. This does not directly mean that the current fiscal position of the EU countries is much stronger than it was in advanced economies were twenty years ago. As differentials increase with projections, the limits decrease toward what Ghosh *et al.* (2013) found, which shows that the current debt estimates should not be read as clear evidence of permanently greater fiscal resilience. The results in this thesis are closer to those of Fournier and Fall (2017), who also found higher debt limits compared to Ghosh *et al.* (2013). This is partly because their sample covered the post-crisis period, when many countries were increasing their debt levels, which pushed up the estimated fiscal response and raised the calculated debt limits.

The estimation results for Italy are the most concerning as no finite debt limit exists under any of the three scenarios. Given Italy's estimated historical fiscal behaviour, the interest payment curve always lies above the estimated primary balance function, so there is no intersection and no convergent debt path. That means Italy's current debt level already exceeds what can be serviced under any of the assumed interest rate scenarios. Stabilising such debt ratio would require significant improvements in primary balance, beyond what has been historically observed. This is consistent with the original finding of Ghosh *et al.* (2013) for Italy and the result has not improved with the updated data. As a result, Italy has no calculable fiscal space under any scenario.

France presents a finite debt limit of 183 percent of GDP under historical differential rates, leaving a fiscal space of approximately 66 percentage points given its 2025 debt level of 116 percent (Table 9). This is already the smallest positive fiscal space in the sample under historical conditions. However, under medium and long-term projections, France's primary balance function does not intersect with interest payment curve at a finite debt level anymore, and no limit can be calculated. This suggests that France's current fiscal position depends on the continuation of favourable borrowing conditions.

Portugal, Spain and Hungary are also dependent on favourable borrowing conditions as they both retain finite debt limits under historical and medium-term differentials but lose them entirely under long-term projections. Portugal's fiscal space declines from 119 to 96 percentage points across the first two scenarios before disappearing, while Spain's follows a similar path at 99 and 96 percentage points. Hungary stands out as under historical rates, its differential was -5.1 per cent, resulting in a debt limit of 264 percent of GDP. Under the medium-term scenario, differential rises to close to zero and becomes positive in long-term scenario. As a result, Hungary moves from very comfortable borrowing position to one with no calculatable debt limit, which is entirely driven by the interest rate-growth differential.

Table 9. Fiscal space and room to lower convergence point based on 2025 debt level, by scenario

country	Fiscal space			Room to lower convergence		
	historical (2015-24)	medium-term (2025-27)	long-term (2026-30)	historical (2015-24)	medium-term (2025-27)	long-term (2026-30)
Austria	138	124	92	-8	-1	20
Belgium	121	89	59	-43	-27	-7
Bulgaria*	269	238	N/A	-7	-1	N/A
Croatia*	194	183	N/A	3	8	N/A
Cyprus*	216	188	N/A	-20	-12	N/A
Czechia	209	166	137	9	28	45
Denmark	228	220	213	-23	-22	-22
Estonia*	273	232	N/A	-9	-3	N/A
Finland	148	130	125	-49	-44	-42
France	66	––	––	-2	––	––
Germany	170	146	128	-4	7	17
Hungary	190	91	––	-15	40	––
Italy	––	––	––	––	––	––
Latvia	213	198	185	-11	-7	-2
Lithuania	245	216	196	-11	-4	2
Malta*	250	207	N/A	-15	-4	N/A
Netherlands	214	193	164	-7	0	11
Poland	202	158	127	-7	11	29
Portugal	119	96	––	8	24	––
Romania*	219	150	N/A	-6	25	N/A
Slovakia	171	152	135	9	19	29
Slovenia	183	165	143	-7	0	11
Spain	99	96	––	5	7	––
Sweden	235	205	197	-17	-12	-10
Average	190	166	146	-10	2	6
Median	202	165	137	-7	0	11

Source: Author’s calculations
Notes:
1. Countries marked with an asterisk have no a projected long-term scenario available.
2. Results marked with (N/A) have no long-term scenario is available.
3. Results marked with (––) have no finite debt limit or convergence point under that scenario.

Denmark, Sweden and the Baltic states consistently show the largest fiscal space across all scenarios. Denmark's debt limits are above 240 percent of GDP even under long-term projections, which gives a fiscal space of over 210 percentage points. These five countries show low current debt level, which contributes to making their positions stable across all three scenarios. For most remaining countries, fiscal space under historical rates is above 100 percentage points but narrows under projected conditions, with some countries losing close to half their estimated fiscal space by the long-term scenario.

The room to lower convergence point is negative for most countries under historical rates, which means debt is on a declining path when countries continue behaving as they have so far (Table 9) and economic conditions stay the same. Czechia, Portugal, Croatia and Spain have small positive values, which indicates that even under favourable historical conditions, their debt is still expected to rise when no other conditions change. Under medium-term projections the average room to lower convergence increases from -10 to 2 percentage points, while Hungary, Poland and Romania show the largest positive values, meaning their debt is expected to increase the most before reaching equilibrium. Under long-term projections, the pattern continues and Polands and Slovakias debt is expected to rise further 29 percentage points, while overall average increase is 6 percentage points. This means that an increasing number of countries are on a debt-increasing path under their historical fiscal behaviour once borrowing conditions turn less favourable, even if their current fiscal space point estimates remain positive.

3.1.4. Discussion of the results

Figure 6 shows that countries with lower current debt tend to have higher estimated debt limits and more fiscal space. The correlation between 2025 debt levels and historical scenario debt limits is -0.85 and statistically significant (Table 10). The main explanation is the interest rate-growth rate differential. High-debt countries have systematically less negative differentials compared to low-debt countries (Table 10). This means high debt countries differentials are less favourable and it is more expensive for them to borrow. For example, Italy has a historical differential of -0.29, which generates no fiscal space while countries like Estonia, Bulgaria and Malta have differentials below -6 percent points and fiscal space above 250.

