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Economic Growth and Public Debt: Beyond Debt-Thresholds. Theoretical and Empirical Issues.

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Declaration

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature. The work was done with collaborative discussions and under the guidance of Professors Roberto Tamborini and Giuliana Passamani at the University of Trento, Italy. Chapter 4 was primarily done under the guidance of Professor Luigi Mittone (University of Trento).

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A national debt, if it is not excessive,
will be to us a national blessing.

— Alexander Hamilton (1755 - 1804)

Introduction and overview

Policymakers and economists have long been engaged in the debate about the evaluation of public debt, its impact on economic activity and growth, and whether and when it is necessary to curb it. As emerges from the initial quote about Alexander Hamilton, the idea that public debt can be excessive and that it could have positive as well as negative consequences has a long tradition.

The large fiscal imbalances created worldwide by the Great Recession of 2008 revived general interest in the issue and focused the attention on the developed countries. Indeed, early in 2010, at the Toronto summit, leading governments decided to implement a set of restrictive fiscal policies, whose aim was to reduce public budget deficits and, eventually, outstanding debts that were considered no longer sustainable and a burden on the future growth of the economies.

The epicentre of the implementation of these policies, commonly known as *austerity measures*, were the countries of the European Monetary Union (EMU), where the financial and the economic crisis was followed, between 2010 and 2012, by acute public debt crises. Consequently, many countries embittered, or were forced to embitter, also in compliance with the Eurozone fiscal rules, restrictive fiscal policies aiming at reducing quickly and consistently their public deficits and their public debts. As Chapter 3 will show, this was the case of those peripheral Eurozone countries that were heavily involved in the debt crisis (notably Greece, Portugal, and Ireland), and that suffered most the negative consequences of the austerity policies.

The idea that public debt may represent a burden for the economic system as a whole has distant origins and focuses on who and how should pay for debt, and with what consequences on the economy. Nevertheless, particularly influential both for academic research and the implementation of the fiscal corrective policies was the empirical paper proposed by Reinhart and Rogoff in 2010 at the dawn of the crisis. Reinhart and Rogoff (2010), in a large panel of countries, identified a critical threshold of 90% of the debt-to-GDP ratio beyond which debt is harmful to growth. Several countries in the world were fast approaching that threshold or already were well beyond it.

Though Reinhart and Rogoff's work was affected by many flaws, it has spurred buoyant empirical research in search of the general debt thresholds above which growth is jeopardised by public debt. Further works have supported the existence of critical debt-to-GDP ratios under various time and space observational fields, but results of these researches are inconclusive or controversial, as discussed in Chapter 2. Country-specific characteristics and contingencies play in fact a prominent role, thus prompting a branch of literature that attempts to comprehensively understand the debt-growth relationship and its determinants (see for instance Panizza and Presbitero, 2014; Eberhardt and Presbitero, 2015).

In contrast with the findings of the broad threshold literature and of many theoretical models, the idea that public debt is always harmful to economic growth has partially been reconsidered in the last few years. Nevertheless, the existence of a linkage between debt and growth has not been rejected: the long-run relationship between such macroeconomic variables is inevitably and broadly affected by heterogeneous factors.

However, in retrospect and as emerges in Chapter 1, one may say that the empirical pursuit of the debt-to-GDP threshold harmful to growth lacks deeper foundational work: why should we expect a negative public debt-growth relationship? In addition, if such a relationship exists, why should it take the specific form of a threshold of the debt-to-GDP ratio, and why should we expect this threshold to be equally valid across time and space?

These questions are the starting point of this Doctoral Thesis, which is organised as follows. Chapter 1 surveys the theoretical literature concerning public debt and economic growth, aiming at finding a theoretical foundation for the debt-threshold literature. Overall, there is no clear and straightforward answer to the questions of why we should expect a negative public debt-growth relationship in the first place, why it should take the specific form of a threshold of the debt-to-GDP ratio, and why we should expect this threshold to be equally valid across time and space. Or, from another perspective, there are many possible answers and many elements affecting them, thus reflecting the complexity of the argument, as well as the variety of the empirical situations.

In particular, the literature that I examine, on the one hand offers a rich variety of explanations and insights to researchers of the debt-growth relationship but, on the other, it does not provide any one-way conclusion: the relationship may be negative, positive, or even no relationship may exist, both from a theoretical and an empirical point of view. Even less is theoretically founded the existence of a general debt-to-GDP threshold above which growth is consistently stifled. Each country's specific characteristics, circumstances, and events have an overwhelming importance that cannot be encapsulated in a single general law.

In Chapter 1, I also present a fiscal model of endogenous growth that may help address the theoretical issues in an orderly and consistent manner along two specific coordinates of debt assessment: sustainability/unsustainability, and efficiency/inefficiency. The thrust of the model is that no meaningful assessment of debt and its effect on growth at any point in time is possible without reference to the whole debt trajectory and the specific state of the economy along the trajectory.

Chapter 2 reviews the empirical literature and focuses on the debt-growth relationship from an econometric point of view. As before, it is difficult to derive a univocal conclusion on the nature of such a relationship on the basis of the literature's findings: the existence of a significant negative relationship between debt and growth is the predominant thinking, though in contrast with the conclusions of several works.

For these reasons, the aim of Chapter 2 is to go to the roots of the debt-growth relationship, to investigate whether the outstanding debt and the GDP are linked. To this end, I have adopted a research methodology that differs from the most common employed in the literature on debt-to-GDP thresholds. First, my analysis does not hinge on any specific theory, and it should not be considered as a proof of a specific theoretical statement. Rather, it is based on the approach outlined by Hoover et al. (2008) and aims at understanding "what the data say" without imposing aprioristic theoretical structures.

A second methodological choice consistent with this approach is to treat the (growth of the) amount of public debt and (the growth of) GDP as the two genuine primitives, without imposing the debt-to-GDP ratio as a primitive

itself. In fact, for this to be possible, the two underlying primitives should display well defend statistical properties, namely cointegration and convergence towards a long-term equilibrium value, which are usually not tested in the literature.

Third, I believe that the heterogeneity, or non-generality, of results that I have pointed out before should be taken as an intrinsic feature of the problem at hand, so that a viable strategy is to restrict, rather than expand, the observational field. I have set time and space limits to my dataset by purpose: my analysis is based on a panel dataset including quarterly data for 25 Eastern and Western European countries from 1999Q1 to 2015Q4. The Eurozone represents a unique "field experiment" of a large number of countries where some key conditioning factors of fiscal policy are common and exogenous, namely fiscal targets and rules, monetary policy, and the exchange rate with the rest of the world.

The main result is that a long-run equilibrium relationship between GDP and debt exists for some countries — and debt and GDP tend to adjust towards it — but it is not generalisable. Where a relationship exists, it does not always imply that the debt-to-GDP ratio may be the appropriate variable for describing it. Moreover, cross-country heterogeneity and the role of the financial crisis and of the austerity periods remain substantial and overwhelming factors. Therefore, a unique equation describing the GDP-debt relationship does not seem to exist, which entails the impossibility to derive a meaningful general debt-to-GDP threshold.

Thus far I have focused on the general relationship between debt and growth from both the theoretical and the empirical points of view. Turning to the analysis of the Sovereign Debt Crisis and of the austerity period, Chapter 3 attempts to explain what has driven austerity — measured as the first difference of the cyclically adjusted structural primary balance — within a dataset of 28 European countries.