This can be explained by two mechanisms discussed earlier in subsection 1.1.3. First of all, higher debt tends to increase sovereign risk premia, which raises borrowing costs and worsens the interest rate relative to growth rate (Ghosh *et al.*, 2013; Aizenman *et al.*, 2013). Second, high debt is associated with weaker long-term economic growth which can be caused by decreased public investment and higher private borrowing costs (Checherita-Westphal and Rother, 2012). Together, these effects decrease both sides of the differential and as a result, higher debt weakens the differentials and lowers the debt limit. A less negative differential also steepens the interest payment curve, which raises the primary balance required to stabilise debt at given level (Ghosh *et al.*, 2013). The long-term projection shows this dynamic for Italy, France, Portugal, Spain and Hungary.

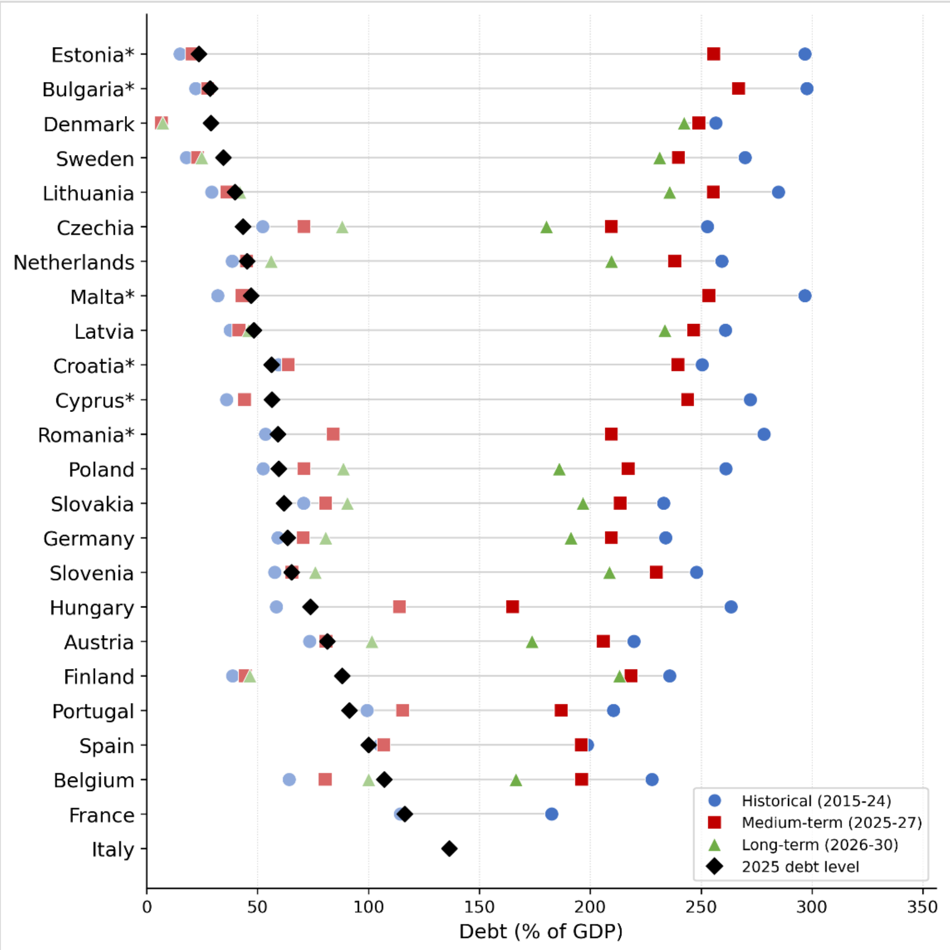

Figure 6. Level of debt in 2025 compared with debt limits and room to lower convergence point.
Source: Created by author
Notes: Countries marked with an asterisk do not have a projected long-term scenario available

Structural differences in the level of primary balance do not explain much of the variation in debt limits or fiscal space as the correlation between fixed effects and current debt level is -0.15 and not statistically significant (Table 10). This suggests interest rate-growth rate differential explains most of the variation between countries.

Estimated fiscal space values may appear rather large, over 150 percent of GDP, for many countries, but these results should not be interpreted as safe by default. During the COVID-19 pandemic, average debt level in EU increased about 13 percentage points in a single year and global financial crisis increased debt around 20 percentage points over three years (Kose *et al.*, 2021). If countries experienced similar shocks in the future, substantial share of fiscal space would get used up quickly, especially in countries where long-term fiscal space is already significantly below historical scenario.

Table 10. 2025 debt level correlation with historical interest rate-growth rate differential and country level fixed effects from fiscal reaction function.

	Debt limit (historical)	Interest rate-growth rate differential (historical)	Country-level fixed effects
2025 debt level	-0.85***	0.70***	-0.15

Source: Author's calculations

It is also important to note that the estimated debt limit is a ceiling and not a sustainable level. Markets tend to react earlier than this point is reached as investors lose their confidence earlier. This was seen during the European sovereign debt crisis, when borrowing costs increased sharply in multiple counties even when their debt levels were below their estimated limits (Aizenman *et al.*, 2013). The estimates presented here therefore indicate how much debt countries could sustain, not how much they can accumulate without facing pressure from market.

3.2. Robustness checks

This section presents robustness checks used to assess the stability of the main results under alternative specifications and sample choices. The checks help evaluate whether the estimated fiscal reaction function and potentially fiscal fatigue results remain consistent when different modelling assumptions are applied.

To ensure that the model results are not sensitive to how debt percentage variables are scaled, model was re-estimated after dividing debt percentage value by 100. Fiscal fatigue thresholds were also recalculated using this alternative scaling. The results, that are reported in appendix 4 and appendix 5, show that there is no meaningful change in model estimates, which means scaling of percentage variables does not affect the conclusions. Debt coefficients values changed, but fiscal fatigue thresholds derived from coefficients stayed the same.

To assess the sensitivity of the main results to the choice of estimation method, the fiscal reaction function is estimated again with four alternative methods: pooled ordinary least squares (OLS), country fixed effects without assuming an AR(1) error structure, country fixed effects with year effects without assuming an AR(1) error structure and country fixed effects with year effects assuming an AR(1) error structure. This is broadly similar to robustness check approach used by Ghosh *et al.* (2013) to examine if fiscal response to debt is robust across various estimation methods.

A common approach to address endogeneity issues in dynamic panels like in this paper is Generalized Method of Moments (GMM), which instruments the regressors with version of their own lags. However, GMM works best with large number of countries. In this case, there are up to 29 annual observations per country, which means that the instrument count would exceed the number of countries. This makes the Hansen validity test fail, especially in the high debt countries segment (Roodman, 2009). Given these limitations, this thesis relies on fixed effects and AR(1) error correction and GMM is not included as robustness check, similar to Ghosh *et al.* (2013).

Table 11 presents the robustness checks for all countries' extended fiscal reaction function, which was the base for evaluating fiscal fatigue and space. None of the four robustness specifications result in statistically significant coefficients on any of the three debt terms, which is consistent with the main results reported in table 3. It is expected that this is caused by high multicollinearity, similarly as discussed in main results. The sign structure of the cubic polynomial is not stable across estimation methods. More specifically, the coefficient of lagged debt is negative in the pooled OLS specification but positive in the three fixed effects specifications, while the quadratic and cubic terms also change sign between models. This can mean that OLS is not a suitable estimation method here as it assumes the same constant for all countries in the sample while fixed effects models assume that countries do not have a same constant.

Two cyclical controls are stable across the models, following the same sign structure in each of them and in main results. The output gap has a positive and statistically significant coefficient in all models. The government expenditure gap is consistently negative and significant. Extended control variables signs are mostly stable across the methods. As discussed in main results, this is consistent with previous findings in the fiscal reaction function literature (Bohn, 1998; Mendoza and Ostry, 2008; Ghosh *et al.*, 2013).

Table 11. All countries extended model robustness checks

Model Variable	OLS (1)	Fixed Effects (2)	FE+YearFE (3)	FE+YearFE+AR(1) (4)
debt	-0.0325	0.0808	0.0300	0.0596
	(0.0293)	(0.0904)	(0.0607)	(0.0526)
d_squared	0.0006	-0.0003	0.0002	0.0001
	(0.0005)	(0.0012)	(0.0008)	(0.0007)
d_cubed	-2.1e-06	2.5e-07	-1.9e-06	-1.5e-06
	(2.6e-06)	(5.0e-06)	(3.7e-06)	(3.3e-06)
outputgap	0.3349***	0.3668***	0.0969**	0.1320***
	(0.0373)	(0.0497)	(0.0358)	(0.0387)
govexpgap	-0.4237***	-0.4002***	-0.1954**	-0.1094***
	(0.0520)	(0.0680)	(0.0746)	(0.0357)
tradeopen	-0.0037**	0.0163	0.0359**	0.0348***
	(0.0018)	(0.0130)	(0.0165)	(0.0097)
inflation	-0.0219	0.0154	0.0057	0.0213
	(0.0401)	(0.0540)	(0.0604)	(0.0659)
agedep	0.1113***	-0.0514	0.0203	0.0160
	(0.0267)	(0.0705)	(0.0740)	(0.0767)
futureagedep	-0.1348***	-0.1857***	-0.0358	-0.0459
	(0.0210)	(0.0625)	(0.0779)	(0.0621)
polstab	2.7579***	1.8919*	2.0527***	1.0415*
	(0.3179)	(0.9221)	(0.6997)	(0.5429)
imfprog	0.7534	0.0759	0.0479	0.0577
	(0.5041)	(0.6930)	(0.6348)	(0.3893)
fiscalrule	1.6584***	0.3296	1.6948**	1.2034**
	(0.4534)	(0.8705)	(0.7716)	(0.5367)
_cons	-1.0243	6.3026*	-9.3588	-8.6761*
	(1.4877)	(3.0752)	(7.3021)	(4.5790)
N obs	647	647	647	623
N countries	24	24	24	24

Source: Author's calculations
Notes: Significance level values *, **, *** indicate significance at 10%, 5% and 1% level.

More certain and visible fiscal fatigue was present in high debt sample, which is why the robustness checks were also run for that samples extended specification. Results are presented in table 12. In contrast to the all country samples, the sign structure for debt terms is consistent across all the models. All estimation methods results are also showing clear signs of fiscal fatigue by following sign structure required by Ghosh *et al.* (2013): $\beta_1 < 0$, $\beta_2 > 0$, and $\beta_3 < 0$. This provides considerably stronger evidence of fiscal fatigue in the high debt segment. Core cyclical variables sign structure stays consistent across the estimation methods, but the other control variables sign structure varies more across estimation methods compared to the all countries robustness check.

Table 12. High debt country sample extended model robustness checks

Model Variable	OLS (1)	Fixed Effects (2)	FE+YearFE (3)	FE+YearFE+AR(1) (4)
debt	-0.5425*	-0.3699	-0.7347*	-0.5394**
	(0.3236)	(0.3655)	(0.3037)	(0.2543)
d_squared	0.0061*	0.0040	0.0085*	0.0062**
	(0.0035)	(0.0039)	(0.0032)	(0.0027)
d_cubed	-1.9e-05	-1.2e-05	-2.8e-05*	-2.1e-05**
	(1.2e-05)	(1.4e-05)	(1.1e-05)	(9.3e-06)
outputgap	0.6435***	0.6545***	0.3618	0.2503
	(0.0833)	(0.1117)	(0.2905)	(0.1795)
govexpgap	-0.4757***	-0.4332**	-0.1911**	-0.0643
	(0.1148)	(0.1227)	(0.0686)	(0.0975)
tradeopen	-0.0044	0.0459	0.1467***	0.1259***
	(0.0061)	(0.0510)	(0.0195)	(0.0294)
inflation	0.1976	0.0968	0.1677	-0.7652
	(0.2706)	(0.4462)	(0.5389)	(0.6229)
agedep	0.1154	0.0465	0.3068	0.3703*
	(0.0884)	(0.3339)	(0.1665)	(0.1986)
futureagedep	-0.2342***	-0.2857	0.0850	0.0420
	(0.0568)	(0.1352)	(0.0609)	(0.1020)
polstab	3.4792***	3.9006*	1.7451	1.4327
	(0.6881)	(1.8263)	(1.2988)	(1.3764)
imfprog	-0.7993	0.9172	-0.0789	2.3769
	(1.6778)	(2.1387)	(2.3033)	(1.6585)
fiscalrule	0.6023	-0.7700	5.9881*	4.2001**
	(1.0554)	(2.5614)	(2.1955)	(1.9176)
_cons	19.2371**	18.3304	-30.8132**	-27.4010***
	(8.8533)	(15.8730)	(10.0658)	(9.3556)
N obs	139	139	139	134
N countries	6	6	6	6

Source: Author's calculations
Notes: Significance level values *, **, *** indicate significance at 10%, 5% and 1% level.