In the first part of this chapter I present a correlation analysis that describes the relationship between the variable *austerity* and each of the considered determinants, that are brought back to four main sets of variables: fiscal

discipline, market discipline, fiscal consolidation, and macroeconomic stabilisation.

The second part implements a panel econometric analysis based on the principal component factor analysis and on the pooled partial common correlation effect estimator. Results show that the variables and factors of the analysis are not able to fully explain austerity, though an important contribution is provided by the enforcement of the Eurozone fiscal rules (the adoption of excessive deficit procedures) and is partially counterbalanced by the cyclical position of the economy.

The last chapter, Chapter 4, aims at gaining insight into the role of debt and government expectations and their impact on growth under uncertainty conditions. In fact, it is possible that the effects of austerity measures in some countries, for instance the so-called PIIGS, were amplified by uncertainty. My ambition is to relate austerity with consumers' expectations, thus studying whether and when consumers' beliefs about public debt and government intervention affect their consumption, savings, and tax compliance choices with a direct impact, at the aggregate level, on economic growth.

Therefore, Chapter 4 implements a laboratory experiment to study how people react in a generalized framework in which public debt may be unexpectedly reduced. The debt dynamics arises endogenously: within a public good game, taxes are collected from all participants and are used to cover a given level of public expenditure, which is then equally distributed to the same participants at the beginning of each round. If the collected amount of taxes is lower than what the public expenditure would require, a deficit is generated. Moreover, reproducing a forced withdrawal, the outstanding amount of public debt can be reduced upon accessing subjects' savings.

Within this setting, expectations are directly elicited by asking subjects if they believe that public debt is going to be reduced, and if they think that the other subjects believe that public debt is sustainable. Therefore, it is possible to identify whether and how agents' allocations and expectations are affected by the public debt path. As mentioned above, a peculiarity of my approach is the endogenous dynamics of public debt: not only it avoids introducing

predetermined dynamics, but also increases the ecological validity of the experiment. Participants are indeed more psychologically involved in the debt mechanism and they might feel responsible for the raise in debt. On the other hand, an exogenous dynamics could depict public debt and tax compliance as irrelevant.

Results show that this experimental framework is characterized by relatively high and often increasing aggregate savings and relatively low and decreasing aggregate consumption. Interestingly, an increase in the debt-reduction expectations and a decrease in the perceived debt sustainability are also found to explain savings and consumption behaviours, as is shown in the econometric part of Chapter 4.

While this quick outlook of the thesis makes evident the importance of reconsidering the debt-growth relationship and the implementation of the austerity policies, further investigations are also necessary. The impact of austerity on inequalities, the causality direction between debt and growth, the distinction between internal and external debt, and the debt maturity structure are only some of the elements that should be reconsidered and analysed to answer still open questions and to fully depict the relationship between economic growth and public debt.

Chapter 1

Public Debt and Economic Growth: A Literature Review in Search of Theory

Abstract

The recent wave of research on the relationship between public debt and growth has been largely dominated by the pursuit of "the" debt-to-GDP ratio beyond which debt depresses growth; yet no univocal conclusion has been reached either about the quantification of the critical ratio or even about its existence. Foundational work is however lacking: why should we expect a negative public debt-growth relationship in the first place? If such a relationship exists, why should it take the specific form of a threshold of the debt-GDP ratio, and why should we expect this threshold to be equally valid across time and space? This chapter surveys the theoretical literature concerning public debt and economic growth. Overall, there is no clear and straightforward answer to the previous questions. Or, from another perspective, there are many possible answers and many elements affecting them, thus reflecting the complexity of the argument, as well as the variety of the empirical situations. In particular, I have found no direct or indirect theoretical foundation to the existence of a critical debt-to-GDP ratio with general validity. I also present a fiscal model of endogenous growth that may help address the theoretical issues in an orderly and consistent manner along two coordinates of the debt assessment: sustainability/unsustainability, and efficiency/inefficiency. The thrust of the model is that no meaningful assessment of debt and its effect on growth at any point in time is possible without reference to the whole debt trajectory and the specific state of the economy along the trajectory. In my view, research should concentrate on the study of specific conditions and cases and abandon the pursuit of a general law.

Keywords: public debt, debt sustainability, debt efficiency, Ricardian equivalence, debt burden, debt overhang, economic growth, endogenous growth models.

1. INTRODUCTION

Policymakers and economists have long been engaged in the debate about the evaluation of public debt, its impact on economic activity and growth, and whether and when it is necessary to curb it. The large fiscal imbalances created worldwide by the Great Recession of 2008-09 revived general interest in the issue. The epicentre became Europe, and the Eurozone in particular, where the Great Recession was followed by acute public debt crises between 2010 and 2012. As a result, many countries implemented, or were forced to implement, also in compliance with the fiscal rules of the Eurozone, restrictive fiscal policies aiming at reducing their budget deficit and, eventually, their public debt.

If not dictated by immediate threats, fiscal consolidation, the so-called *austerity*, was also prescribed as a requisite for reinstating sound growth conditions before prolonged fiscal stimuli to the economy became self-defeating as public debt was growing too high.

> There should be little question that European economies share the need to reduce public deficits and debts from levels that, as confirmed by a growing strand of empirical literature (Reinhart and Rogoff, 2010; Kumar and Woo, 2015) are likely to be harmful for growth in the medium term […] (Buti and Pench, 2012, p.1)

Reinhart and Rogoff (2010), in a large panel of countries, identified a critical threshold of 90% of the debt-to-GDP ratio beyond which debt is harmful to growth. Several countries in the world, notably in the Eurozone, were fast approaching that threshold or already were well beyond. The Reinhart-Rogoff finding has spurred a buoyant empirical research in search of the debt threshold above which growth is jeopardised by public debt. Hitherto results of these researches are inconclusive or controversial (a comprehensive review of such an empirical literature is given in Chapter 2).

In the first place, the work of Reinhart and Rogoff was criticized with regard to the implied causality (Irons and Bivens, 2010),[1] and then for some methodological and statistical problems (Herndon et al., 2013).[2] Further strictly empirical works support the existence of critical debt-to-GDP ratios under various time and space observational fields (but there is no agreement on their level: see, among others, Pattillo et al., 2011; Baum et al., 2012). Some authors point out the existence of a positive relationship between debt and growth above a certain threshold (Minea et al., 2012). A third group of studies do not completely deny the existence of a negative relationship between the two variables, but rather claim that a *general* threshold is unlikely to exist, and it provides no guidance towards the adoption of widespread policies of debt reduction (e.g. Bowdler and Esteves, 2013; Pescatori et al., 2014). Country-specific characteristics, contingencies and events play a prominent role, thus prompting a branch of literature that attempts to understand the debt-growth relationship and its determinants thoroughly (see, for instance, Panizza and Presbitero, 2014; Eberhardt and Presbitero, 2015).

In retrospect, one may say that the empirical pursuit of the debt-to-GDP threshold harmful to growth lacks deeper foundational work. In the first place, on the basis of the available theoretical literature, why should we expect a negative public debt-growth relationship? And, if such a relationship exists, why should it take the specific form of a threshold of the debt-to-GDP ratio, and why should we expect this threshold to be equally valid across time and space?