Robustness checks support two conclusions. The instability of the sign structure across models for the full sample suggests that the shape of the fiscal reaction function is not stable across estimation methods, which can lead to fiscal fatigue not being a robust feature of EU fiscal behaviour when low and high debt countries are put together. By contrast, in the high-debt subsample, the expected sign structure is present across all estimation methods. The evidence for an inverted U-shaped marginal fiscal response is considerably more stable. This supports the finding that fiscal fatigue and polynomial shape of fiscal reaction function is concentrated to high debt country segment. The cyclical determinants of the primary balance are also robust across different estimation methods.

3.3. Limitations

Several methodological limitations should be kept in mind when interpreting the results. First, the fiscal reaction function is estimated under the assumption that all countries respond similarly to rising debt at any given debt level. While the robustness checks support this assumption for the high-debt group, it does not support it across the full sample.

The sample ranges from 1996 to 2024, which raises two related concerns. Both output and government expenditure gaps are constructed with HP filter, which is known to produce unreliable estimates near ends of the sample. Combined with the relatively short time series available for each country, ends of the sample may be measured with less precision. This can affect both the estimated coefficients and the fixed effects used to calculate debt limits.

The interest payment schedule is treated as linear throughout, with a fixed differential applied across all debt levels. In practice, borrowing costs are endogenous to debt levels, which means that as debt approaches the limit, markets demand higher risk premia, which steepens the interest payment schedule and lowers the effective debt limit. Ghosh *et al.* (2013) discusses this and notes that their linear approach overestimates the true limit. The same applies here, meaning the true fiscal space estimates would be lower.

CONCLUSION

This thesis estimated country specific debt limits and fiscal space for European Union countries by using debt sustainability framework of Ghosh *et al.* (2013) for a panel of 24 European Union member countries over the period 1996 to 2024. To answer the research questions, four main steps were taken in the thesis: a cubic polynomial fiscal reaction function was estimated, fiscal fatigue thresholds derived, country-specific interest rate-growth rate differentials determined under three projection scenarios, and debt limits and fiscal space calculated for each country.

The first research question asks whether the fiscal reaction function estimated for EU countries exhibits non-linear behaviour consistent with fiscal fatigue, and at what debt level the primary balance response begins to weaken. Fiscal fatigue is confirmed in the extended all-countries model and in the high-debt country subsample, where the marginal fiscal response follows an inverted U-shape, consistent with the theoretical expectation. In the extended all-countries model, fiscal fatigue starts at approximately 28 percent of GDP and turns negative at around 140 percent of GDP. In the high-debt subsample, the response starts to weaken at 83 percent of GDP and turns negative at 118 percent of GDP.

For low-to-mid debt countries, fiscal fatigue is not detected and the marginal response remains positive and even strengthens as debt rises. The finding that fiscal fatigue occurs at relatively low debt levels, particularly in the full sample, suggests that EU governments do have limited capacity for primary balance adjustment compared to what a linear view of fiscal behaviour would imply. Countries that have exceeded the threshold where the fiscal response weakens are therefore more constrained than their debt level might indicate.

The second research question asks what debt limits the framework implies for EU countries under different interest rate-growth rate differentials, and how these vary across countries. The average estimated debt limit declines from 252 percent of GDP under historical rates to 225 percent under medium-term projections and 205 percent under long-term projections. Italy has no finite debt limit under any scenario, meaning its historical fiscal behaviour is insufficient to stabilise debt regardless of the interest rate assumption, consistent with Ghosh *et al.* (2013). France retains a finite limit under historical conditions but loses it under both forward-looking scenarios. Portugal, Spain and Hungary follow the same pattern.

The estimated limits are higher than those in Ghosh *et al.* (2013). The difference is driven almost entirely by the negative interest rate-growth rate differentials EU countries have experienced in recent years while such environment was not present in Ghosh *et al.* (2013) sample. As differentials normalise, limits fall rather sharply, and countries that currently appear to have substantial room lose their calculable debt limit altogether. This can be seen with long-term projected differential. Cross-country variation is also mainly explained by differences in the interest rate-growth rate differential. More specifically, high-debt countries face systematically higher differentials due to higher risk premia and weaker growth, which both raises their interest payment burden and lowers the debt limit.

The third research question asks how much fiscal space EU countries retain and which face the most constrained positions. Average fiscal space declines from 190 percentage points under historical conditions to 146 under long-term projections. Denmark, Sweden and the Baltic states have the largest fiscal space buffers across all scenarios. They have low debt levels and have experienced very favourable differentials. Italy has no calculable fiscal space under any scenario, while France, Portugal, Spain and Hungary retain fiscal space under historical conditions, but not under forward-looking conditions. However, the debt limit should be interpreted as a ceiling as markets tend to increase borrowing costs well before it is reached. This means the fiscal space can decrease quickly if interest rates start to increase. Recent fiscal shocks during the COVID-19 pandemic also showed that a substantial share of the fiscal space can be used up rather quickly. This means actual fiscal space can be even more conservative than currently estimated.

There are several limitations to the analyses though. The fiscal reaction function assumes homogeneous country behaviour at any given debt level as most countries behaviour is not observed across all debt levels. Additionally, the interest payment schedule is treated as linear, even though in reality, interest rates start to increase rapidly the higher the debt level is. This causes the true debt limits to be lower than estimated. Future research could address these issues through country-level specifications and with a framework that account for the endogeneity of borrowing costs to debt. Despite the limitations, results show that the debt sustainability in many EU countries relies on favourable interest rate and growth rate conditions, which means when conditions change, countries debt sustainability weakens noticeably.

KOKKUVÕTE

AVALIKU SEKTORI VÕLA JÄTKUSUUTLIKKUS JA EELARVERUUM EUROOPA LIIDU RIIKIDES

Elerin Varek

Avaliku sektori võlatase on Euroopa Liidu (EL) riikides viimaste kümnendite jooksul märkimisväärselt kasvanud, eriti pärast üleilmset finantskriisi ja COVID-19 pandeemiat. Võlataseme kasv on jätkunud ning ka ettevaatavad prognoosid viitavad võlakoormuse jätkuvale kasvule. See on tõstatanud küsimuse, kui jätkusuutlik on riikide võlakoormus tegelikult ning kas valitsustel säilib piisav suutlikkus oma võlakohustusi täita.

Käesoleva magistritöö eesmärk on hinnata riigipõhiseid võlapiire ja eelarveruumi EL-i riikide jaoks, rakendades Ghosh jt (2013) raamistikku ajakohastatud andmetega ning EL valimil. Töös käsitletakse kolme uurimisküsimust:

1. Kas EL-i riikide eelarve reaktsioonifunktsioon näitab eelarveväsimusele iseloomulikku mittelineaarset käitumist ning millisel võlatasemel eelarve reageering nõrgenema hakkab?
2. Milliseid võlapiire raamistik implikeerib eri intressimäära ja majanduskasvu diferentsiaali stsenaariumide korral ning kuidas need riigiti erinevad?
3. Kui suur on üksikute EL-i riikide eelarveruum ning millistes riikides on võla jätkusuutlikkus kõige rohkem ohus?

Analüüs põhineb tasakaalustamata paneelandmestikul, mis hõlmab 24 EL-i liikmesriiki ajavahemikul 1996–2024. Riigid on jaotatud kolme gruppi: kõik riigid, kõrge võlakoormusega riigid ning madala ja keskmise võlakoormusega riigid. Eelarve reaktsioonifunktsioon hinnatakse kuuppolünoomina, mis sisaldab riigipõhiseid fikseeritud efekte ja AR(1) veastruktuuri. Seejärel arvutatakse riigipõhised võlapiirid ja eelarveruum kolme intressimäära ning SKP kasvumäära diferentsiaali stsenaariumi alusel: ajalooline stsenaarium, keskpika perioodi prognoos ja pikaajaline prognoos.

Tulemused näitavad, et eelarveväsimus leiab kinnitust laiendatud täisvalimi spetsifikatsioonis ning kõrge võlakoormusega riikide valimis, kus marginaalne eelarvereageering järgib ümberpööratud U-kuju. Täisvalimi laiendatud spetsifikatsioonis hakkab primaarse eelarve reageering nõrgenema juba umbes 28 protsendi suuruse võlakoormuse juures SKP-st ning muutub negatiivseks ligikaudu 140 protsendi tasemel SKP-st. Kõrge võlakoormusega riikide allvalimis on vastav lävend kõrgem, nõrgenemine algab umbes 83 protsendi juures SKP-st ning reageering muutub negatiivseks ligikaudu 118 protsendi tasemel SKP-st. Madala ja keskmise võlakoormusega riikide puhul ei tuvastata eelarveväsimust kummagi spetsifikatsiooni korral.

Hinnatud võlapiirid vähenevad koos intressimäära ja majanduskasvu diferentsiaali halvenemisega. Keskmine hinnatud võlapiir langeb ajaloolise diferentsiaali korral 252 protsendilt SKP-st keskpika perioodi prognoosi puhul 225 protsendini ning pikaajalise prognoosi puhul 205 protsendini. Itaalial puudub lõplik võlapiir kõigi kolme stsenaariumi korral, kuna riigi ajaloolise eelarvekäitumise põhjal ei ole võlg ühegi diferentsiaali eelduse korral stabiliseeritav. Prantsusmaal eksisteerib lõplik võlapiir ainult ajalooliste määrade korral, samas kui Portugal, Hispaania ja Ungari kaotavad lõpliku võlapiiri pikaajalise prognoosi puhul.

Keskmine eelarveruum väheneb ajalooliste määrade korral 190 protsendipunktilt 146 protsendipunktini pikaajaliste prognooside puhul. Taani, Rootsi ja Balti riigid näitavad kõigi stsenaariumide korral järjepidevalt suurimat puhvrit, mis tuleneb eelkõige madalast võlatasemest ja seni soodsast intressimäära ning majanduskasvu diferentsiaalist. Diferentsiaal on ühtlasi peamine riikidevaheliste erinevuste selgitaja. Kõrge võlakoormusega riigid seisavad silmitsi süsteemselt kõrgemate diferentsiaalidega, kuna kõrgem riskipreemia ja aeglasem majanduskasv mõjutavad nii intressikulusid kui ka võlapiiri ulatust.

Tulemused näitavad, et paljude EL-i riikide võla jätkusuutlikkus sõltub praegu soodsatest laenamistingimustest. Kui need tingimused halvenevad või normaliseeruvad, nõrgenevad mitme riigi võla jätkusuutlikkuse väljavaated märkimisväärselt.

LIST OF REFERENCES

Abiad, A., & Ostry, J. (2005). Primary surpluses and sustainable debt levels in emerging market countries. *IMF Policy Discussion Papers*, *2005*(006), 1. https://doi.org/10.5089/9781451975703.003

Aizenman, J., Hutchison, M., & Jinjarak, Y. (2013). What is the risk of European sovereign debt defaults? Fiscal space, CDS spreads and market pricing of risk. *Journal of International Money and Finance*, *34*, 37–59. https://doi.org/10.1016/j.jimonfin.2012.11.011

Alesina, A., & Drazen, A. (1991). Why are stabilizations delayed? *The American Economic Review*, *81*(5), 1170–1188. http://www.jstor.org/stable/2006912

Beqiraj, E., Fedeli, S., & Forte, F. (2018). Public debt sustainability: An empirical study on OECD countries. *Journal of Macroeconomics*, *58*, 238–248. https://doi.org/10.1016/j.jmacro.2018.10.002

Bi, H. (2012). Sovereign default risk premia, fiscal limits, and fiscal policy. *European Economic Review*, *56*(3), 389–410. https://doi.org/10.1016/j.euroecorev.2011.11.001

Bi, H., & Leeper, E. M. (2013). Analyzing Fiscal Sustainability. Bank of Canada. https://doi.org/10.34989/SWP-2013-27

Blanchard, O. (2019). Public debt and low interest rates. *American Economic Review*, *109*(4), 1197–1229. https://doi.org/10.1257/aer.109.4.1197

Bohn, H. (1998). The behavior of U.S. public debt and deficits. *The Quarterly Journal of Economics*, *113*(3), 949–963. https://doi.org/10.1162/003355398555793

Burriel, P., Checherita-Westphal, C. D., Jacquinot, P., Schön, M., & Stähler, N. (2020). Economic consequences of high public debt: Evidence from three large scale DSGE models. *ECB Working Paper Series No. 2450*. European Central Bank.