To address these questions, propedeutic for any empirical analysis, I focus attention on the possible theoretical underpinnings of the debt-growth relationship. In the first part of this chapter, in Sections 2 to 5, I shall explore the rather extended range and vintages of theoretical explanations that can be found in the literature, which presents itself as a scattered, heterogeneous and rather incoherent constellation of theories, models and case studies, with largely contradictory predictions. With the aim to provide the reader with an

[1] Their application of the Granger causality test has showed that debt does not cause growth and growth does not cause debt.

[2] The analysis was spoiled by coding errors, selective exclusion of available data, and unconventional weighting of summary statistics.

effective guide in the search for explanation of the debt-growth relationship, the material is organised in four blocks. The first two (Sections 2 and 3) comprise the literature descending from the roots of modern macroeconomics and their developments: the neoclassical and the Keynesian respectively. As will become clear later in the chapter, different findings have been described within the same theoretical approach. The third (Section 4) presents the two fundamental concepts of debt sustainability and efficiency within the public finance literature. The fourth (Section 5) and last block gathers another specialised literature concerned with problems of debt default. Of course, there are overlaps across this classification, which inevitably involves some degree of arbitrariness in the development of this chapter. Moreover, since the number of models dealing with debt and growth is relatively limited, I will present some works that do not directly deals with it but that are useful to describe the theoretical framework within which the debt-growth relationship can be studied.

One main problem is that a consistent theoretical framework for the debt-growth research is still missing. Therefore, in section 6 I will present a model within which the crucial issues in the debt-growth problem can be located, and possibly clarified, in a consistent and orderly manner. It is a non-standard fiscal model of endogenous growth freely inspired to Barro (1990) and Diamond (1965). In Barro (1990) endogenous growth is sustained by productive public expenditure fully covered by taxation. To introduce debt, I adopt a sequential economy with two-period generations *à la* Diamond (1965)[3] where public expenditure is financed by debt in the first period and the debt burden is covered by taxation in the second period. Thus, it is possible to characterise and discuss the debt-growth relationship in four scenarios centred on the *efficiency/inefficiency*, *sustainability/unsustainability* of debt, which embed some specific debt-growth relationships present in the literature.

Section 7 concludes: the literature that I have examined and organised, on the one hand offers a rich variety of explanations and insights to researchers of the

[3] The difference here is that the generations do not overlap, but I assume that they comply with the intergenerational pact that each generation leaves the same endowment of capital to the next one.

debt-growth relationship, but on the other it does not provide any one-way conclusion: the relationship may be negative, positive, or even no relationship may exist, whereas in other models either debt or growth is not directly included. Even less is theoretically founded the existence of a general debt-to-GDP threshold above which growth is consistently stifled. Each country's specific characteristics, circumstances, and events have an overwhelming importance that cannot be encapsulated in a single general law. Research should therefore concentrate on the former and abandon the pursuit of the latter.

2. NEOCLASSICAL VIEWS

The strand of literature discussing the neoclassical models is particularly vast and difficult to follow. On the one hand, they share common microfoundations as regards competitive markets, market clearing and optimising behaviour. On the other hand, they differ depending on whether they consider a one-period or a multi-period setup, a stock or a flow analysis, etc. Consequently, I shall not present and discuss here the details of such models, but I shall consider the most popular results only, with some examples from the literature: the standard neoclassical approach and the crowding out effect, the Ricardian equivalence, the unconventional expansionary fiscal consolidation approach, and the endogenous growth models.

2.1. Deficit spending and crowding out

Starting from the neoclassical approach, an early suggestion of negative effect of debt on growth is the well-known "crowding-out" effect of public budget deficits (for a reassessment see Bernheim, 1989), already introduced by Adam Smith in *The Wealth of Nations*. This class of earlier neoclassical models is characterized by perfectly rational consumers with a finite lifespan, with access to a perfect capital market, and where the consumption level is determined by a utility maximisation process. Analysis focuses on the amount of loanable funds in the capital market. In this context, a budget deficit increases lifetime

consumption because the required taxes are shifted to future generations. However, provided that the economic resources are fully employed as usually assumed in these models, an increase in consumption implies a lower level of savings. The interest rate rises to keep investments equal to savings, crowding-out private expenditure. In other words, the impact that the government deficit spending has on the economic system depends on the substitution between public expenditure and private expenditure.

If the government borrows a dollar from you, that is a dollar that you do not spend, or that you do not lend to a company to spend on new investment. Every dollar of increased government spending must correspond to one less dollar of private spending. Jobs created by stimulus spending are offset by jobs lost from the decline in private spending. We can build roads instead of factories, but fiscal stimulus can't help us to build more of both (Cochrane, 2009).

Note two important caveats, however. The first is that the extent of crowding out is largely seen as an empirical matter, and in some circumstances deficit spending may retain some limited positive effect on economic activity (Bernheim 1989). The second is that there is no explicit treatment of debt accumulation and its effects on growth over time: if deficit spending is ineffective on aggregate output today, this does not necessarily imply that debt will reduce growth tomorrow. Indeed, one may think that if the government creates a surplus in order to pay for debt, this will be neutral on the economy.

In this context, Diamond (1965) was the first to study the effects of debt on economic growth properly. Diamond (1965) was the first to design a neoclassical model aiming at exploring the effects of public debt within an infinitely long life and discrete-time economy, with a constant return to scale aggregate production function and with individuals that live for two periods of time. The government levies taxes on domestic lenders to finance its public debt, which is divided into external debt (borrowed from foreign lenders) and internal debt (borrowed from domestic lenders).

Diamond shows that external debt has negative effects on growth in the long-run because of the taxes needed to finance interest payments: in fact, taxes are

levied on domestic lenders whereas interests are paid to the foreign ones. Taxes reduce consumers' total lifetime income, and hence consumption. As a further consequence, taxes reduce savings and the capital stock.

Internal debt, on the other hand, entails both effects as well as a reduction in the capital stock due to the fact that individuals substitute government debt for physical capital in their portfolios. Therefore, within this model public debt crowds out private capital.

The 1990s have seen the emergence of discordant views. Some authors proposed models leading to opposite conclusions with respect to those of Diamond. For instance, Dotsey and Mao (1994) introduced distortionary taxation[4] and debt turned out to crowd-in investments. Ludvingson (1996) analysed deficit-financed fiscal policies in a forward-looking general equilibrium model and showed that the economy's response to an increase in government expenditure depends on how it is financed. In particular, distortionary taxes may lead to a decline in output, consumption and investments, while deficits may increase output and consumption. Moreover, deficit-financed cuts in income taxation may increase investments even though agents expect future taxes to be higher (due to the substitution between leisure and labour), a conclusion supported also by Lin (2000). Therefore, according to this branch of works, there are no crowding-out effects and the impact of government deficits on growth can be positive.

Recapitulating, earlier neoclassical views are nuanced. One may find support for the statement that public debt exerts a negative impact on growth through subsequent deficits mainly by way of substitution of public expenditure for private capital or through distortionary taxation. Some developments have included more elements of analysis, thereby leading to departures from the main crowding-out conclusion.

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[4] According to Kneller (1999), distortionary taxes in this context are those which affect the investment decisions of agents (with respect to physical and/or human capital), creating tax wedges and hence distorting the steady-state rate of growth. Non-distortionary taxation, on the other hand, does not affect savings and investment decisions and therefore has no effects on the growth rate.