Catão, L. A., & Terrones, M. E. (2005). Fiscal deficits and inflation. *Journal of Monetary Economics*, *52*(3), 529–554. https://doi.org/10.1016/j.jmoneco.2004.06.003

Checherita-Westphal, C., & Rother, P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European Economic Review*, *56*(7), 1392–1405. https://doi.org/10.1016/j.euroecorev.2012.06.007

Di Iorio, F., & Fachin, S. (2022). Fiscal reaction functions for the advanced economies revisited. *Empirical Economics*, *62*(6), 2793–2823. https://doi.org/10.1007/s00181-021-02114-4

European Commission. (2015). *Memorandum of understanding on financial assistance for Greece.* https://economy-finance.ec.europa.eu/document/download/54a27cc5-c22f-4d4b-bedd-c5ae98747c61_en

European Commission (2026), *Debt Sustainability Monitor 2025*, European Economy Institutional Paper, No. 332.

Estefania-Flores, J., Furceri, D., Kothari, S., & Ostry, J. D. (2023). Worse than you think: Public debt forecast errors in advanced and developing economies. *Journal of Forecasting*, *42*(3), 685–714. https://doi.org/10.1002/for.2942

Fournier, J.-M., & Fall, F. (2017). Limits to government debt sustainability in OECD countries. *Economic Modelling*, *66*, 30–41. https://doi.org/10.1016/j.econmod.2017.05.013

Ghosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D., & Qureshi, M. S. (2013). Fiscal fatigue, fiscal space and debt sustainability in advanced economies. *The Economic Journal*, *123*(566), F4–F30. https://doi.org/10.1111/ecoj.12010

Hamilton, J. D., & Flavin, M. A. (1986). On the limitations of government borrowing: A framework for empirical testing. *American Economic Review*, *76*(4), 808–819.

Heller, P. (2005). Understanding fiscal space. *IMF Policy Discussion Papers*, *2005*(004), 1. https://doi.org/10.5089/9781451975635.003

Hodrick, R. J., & Prescott, E. C. (1997). Postwar U.S. business cycles: An empirical investigation. *Journal of Money Credit and Banking*, *29*(1), 1. https://doi.org/10.2307/2953682

International Monetary Fund. (2012). *Greece: Letter of intent, memorandum of economic and financial policies, and technical memorandum of understanding.* https://www.imf.org/external/np/loi/2012/grc/030912.pdf

International Monetary Fund. (2018). *Ireland: 2018 Article IV consultation.* https://www.imf.org/-/media/files/publications/cr/2018/cr18194.pdf

International Monetary Fund. (2023). *Luxembourg: 2023 Article IV consultation*. https://www.imf.org/-/media/files/publications/cr/2023/english/1luxea2023001.pdf

Kose, M. A., Nagle, P., Ohnsorge, F., & Sugawara, N. (2021). *What has been the impact of COVID-19 on debt? Turning a wave into a tsunami* (Policy Research Working Paper No. 9871). World Bank. https://doi.org/10.1596/1813-9450-9871

Kose, M. A., Kurlat, S., Ohnsorge, F., & Sugawara, N. (2022). A cross-country database of fiscal space. *Journal of International Money and Finance*, *128*, 102682. https://doi.org/10.1016/j.jimonfin.2022.102682

Lukkezen, J., & Rojas-Romagosa, H. (2016). A stochastic indicator for sovereign debt sustainability. *FinanzArchiv Public Finance Analysis*, *72*(3), 229–267. https://doi.org/10.1628/001522116x1473325697904

Medeiros, J. (2012). *Stochastic debt simulation using VAR models and a panel fiscal reaction function : results for a selected number of countries*. European Commission. https://data.europa.eu/doi/10.2765/26702.

Mendoza, E. G., & Ostry, J. D. (2008). International evidence on fiscal solvency: Is fiscal policy "responsible"? *Journal of Monetary Economics*, *55*(6), 1081–1093. https://doi.org/10.1016/j.jmoneco.2008.06.003

Perotti, R., 2007. Fiscal policy in developing countries: A framework and some questions. *Policy Research Working Paper 4365*, World Bank, Washington, DC.

Reinhart, C. M., & Rogoff, K. S. (2010). Growth in a time of debt. *American Economic Review*, *100*(2), 573–578. https://doi.org/10.1257/aer.100.2.573

Reinhart, C. M., & Rogoff, K. S. (2011). The forgotten history of domestic debt. *The Economic Journal*, *121*(552), 319–350. https://doi.org/10.1111/j.1468-0297.2011.02426.x

Reis, R. (2021). The constraint on public debt when r < g but g < m. *BIS Working Papers No. 939*. Bank for International Settlements.