An important feature of all these theories is that the effects of debt on growth arise because the government, in one way or another, manages to repay it. It may loosely be argued that high debt entails worse effects, but the level of debt *per se* is not examined specifically. As to the pursuit of threshold debt-to-GDP ratios, the standard neoclassical theory allows no inference about the optimal level of debt (Barro, 1979).

2.2. Ricardian equivalence

The celebrated paper by Barro (1974) on the so-called "Ricardian equivalence" between taxes and government debt in financing public expenditure paved the way to a restatement of the neoclassical approach in the modern framework of intertemporal optimisation (also Barro 1989a, 1989b). Drawing on an argument put forward by David Ricardo in his *Principles of Political Economy and Taxation*, taxpayers anticipate that deficit spending today entails higher taxes tomorrow and react by saving more. Therefore, the only effect of public deficits (or changes in the public debt) is to influence the timing of taxation. In the Barro's words:

> Households view as equivalent a current aggregate tax of $1 and a current budget deficit of $1 (Barro, 1984, Macroeconomics, pp. 373, 377)

The algebra of the Ricardian equivalence is relatively simple. Intertemporal accounting with free borrowing and lending at the market interest rate r and the no-Ponzi condition require, for any economic agent, that the present value of expenditures does not exceeds the present value of revenues. Let the government borrow $B_t = G_t - T_t$ at time t, where G_t is government purchases (government investments included), and T_t is taxation.[5] Therefore, the following constraint holds:

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[5] G_t is often called "public consumption", which is, however, misleading. First, G_t may include expenditure for current goods and service as well as expenditure for capital goods (i.e. public investments). Second, even with the former type of expenditure, the public sector does not "consume", say, health services, education or national defence. It produces them, and it is of course citizens who consume public goods and services. The public sector does employ resources to produce its supply of goods and services, which, as in any other production unit, include

$$(1.1) \quad B_t = -\sum_{n=1}^{\infty} \frac{B_{t+n}}{(1+r)^n}$$

that is, the present deficit equals the present value of future surpluses. This equivalence enters households' intertemporal budget constraint via the sequence of consumption of public goods, G_t, and of disposable incomes, (Y_t – T_t). Then, if C_t denotes the present private consumption, the households' intertemporal budget constraint implies:

$$(1.2) \quad C_t + \sum_{n=1}^{\infty} \frac{C_{t+n}}{(1+r)^n} = Y_t - T_t + \sum_{n=1}^{\infty} \frac{Y_{t+n} - T_{t+n}}{(1+r)^n}$$

Since $T_t = G_t - B_t$, then

$$(1.3) \quad C_t + \sum_{n=1}^{\infty} \frac{C_{t+n}}{(1+r)^n} = Y_t + B_t - G_t + \sum_{n=1}^{\infty} \frac{Y_{t+n} + B_{t+n} - G_{t+n}}{(1+r)^n}$$

The government constraint and rearrangement yield

$$(1.4) \quad C_t + G_t + \sum_{n=1}^{\infty} \frac{C_{t+n} + G_{t+n}}{(1+r)^n} = Y_t + \sum_{n=1}^{\infty} \frac{Y_{t+n}}{(1+r)^n}$$

that is, the present value of aggregate demand on the left-hand side is constrained by the present value of GDP, which is given by technology and resources, no matter how households and the government distribute their expenditures over time.

This approach received a great impulse between the 1970s and the 1980s. Barro (1979) proposed a specific model incorporating the Ricardian Equivalence and an empirical analysis supporting it, while in Barro (1989b, p.1) he concluded that the Ricardian Equivalence is a "good first-order approximation to reality", supported also by the empirical evidence. A noteworthy difference with earlier neoclassical models is that households are characterized by a sort of "inter-generational altruism", namely a sense of obligation to the next generation, as if they were living infinitely. If current public expenditure is

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capital, labour and intermediate goods. For instance, in the Barro model, G_t is purchases of the public sector in order to provide goods and services, and therefore appears as *absorption* of output. This is also misleading. Like any other sector, according to the National Accounts principles, the public sector *contributes* to the formation of GDP with the value added of its supply of goods and services, that is, total value *net* of intermediate goods. Since the public sector is a zero-profit institution, its value added is total labour incomes.

financed by resorting to public debt, the current generation will leave the necessary amount of money to the following generation in order to compensate the future increment in taxes. Thus, Ricardian equivalence has also the strong implication that public deficits have no effects on the interest rate. The hallmark of traditional neoclassical theory (and quite a popular argument about the negative effects of high indebtedness) is muted. Moreover, as already noted above, if creating a deficit is neutral on economic activity, correcting the deficit when the debt service falls due will also be neutral (taxpayers have already hoarded the equivalent of taxation). Hence Ricardian equivalence alone does not seem an appropriate approach to the debt-growth problem, at least as long as the government is on its intertemporal budget constraint. These aspects have raised doubts and debates also in the neoclassical camp fostering research of caveats and limitations to this theory.

As reported by Bernheim (1989), the Ricardian paradigm needs unrealistic assumptions to hold that make it implausible. Ricardian equivalence has also been tested in experimental laboratories by resorting, in general, to an overlapping generations design. Cadsby and Frank (1991) support the validity of the Ricardian equivalence, but further developments have found evidence of departures when more articulated experimental designs are employed (Slate et al., 1995; Ricciuti and Di Laurea, 2003). This brach of literature is briefly reviewed in Chapter 4.

Finally, it is worth mentioning a few alternative models that deviate from the standard framework devised by Barro. For instance, Woodford (1990) argues that "the analysis provided by the neoclassical model may not be an adequate guide to policy, even if certain of its predictions are correct" and that "the Ricardian equivalence fails because it does not consider imperfect financial intermediation". Therefore, he proposes a simple economy embedding credit constraints and finds that public debt can be efficient because it keeps interest rates higher and closer to time preference rates. At the same time, public debt can crowd investments in by a permanent increase in the level of the public debt.

In a similar vein, Aiyagari and McGrattan (1994) argue that government debt improves the liquidity of households by providing an additional means of smoothing consumption, while Holmstrom and Tirole (1998), interpreting government debt as a vehicle for storing wealth, claim that public-debt issuance serves as a collateral in the economy, a conclusion in line with Krishnamurthy and Vissing-Jorgensen (2012).

2.3. Expansionary fiscal consolidations

A new neoclassical variant was introduced in the 1990s under the name of "expansionary fiscal consolidations", or "Non-Keynesian effects of fiscal policy", and it maintains that consolidation policy is not harmful for growth but, on the contrary, may have a positive effect. Giavazzi and Pagano (1990), and Alesina and Perotti (1995) were among the first to empirically test this hypothesis, followed by Alesina and Ardagna (2010, 2013), and others. Their main conclusion, the fact that "even drastic fiscal adjustments are not associated with major recessions" (Alesina and Perotti, 1995, p.24), has been recovered in support of the Eurozone austerity policies,[6] that are analysed in Chapter 3.