Roodman, D. (2009). A note on the theme of Too many instruments. *Oxford Bulletin of Economics and Statistics*, *71*(1), 135–158. https://doi.org/10.1111/j.1468-0084.2008.00542.x

Salamaliki, P. K., & Venetis, I. A. (2023). Fiscal space and policy response to financial crises. *Review of International Economics*, *31*(3), 865–893. https://doi.org/10.1111/roie.12653

Trabandt, M., & Uhlig, H. (2011). The Laffer curve revisited. *Journal of Monetary Economics*, *58*(4), 305–327. https://doi.org/10.1016/j.jmoneco.2011.07.003

Trehan, B., & Walsh, C. E. (1988). Common trends, the government's budget constraint, and revenue smoothing. *Journal of Economic Dynamics and Control*, *12*(2-3), 425–444. https://doi.org/10.1016/0165-1889(88)90048-6

Trehan, B., & Walsh, C. E. (1991). Testing intertemporal budget constraints: Theory and applications to U.S. federal budget and current account deficits. *Journal of Money, Credit and Banking*, *23*(2), 206–223. https://doi.org/10.2307/1992777

UN Trade and Development. (2023). State of Commodity Dependence 2023. In *UN Trade and Development*. United Nations. https://unctad.org/system/files/official-document/ditccom2023d3_en.pdf

Wilcox, D. W. (1989). The sustainability of government deficits: Implications of the present-value borrowing constraint. *Journal of Money, Credit and Banking*, *21*(3), 291–306. https://doi.org/10.2307/1992415

Wyplosz, C. (2020). *What's wrong with fiscal space?* (CEPR Discussion Paper No. DP14431). Centre for Economic Policy Research.

APPENDICES

Appendix 1. Interest rate-growth rate differentials table

Table 13. Interest rate-growth rate differentials by country

country	Historical	Medium-term	Long-term
Austria	-1.96	-1.24	0.02
Belgium	-2.15	-0.47	0.60
Bulgaria*	-6.55	-3.80	N/A
Croatia*	-3.89	-3.15	N/A
Cyprus*	-4.71	-2.52	N/A
Czechia	-3.73	-1.00	0.30
Denmark	-2.01	-1.40	-0.87
Estonia*	-6.12	-2.48	N/A
Finland	-1.57	-0.44	-0.12
France	-1.40	-0.26	0.58
Germany	-2.41	-0.98	-0.11
Hungary	-5.08	-0.09	0.59
Italy	-0.29	0.30	1.29
Latvia	-3.72	-2.63	-1.72
Lithuania	-5.61	-3.16	-1.72
Malta*	-6.98	-3.31	N/A
Netherlands	-3.63	-2.07	-0.28
Poland	-4.52	-1.61	-0.16
Portugal	-2.70	-1.82	-0.40
Romania*	-6.28	-1.73	N/A
Slovakia	-2.95	-1.85	-1.07
Slovenia	-3.57	-2.37	-1.19
Spain	-2.09	-1.99	-0.56
Sweden	-3.63	-1.24	-0.62
Average	-3.24	-1.53	-0.20
Median	-3.63	-1.77	-0.22

Source: Author's calculations
Notes:

1. Countries marked with an asterisk have no a projected long-term scenario available.
2. Results marked with (N/A) have no long-term scenario is available.

Appendix 2. Fiscal reaction function estimates including Ireland, Luxembourg and Greece in sample

Table 14. Estimated fiscal reaction functions with Ireland, Luxembourg and Greece included in the sample

scenario	all countries		high debt		low-mid debt	
variable	(1)	(2)	(3)	(4)	(5)	(6)
debt	0.0011	-0.0240	-0.1579	-0.2230	0.1289	0.1241
	(0.0488)	(0.0527)	(0.1219)	(0.1331)	(0.1074)	(0.1094)
d_squared	0.0006	0.0009	0.0020	0.0027*	-0.0019	-0.0017
	(0.0005)	(0.0006)	(0.0011)	(0.0012)	(0.0024)	(0.0024)
d_cubed	-3.0e-06*	-3.0e-06	-6.0e-06*	-8.0e-06*	1.4e-05	1.4e-05
	(1.0e-06)	(2.0e-06)	(3.0e-06)	(4.0e-06)	(1.7e-05)	(1.6e-05)
outputgap	0.4104***	0.3704***	0.4246***	0.3979***	0.4025***	0.3712***
	(0.0288)	(0.0311)	(0.0641)	(0.0685)	(0.0287)	(0.0308)
govexpgap	-0.2515***	-0.2405***	-0.1907*	-0.1467	-0.2937***	-0.2766***
	(0.0401)	(0.0423)	(0.0834)	(0.0960)	(0.0416)	(0.0412)
tradeopen		0.0300***		0.0410		0.0221**
		(0.0091)		(0.0232)		(0.0089)
inflation		0.0384		-0.3367		0.1067*
		(0.0689)		(0.2033)		(0.0609)
agedep		-0.0521		0.0398		-0.0528
		(0.0782)		(0.3326)		(0.0693)
futureagedep		-0.1458**		-0.1227		-0.2047***
		(0.0580)		(0.1503)		(0.0675)
polstab		1.1862*		1.5370		0.3557
		(0.6403)		(1.3800)		(0.6550)
imfprog		-0.8706*		-1.0872		-0.4629
		(0.4682)		(1.0527)		(0.4569)
fiscalrule		0.1327		1.2488		0.0750
		(0.6716)		(2.2123)		(0.5848)
_cons	-2.1842	4.8489	1.6209	2.9406	-3.5205	7.4101
	(0.4124)	(1.1789)	(1.1157)	(2.9793)	(0.4998)	(1.2138)
N obs	734	704	251	240	483	464
N countries	27	27	9	9	18	18
rho	0.6873	0.6567	0.7246	0.7581	0.6707	0.6563
R^2 within	0.2413	0.2742	0.1764	0.2353	0.3290	0.3755

Source: Author's calculations
Notes: Significance level values *, **, *** indicate significance at 10%, 5% and 1% level.