Though framed within the modern intertemporal approach, this strand of literature was born — and has remained — essentially empirical, being based on analyses of success stories of fiscal consolidations followed by fast recovery. Indeed, these analyses boil down to the choice of a growth-friendly consolidation design: large, front-loaded, with expenditure cuts rather than tax hikes (Alesina and Ardagna 2010, 2013, Carnot 2013). As regards the fiscal mix, this recommendation is in line with the earlier model by Diamond (1965) and with the standard presumption that public expenditure is just consumption and taxes are distortionary. The recommendation of a large and front-loaded consolidation relies on the argument that incomplete or delayed consolidation raises the present value of future surpluses; this is matched with less current spending and more hoarding by the private sector with a depressive effect on economic activity. If the government fails to adopt the right consolidation

[6] See Blyth (2013, pp. 205 ff.) for a recollection of the evolution of this idea.

design, then the conclusion may be that the debt repayment has a negative effect on growth. Yet this conclusion also means that it is not the level of debt *per se* that can be pointed to as the determinant of future growth.

On the empirical ground, some recent studies have cast doubts on the reliability of expansionary consolidations and, more importantly, on their general value. For instance, Perotti (2012) studied four individual episodes in different countries. He showed that all these episodes were in fact associated with an increase in growth but the explanation of why this occurred was to be found in the specific conditions of those countries. In line with this finding, Guajardo et al. (2014) argued that once changes in fiscal policy are motivated by a "desire to reduce the budget deficit and not by responding to prospective economic conditions", there is little evidence of expansionary effects. Jordà and Tylor (2016) also concluded that a fiscal consolidation is always associated with a fall in real GDP over a period of five years.

The Eurozone is a natural observational field of large fiscal consolidations, and the prevalent assessments yield negative effects on subsequent growth at least in the short to medium run (Berti et al., 2013; in't Veld, 2013; Beetsma et al., 2015; Buti and Carnot, 2013). Critiques to the austerity policies implemented in the Eurozone hinge on the point that it was enacted too early and too much, with the economies dwelling in recession, thereby creating a strong procyclical effect (as to the wide debate on austerity see e.g. Corsetti (ed.) 2012; Gros and Maurer, 2012; Tamborini, 2015b). If the fiscal consolidation is procyclical, the debt-to-GDP ratio may rise instead of falling, as in fact happened throughout the Eurozone.[7] Such an effect, therefore, envisages a possible reverse causality between higher debt ratio and lower growth. On the other hand, success "Non-Keynesian" consolidation stories may in fact be due to several favourable Keynesian side conditions, regarding in particular the concomitant stance of monetary and exchange-rate policies (e.g. Favero et al., 2011; Perotti, 2012; Blyth, 2013, Part 3). That a fiscal contraction accompanied by expansionary

[7] This effect occurs when the fiscal multiplier is greater than the *reciprocal* of the initial debt-to-GDP ratio (Tamborini, 2013). Therefore, when the debt ratio is large, even a relatively small multiplier may produce the effect.

monetary policy and exchange-rate depreciation may end up with a neutral, or net positive, effect on GDP has been well known ever since the basic Mundell-Fleming model.

Can the expansionary fiscal consolidation hypothesis add insight into the debt-growth relationship? If taken at face value, this hypothesis seems to imply that (high) debt need *not* be harmful to growth, *if the problem lies in the extent of fiscal consolidation*, and *if specific conditions occur*. Its theoretical underpinnings, however, are seldom spelt out clearly. As said above, the framework is one where private agents anticipate and internalise in their constraints optimal spending decision and the future path of public expenditure and taxation for a given initial state of public borrowing (debt).

Leaving the neoclassical *homo oeconomicus* aside and intact, an interesting case in point should be that the public sector is *not* (no longer) on its intertemporal budget constraint. A simple device is an unexpected shock that raises outstanding debt. In that moment, the private agents discover that fiscal consolidation — the present value of future public surpluses — should be *larger* than previously expected. Then two alternative scenarios are possible: the government consolidates or not. In the former scenario, the effects on the economy arise as a consequence of consolidation. In the latter, they arise as an anticipation of future insolvency. As to the non-consolidation scenario, the theoretical framework should be different, and more challenging, precisely because one of the agents in the economy is drifting away from its intertemporal budget constraint (i.e. it is necessary to deal with out-of-equilibrium states). I shall return to this issue in Section 5.

2.4. The endogenous growth approach

Within the neoclassical approach, endogenous growth theory deserves a specific treatment. This approach spread during the 1990s attempting to explain how long-term growth can be generated without relying solely on exogenous or "residual" technological changes as in the Solow foundational model. This strand of literature is relevant because, following the model proposed by Barro (1990), it examines how fiscal variables interact with the variables that

generate endogenous growth, and I base my theoretical model on this paper. Interaction can be indirect (this is typically the case of taxation) or direct to the extent that public expenditure can sustain endogenous growth. This latter case is particularly important because it marks a shift of approach with respect to the neoclassical views examined above which typically see public expenditure as sheer consumption of resources. The Barro model obtains a typical inverted U function of the relationship between public expenditure and growth, with an optimal level of expenditure (taxation) that maximises growth. Public expenditure is fully covered by taxation (of capital incomes), and taxation depresses growth. Below the optimal level of public expenditure, the government does not exploit its growth-enhancing effect, beyond that point the growth-depressing effect of taxation prevails. On the other hand, the bulk of this literature is concerned with the effects of fiscal variables on growth along a balanced budget path, showing a rich variety of results and policy implications (see Zagler and Dürnecker, 2003 for an accurate survey), which, however, are not immediately suitable for analysis of the debt-growth problem.

More to the point, Teles and Cesar-Mussolini (2014) proposed an endogenous growth model in which the effect of fiscal policy on economic growth is negatively affected by the level of the debt-to-GDP ratio. This effect works via the debt interest: a portion of young people's savings is extracted and paid to elderly people, who do not save, thus implying an allocation exchange between generations. The negative effects of government debt on growth have been shown also by Saint-Paul (1992) and, by studying the impact of fiscal constraints on growth, i.e. limited tax and debt capacity, Aizenman et al. (2007) reached similar conclusions: lower maximal tax rate and higher outstanding debt can lower the growth rate, supporting the fact that differences in growth rates can stem from differences in fiscal policy constraints.

3. KEYNESIAN AND NEW-KEYNESIAN VIEWS

As for the neoclassical literature, the Keynesian and the New Keynesian models are heterogeneous and comprise a variety of different findings. In this section,

I shall present the most popular results, following primarily the historical development of these theories.

3.1. Fiscal multipliers

The hallmark of the Keynesian approach to fiscal policy is that the primary neoclassical assumption of fully employed resources is relaxed. It is instead assumed that resources are underemployed, or there is excess capacity in the output market and excess savings in the capital market. To put it in Cochrane's words, the dollar that the government borrows is not subtracted to other uses but is idle (Krugman, 2011). The interest rate need not change, which is, for opposite reasons, the same result with Ricardian equivalence. Consequently, in the basic Keynesian expenditure model of GDP, a fiscal expansion (e.g. a tax cut or an increase in the public expenditure financed with debt) has a multiplier effect on aggregate demand and total output, or the "fiscal multiplier" is greater than 1. Furthermore, if markets are incomplete, it has been argued that public deficits can assist capital formation and economic growth by encouraging the development of financial institutions (Ferguson, 2001, p. 135).

Bernheim (1989) recognises the advantages of the Keynesian approach, but he criticises some aspects related to the fact that budget deficits have not only positive effects but also negative effects when the Keynesian hypotheses are not completely satisfied. In fact, developments of the IS-LM apparatus re-introduced crowding-out effects, that are due to indirect changes in the interest rate (and, in an open economy, in the exchange rate) that reduce the magnitude of the multiplier. These variations in the interest rate have also a direct substitution effect on the private sector's goods and services. The everlasting debate on the magnitude of fiscal multipliers is still unsettled (see e.g. Hebous, 2011; Favero et al., 2011; Gechert et al., 2015), and it is not my direct concern here.

At first sight, one may argue that, as long as conditions of "large" fiscal multipliers prevail, the debt accumulation generated by deficit spending sustains the economy along its trend growth. By the same token, however, it may be argued that debt repayment, *to the extent that a fiscal restriction is*

necessary, has a negative effect. In fact, modern fiscal systems have developed a wide array of "automatic stabilisers" that generate deficits for stabilisation purposes which are (expected to be) self-repaying over the business cycle (Musgrave, 1959). "Let the stabilisers work", without large discretionary interventions, is in fact one of the pillars of the fiscal regulations of the Eurozone (e.g. Buti and Franco, 2005). Eventually contingent situations are more important. According to Favero at al. (2011),

> the question "what is the fiscal multiplier" is an ill-posed one. There is no unconditional fiscal policy multiplier. The effect of fiscal policy on output is different depending on the different debt dynamics, the different degree of openness and the different fiscal reaction functions across different countries (p. 1).

Another particular, indirect debt-growth channel that can be found in this context relates to the so-called "fiscal space". This is a measure of the extent of *fiscal expansion* a government enjoys, given its outstanding debt and some target or constraint on it.[8] The different indicators converge to the point that the higher the debt, the lower the fiscal space. Consequently, high debt inhibits the stabilisation capacity of the government. This consequence may have various negative implications, but it does not necessarily provide a debt-growth channel, especially if one espouses the mainstream view of the separation between cycle and growth trend. Persistent under-stabilisation may instead impinge on growth in the long-run if other phenomena are considered such as hysteresis (DeLong and Summers, 2012).

Overall, though traditional Keynesians would tend to think that (large and prolonged) fiscal restrictions depress economic activity, thus supporting the view that (high) debt reduces growth for this reason, this implication is not univocal. Yet, beyond the issue of the extent of fiscal multipliers, the earlier Keynesian theory of fiscal policy, like the neoclassical one, is ill-suited to address to debt-growth problem because there is no explicit treatment of debt

8 Different indicators have been proposed by e.g. Aizenman and Hutchison (2012), Ghosh et al. (2013), Buti and Carnot (2016).

accumulation and repayment. This said, the Keynesian view of fiscal policy to smooth fluctuations of economic activity has also been extend into a theory, positive and normative, of public debt as a means to redistribute over time, and across generations, the ensuing welfare costs and benefits (see the classic Musgrave 1959 and Section 4 of this chapter). From this point of view, the debt-growth relationship cannot be examined independently of the entire path of debt: when, how and to the benefit of whom it was created, when, how and on the shoulders of whom it falls due. I will consider this aspect in detail below.

3.2. Sovereign risk and confidence

In the so-called "New Keynesian macroeconomics", or "New Neoclassical Synthesis" developed since the early '90s, macromodels of sovereign risk should be mentioned (e. g. Buti and Pench, 2012 for an assessment with reference to austerity in the Eurozone). The key feature of these models is an attempt to directly address the issue of consolidation fiscal policy in the context of high public debt, and the issue whether it is sustainable or not. As is the hallmark of this school, we find a composition of Keynesian and neoclassical non-Ricardian features recasting in new clothes the traditional problem of the balance between negative and positive effects of the fiscal restriction via the interest rate. However, the involvement of the interest rate is not due to excess absorption of loanable funds (a *flow* concept), but to increasing sovereign risk (a *stock* concept). As aptly summarized by Buti and Pench (2012), the key factors can be encapsulated in a formula of the fiscal multiplier like the following:

[1 – confidence] ÷ [1 + (monetary policy) + (competitiveness) – (financial constraints)]

Confidence has two forward looking components. Financial investors believe that the fiscal restriction lowers the probability of future default and demand a lower risk premium. The domestic private sector enjoys a lower interest rate and anticipates the lower path of future taxes: both spur expenditure. The higher the confidence, the smaller the fiscal consolidation multiplier. Other

factors that reduce the multiplier relate to the side Keynesian factors mentioned above: the monetary policy stance (an accommodative stance helps reduce the interest rate and sustain aggregate demand) and competitiveness gains via real exchange rate depreciation (which also sustain the foreign component of aggregate demand). Finally, financial constraints, another typical New Keynesian feature, inhibit Ricardian neutrality and amplify the impact of the fiscal restriction on aggregate demand. The confidence channel has also been tested, and partially supported, through laboratory experiments (see Chapter 4). Unsurprisingly, such a rich set of factors yield nuanced results and, once again, results are conditional on the state of the economy and other side elements (Corsetti et al., 2010 and 2013).

In relatively extreme cases where fiscal strains are severe and monetary policy is constrained for an extended period, fiscal tightening may even exert an expansionary effect. That being said, fiscal retrenchment is no miracle cure. Indeed, all our simulations feature a deep recession even if tighter fiscal policy, under the aforementioned conditions, may stimulate economic activity *relative to an even bleaker baseline* (Corsetti et al., 2010, p. 41, italics added).

Other studies applied to the Eurozone share the same tone (Berti et al., 2013; Roeger and in't Veld J. 2013; Beetsma et al., 2015), though the prevailing conclusion is that fiscal consolidation has depressed growth, at least in the short-medium run. Another analysis dealing with this topic is proposed by Denes et al. (2012), who presents a New Keynesian DSGE model to study how fiscal policies affect budget deficit, how deficit affects expectations and, consequently, how deficit affects short-run aggregate demand. Among the findings emerges that "a commitment to reduce the size of the government in the long run or to reduce future labour taxes increases short-run demand" and also that "if higher deficits trigger expectations of higher future inflation, they are expansionary at a zero-interest rate, since this reduces the real interest rate and then increases demand" (Denes et al., 2012, p.5 and p.35).

4. PUBLIC FINANCE

4.1. Sustainability

Beside macroeconomic connections between debt and growth, the idea that public debt may represent a burden for the economic system has distant origins in public finance. Its focus is on who and how should pay for debt, and with what consequences on the economy. In this regard, such a public finance literature is complementary to, and more detailed than, the macroeconomic one explored so far, and it is propaedeutic to recent developments in debt sustainability analysis.

A formal definition of sustainability, based on financial first principles, states that the outstanding value of debt should not exceed the discounted value of the current and futures expected primary surpluses, and sustainability analysis seeks to identify and measure the ability of a government to meet its debt obligations. Hence the impact of debt repayment on the economy, according to different repayment strategies, is of course central to this analysis, which is in turn propaedeutic to debt-growth analyses where the probability of default is considered.

This definition is fraught with several implementation problems (e.g. the choice of the appropriate discount rate, time horizon, and budget items) leading to controversial if not inconclusive judgements. Therefore, less demanding, empirically based, criteria have been put forward.

Liviatan (1984) proposed a "macro-absorption" approach for the sustainability of the public debt burden and he classified the related indicators into three categories: naive, simple, and composite. Naive indicators concern the total amount of debt and the related measures, such as the interest rate and the maturity; simple indicators involve the debt service and the related ratios, while composite indicators are weighted averages of naive and simple indicators and aim at better identifying the debt burden and the approaching of a default. Further developments include, among others, Collignon and Mundschenk (1999), Arnone and Presbitero (2007), Fincke and Greiner (2012).