Appendix 3. Linear fiscal reaction function estimates

Table 15. Estimated linear fiscal reaction functions

scenario	all countries		high debt		low-mid debt	
variable	(1)	(2)	(3)	(4)	(5)	(6)
debt	0.0434***	0.0562***	0.0289	0.0139	0.0600***	0.0739***
	(0.0120)	(0.0128)	(0.0195)	(0.0237)	(0.0156)	(0.0162)
outputgap	0.4312***	0.3947***	0.5982***	0.5688***	0.3870***	0.3495***
	(0.0270)	(0.0292)	(0.0643)	(0.0717)	(0.0292)	(0.0310)
govexpgap	-0.2769***	-0.2555***	-0.3317**	-0.2812**	-0.2585***	-0.2318***
	(0.0372)	(0.0380)	(0.0828)	(0.0910)	(0.0413)	(0.0410)
tradeopen		0.0342***		0.0516*		0.0306***
		(0.0091)		(0.0254)		(0.0095)
inflation		0.0631		-0.1032		0.0614
		(0.0592)		(0.2319)		(0.0583)
agedep		-0.0738		0.2453		-0.1072
		(0.0696)		(0.3138)		(0.0742)
futureagedep		-0.1697***		-0.1616		-0.1797**
		(0.0528)		(0.1214)		(0.0723)
polstab		0.4499		0.8339		0.2538
		(0.5711)		(1.1254)		(0.6546)
imfprog		0.1706		3.2927**		-0.3680
		(0.4283)		(1.0891)		(0.4491)
fiscalrule		0.1665		0.2774		0.0838
		(0.5715)		(2.1160)		(0.5769)
_cons	-2.8747	5.8209	-2.8317	-9.4084	-3.1963	8.2247
	(0.2077)	(0.9945)	(0.4743)	(2.9939)	(0.2374)	(1.1636)
N obs	649	623	168	161	481	462
N countries	24	24	6	6	18	18
rho	0.7034	0.6582	0.7423	0.7439	0.6712	0.6417
R^2 within	0.3187	0.3589	0.3904	0.4560	0.3069	0.3605

Source: Author’s calculations
Notes: Significance level values *, **, *** indicate significance at 10%, 5% and 1% level.

Appendix 4. Fiscal reaction function estimates with decimal form debt variable

Table 16. Estimated fiscal reaction functions where debt is expressed in decimal

scenario	all countries		high debt		low-mid debt	
variable	(1)	(2)	(3)	(4)	(5)	(6)
debt	10.8768	6.8169	-22.4988	-23.3856	19.3979*	26.9947**
	(6.3602)	(6.4216)	(28.1420)	(28.2921)	(10.9549)	(11.5313)
d_squared	-4.3848	1.6432	35.8400	32.6547	-23.2532	-43.9702*
	(9.0511)	(8.9012)	(29.7855)	(29.7815)	(23.4531)	(25.1461)
d_cubed	-0.1101	-1.9476	-14.7214	-12.8565	11.5935	28.9069
	(3.9354)	(3.8093)	(10.1885)	(10.1765)	(15.4015)	(16.9699)
outputgap	0.4354***	0.3983***	0.6101***	0.5803***	0.3917***	0.3573***
	(0.0270)	(0.0295)	(0.0643)	(0.0729)	(0.0294)	(0.0315)
govexpgap	-0.2670***	-0.2530***	-0.3046**	-0.2722**	-0.2478***	-0.2295***
	(0.0375)	(0.0381)	(0.0834)	(0.0915)	(0.0418)	(0.0410)
tradeopen		0.0328***		0.0486		0.0273**
		(0.0092)		(0.0256)		(0.0098)
inflation		0.0582		-0.0745		0.0537
		(0.0597)		(0.2323)		(0.0587)
agedep		-0.0958		0.2100		-0.1156
		(0.0732)		(0.3207)		(0.0765)
futureagedep		-0.1517**		-0.1551		-0.1698**
		(0.0556)		(0.1228)		(0.0739)
polstab		0.4455		0.8919		0.1130
		(0.5735)		(1.1337)		(0.6617)
imfprog		0.1670		3.1272**		-0.3778
		(0.4284)		(1.0928)		(0.4494)
fiscalrule		0.1291		0.1719		0.0729
		(0.5731)		(2.1225)		(0.5775)
_cons	-4.7393	5.3672	1.9885	-2.3835	-5.2487	6.2567
	(0.4184)	(1.0397)	(2.0330)	(3.4748)	(0.5210)	(1.2372)
N obs	649	623	168	161	481	462
N countries	24	24	6	6	18	18
rho	0.7034	0.6606	0.7638	0.7490	0.6765	0.6448
R^2 within	0.3187	0.3589	0.3904	0.4560	0.3069	0.3605

Source: Author's calculations
Notes: Significance level values *, **, *** indicate significance at 10%, 5% and 1% level.

Appendix 5. Fiscal fatigue thresholds derived from model with decimal form debt variable

Table 17. Estimated fiscal reaction functions where debt is expressed in decimal

sample	all countries		high debt		low-mid debt	
	(1)	(2)	(3)	(4)	(5)	(6)
d^{peak}	-13.3	0.3	0.8	0.8	0.7	0.5
$6\beta_3$	-0.1	-1.9	-14.7	-12.9	11.6	28.9
d^{neg}	1.2	1.4	1.2	1.2	––	––
fatigue confirmed	No	Yes	Yes	Yes	No	No

Source: Author’s calculations

Appendix 6. Non-exclusive licence

A non-exclusive licence for reproduction and publication of a graduation thesis[1]

I Elerin Varek

1. Grant Tallinn University of Technology free licence (non-exclusive licence) for my thesis "Public Debt Sustainability and Fiscal Space in European Union Countries", supervised by Karsten Staehr,

1.1 to be reproduced for the purposes of preservation and electronic publication of the graduation thesis, incl. to be entered in the digital collection of the library of Tallinn University of Technology until expiry of the term of copyright;

1.2 to be published via the web of Tallinn University of Technology, incl. to be entered in the digital collection of the library of Tallinn University of Technology until expiry of the term of copyright.

2. I am aware that the author also retains the rights specified in clause 1 of the non-exclusive licence.

3. I confirm that granting the non-exclusive licence does not infringe other persons' intellectual property rights, the rights arising from the Personal Data Protection Act or rights arising from other legislation.

11.05.2026

[1] *The non-exclusive licence is not valid during the validity of access restriction indicated in the student's application for restriction on access to the graduation thesis that has been signed by the school's dean, except in case of the university's right to reproduce the thesis for preservation purposes only. If a graduation thesis is based on the joint creative activity of two or more persons and the co-author(s) has/have not granted, by the set deadline, the student defending his/her graduation thesis consent to reproduce and publish the graduation thesis in compliance with clauses 1.1 and 1.2 of the non-exclusive licence, the non-exclusive license shall not be valid for the period*