Particularly relevant is the approach put forward by Bohn (1995, 1998). It is based on the fiscal policy reaction function that relates the primary balance, as the control variable, to outstanding debt in such a way that the debt grows at a rate slower than the interest rate (for applications to the Eurozone countries, see e.g. Greiner et al., 2007; Ghosh et al., 2013; Passamani et al., 2015). One main merit of this approach, on which I shall return in Chapter 3, is that it allows for a relatively simple and measurable "fiscal effort" that should consistently be borne by the government (i.e. the relevant economic subjects) over time. In this regard, the composition of the effort (e.g. more taxes *vs*. less expenditure) may matter as suggested by the studies on the expansionary fiscal consolidations. However, the *evaluation* of sustainability of a given fiscal effort by the government is not simply a technical matter, but it also depends on the political assessment of its costs and benefits, or the costs and benefits of some degree of default, which leads to the political economy literature on the solvency/default choice of governments.

The debt burden is usually identified and described by some indicators, and the most common involve the debt service: the interest-to-debt ratio, the interest-to-external debt ratio, the interest-to-taxation ratio, or the interest-to-export ratio. The amount of external debt with respect to the total outstanding debt is considered as a measure of the external burden, a relevant indicator when the focus is on the foreign creditors.

In the mid-1950s, Sun (1954) distinguished between three interrelated concepts of debt burden: psychological (subjective and related to people's confidence in the government debt policies and in the stability of the economy), financial (referred to the amount of taxes required to repay the principal and the interest charges), and real economic burden (related to a decrease in national income, a decline in production, etc.). Sun concluded that the effective burden of the public debt depends on the economic conditions, and that some principles must be respected in order to minimize it. The analysis turned to incentives in Meade (1958), which argued that a reduction in public domestic debt can improve economic incentives, but there could be a cost if the economic conditions worsen in the short-run.

In summary, the debt burden view points out several channels whereby (high) public debt may directly or indirectly hamper economic growth and country's development. In fact, this has been the situation in which the high indebted poor countries have been entangled, and for which initiatives of debt reduction or even debt forgiveness has been widely proposed and studied in the last decades. These studies are important because they add further strength to the warning that specific conditions play a crucial role that can hardly be absorbed into a general law.

4.2. Efficiency

An important contribution coming from public finance is that public debt should be evaluated along its whole-time path rather than at a specific point in time. Indeed, debt is created for a reason or purpose, for instance to finance a specific public investment. Then, it unfolds its effects over time, and these effects are to be considered when assessing the relationship between debt and growth since they may, or may not, contribute to the future debt repayment according to the direct or indirect cash flows that it generates. Naturally, the sheer measurement of the debt level at some point may be uninformative or misleading.

To be more specific, assume that the amount of debt D_t at time t is observed. Thus, the corresponding debt-to-GDP ratio is $d_t \equiv D_t/Y_t$. It should be first recognised that these levels of debt and debt-to-GDP ratio belong to the joint trajectories $(D_{t-k}, \ldots, D_{t-1})$, $(Y_{t-k}, \ldots, Y_{t-1})$, $(d_{t-k}, \ldots, d_{t-1})$ determined by the underlying sequence of budgetary policies and their consequences on the economy. The observed values D_t and d_t may be the outcome of an *efficient* or *inefficient* trajectory, while subsequently they may turn out to be either sustainable or unsustainable. In this literature, the debt trajectory can be considered efficient if the use of debt is consistent with its purpose in terms of general criteria of economic efficiency, and if it has no distortionary effects on social equity and social welfare.

Efficiency implies sustainability *ex ante*. However, debt on an efficient trajectory may turn out to be unsustainable *ex post* owing to unforeseen events.

Two other scenarios are possible: debt may be inefficient but sustainable, and debt may be both inefficient and unsustainable. These four scenarios have quite different implications in terms of growth, and, what is more important, the level of debt and the corresponding level of the debt-to-GDP ratio along the trajectory are irrelevant on their own

An early example of this kind of analysis is the cyclical stabilisation role of fiscal policy theorised by Musgrave (1959). If debt is created during a slump and repaid during the recovery to equalise national income over the business cycle, both efficiency and sustainability (and intergenerational equity) are achieved.[9] The time profile of debt may be quite different in different specific conditions.

Modigliani (1961), instead, pointed out that an increase in the national debt (both internal and external) can be advantageous for the current generation, but it places a burden on future generations entailing a reduction in the available stock of private capital, thus causing a decrease in the future flows of goods and services. Analogous conclusions were reached by Bowen et al. (1960), according to whom, even if the repayment of the debt principal is continuously delayed, each current generation bears a burden represented by the taxes used to pay debt interests. This view was initially criticized by Vickrey (1961, p.1) – "They are right for reasons that are, if not wrong, at least needlessly roundabout and largely irrelevant" – and then by Mishan (1963) – "A presumption against increasing the public debt may well act as a brake on swift remedial action by the government when it faces a decline in economic activity".

Another classic topic in this line of literature that is worth to mention is the so-called "golden rule" of public finance (Musgrave, 1964). This rule is the object of a long-standing branch of public finance which is not examined here, whereas it is important to note how it fits in the four scenarios. As is well known, the rule states that the balance between current expenditure and revenues should be nil, while public debt is only allowed as a means to finance productive investment. Here the efficiency-sustainability criteria are even more transparent. Productive investment is realised as growth-enhancing debt-based

[9] Note that this argument need not hinge on the Keynesian *direct* effect of deficit spending on economic activity.

expenditure, and efficiency requires the equality between marginal product and social cost. Sustainability should be guaranteed by equality between the marginal increase in revenues due to additional growth and the debt service. Equity lies in the fact that the generation paying for debt also enjoys a higher level of income. A rather natural analogy is with the fiscal models of endogenous growth, an analogy that I shall further pursue in Section 6 of this chapter.

5. UNSUSTAINABLE DEBT AND SOLVENCY DEFAULTS

As previously explained, a critical point that is often blurred in the search for the debt-growth relationship is whether it goes through the fiscal policies that are adopted to service the debt or through the consequences of the debt being unsustainable and bound to default. In this survey, it has been seen that more common neoclassical as well as Keynesian views are concerned with the former type of channel. More recent New Keynesian models have introduced the second channel by way of investors' expectations and risk premium. Country studies in the burden view tradition present both channels. It is therefore worth exploring this issue in greater detail.

A partial or total default on public debt, either explicit — a refusal to pay back the bonds and a subsequent reduction in the outstanding amount of debt — or implicit — through high inflation rates or even hyperinflation that conspicuously diminish the value of the real public debt — is an extreme occurrence influenced also by the general financial and political situation as well as by agents' behaviour and expectations. Default may be unexpected, anticipated or even self-generated by creditors; each case has its own specific impact on the economy.

A fist crucial point to be clarified is that in many cases default is a policy choice of the government which trades off the costs of default with those of solvency (Gros, 2012; Buiter and Rahbari, 2013; Tamborini, 2015a). The economic consequences of default may be severe but concentrated in time, whereas the benefits of freeing the economy from the burden of debt may unfold over time. Behavioural aspects can play a role in terms of agents' belief about past debt

efficiency, agents' expectations about current sustainability, and agents' confidence level about future debt repayments, though they are not deemed to be always founded. Notably, they have the potential to be self-fulfilling, thus leading to the actual default that could otherwise have been avoided. The historical literature about sovereign defaults is vast and it goes beyond the purpose of this work[10].

Before the financial and the debt crises in which many advanced countries have been entangled, the debt-growth relationship was of particular interest to the Heavily Indebted Poor Countries (HIPC): many papers have analysed how the debt burden, or the "debt overhang", affects economic development, and whether the debt relief programs would have been useful, and, in case, which was the best way to implement them. Starting with the Costa Rica's and the Mexico's defaults at the beginning of the 80s, the growth of the debt burden for high indebted countries has been recognized as an issue. Kamin et al. (1989) gauged whether Argentina, Chile, Brazil, and Mexico had been better off in terms of GDP path for having borrowed considerable amounts before experiencing the debt crises, concluding that these countries were in fact worse off. Cunningham (1993) proposed one of the first empirical analysis investigating the effect of debt burden on economic growth, in which the debt burden was measured as the rate of change in the long-run debt service to public and publicly guaranteed ratio. Its main empirical finding indicates that the debt burden negatively affects economic growth. This conclusion is in line with the concept of debt overhang, initially proposed by Krugman (1988), according to which the relationship between public debt and national product is described by an inverted U relationship. Thus, above a certain level of the public debt, both the debtor and the creditor countries could find it convenient to forgive a part of the debt. In addition, the incentive to invest in the country may reduce when public debt becomes "large".

[10] See Reinhart and Rogoff (2009); a mainly quantitative and a mainly empirical and qualitative literature reviews are respectively provided by Stähler (2013) and Tomz and Wright (2013).

The flourishing of empirical studies has also raised a number of challenges. In the first place, the relationship between the level (or growth rate) of public debt, the rise of risk premia, and speculative attacks has resulted of dubious nature. Some scholars have pointed out that the true explanatory variable is the amount of *external* debt generated by large and persistent current account deficits (e.g. Gros and Alcidi, 2011; Gros, 2013). External debt is often deemed to be the most relevant component as it implies a real transfer from the debtor to the creditor country. According to Karagol (2002, p.40), "foreign debt acts like a tax when the debt situation is such that an improvement in the economic performance of the indebted country has the side product of higher debt repayments", and he found that, for the specific case of Turkey, external debt service has a negative short-run impact on economic growth.

Others have instead pointed out that speculative attacks have been driven by analogy with the "original sin" of many developing countries which issue debt in a foreign currency (De Grauwe and Ji, 2012 and 2013). This argument brings an institutional factor to the forefront: public debt in euros is "foreign denominated" for Eurozone countries because the issuers do not have a central bank in control of the currency.

Both aspects were probably relevant during the Sovereign Debt Crisis of the Eurozone. Throughout its first decade, countries like Belgium, Italy, and Greece were characterized by high public debt-to-GDP ratios. Meanwhile, "emerging" and fast-growing countries like Spain and Ireland started from very low levels of public debt but rapidly rising levels of private debts. Initially, investors regarded public debts in the Eurozone as substantially equivalent, prompting a remarkable convergence of interest rates towards the German safe rate. They became increasingly worried about debt sustainability after the Papandreu government's disclosure of the huge deterioration of Greek public finances, and after the sharp rise in the debt-to-GDP ratios due to the financial crisis and bank bailouts in other countries (notably Spain and Ireland), leading to a dramatic increase in the interest rates of the bonds of the so-called "periphery countries" (Greece, Ireland, Italy, Portugal, Spain). The New Keynesian models mentioned above have been designed to capture these events. Their negative

debt-growth relationship is the result of the combined effects on consumption and/or investment of higher interest rates and the anticipation of fiscal consolidation or default (as already discussed, conclusions about the effects of consolidation are contradictory).

A third problematic area concerns the transmission channels of risk premia across countries. In this regard, there is evidence that post-2009 spreads not only reflected country-specific fundamentals but were also highly sensitive to "systemic risk" and other exogenous factors (Manganelli and Wolswijk, 2009; Attinasi et al., 2009; Caceres et al., 2010). In particular, research has focused on "contagion", that is, the transmission of high spreads across countries via non-fundamental channels (Constancio, 2012; Arghyrou and Kostunica's, 2012).

Finally, the issue of self-fulfilling default expectations should be considered and is particularly relevant since it affects the *ex-ante* evaluation of public debt. Indeed, self-fulfilling attacks are disconnected from the fundamentals and might thus involve both sustainable and unsustainable public debts, therefore forcing a government to default even if its public debt was, before the attack, perfectly sustainable, and regardless the level of the debt-to-GDP ratio. Therefore, this channel could affect the debt-growth relationship at any debt-to-GDP level, in an unpredictable way and without well-defined *a priori* conditions for its occurrence.

The introduction of self-fulfilling expectations in macroeconomic models dates back to the 1980s (Farmer, 1993). In general, they also entail multiple equilibria, the selection of which depends of the state of expectations. In this context, the typical mechanism is one where, as default expectations arise, the cost of debt solvency also rises (e.g. because of higher risk premium) thus making the government default decision more likely.

The seminal study is represented by the influential paper by Calvo (1988), who recognised that expectations about debt default may determine the equilibrium that is reached by the economy. This model was then further developed by Beetsma (1996) to allow for inequality in real debt holdings, and multiple equilibria still emerged. Many other applications followed up to nowadays, and

it is not possible to cite all of them. For instance, Cole and Kehoe (2000) presented a model in which, among other aspects, investors' fear may cause a financial crisis. In details, the fear of a future government default leads domestic investors to reduce the investment level, which in turn reduces future output and leads to a financial crisis.

The Eurozone debt crisis has also prompted new contributions. De Grauwe (2012) presented a model of exogenous expectations determining an area of threat of self-fulfilling speculative attacks. Gros (2012) introduced a political-economy model of investors' subjective expectations of default affecting the market interest rate and the likelihood to observe multiple equilibria. Moreover, creditors may find it profitable to forgive part of a country's debt to avoid the default, in line with the debt overhang theory. By following the same methodology, Tamborini (2015a) showed that multiple equilibria can arise as a consequence of investors' heterogeneous beliefs about primary balance sustainability (the so-called "fiscal effort"), where the risk premium is higher the larger is the share of "pessimistic" investors about the level of fiscal effort beyond which the government prefers default. This model clarifies how the level of debt, its burden and sustainability are highly conditioned by the distribution of investors' beliefs.

Empirical evidence of self-fulfilling speculative attacks is uneasy to collect. Padoan et al. (2012) studied debt, growth and risk premium in a two equilibria model characterized by an intertemporal view and by a negative relationship between debt and growth, explicitly inspired to Reinhart and Rogoff (2010). This study empirically identified the good and the bad debt and growth equilibria — the first given by stable growth, debt and confidence; the second by growing debt, and decreasing growth and confidence — and used them to suggest structural reforms as a way to escape from debt traps. De Grauwe and Ji (2013), and Passamani et al. (2015) can also be mentioned. It can also be recalled that the ECB President Mario Draghi opened his famous "whatever-it-takes" speech by saying that

[…] we are in a situation now where you have large parts of the euro area in what we call a "bad equilibrium", namely an equilibrium in which you may have self-fulfilling

expectations that feed upon themselves and generate very adverse scenarios. So, there is a case for intervening, in a sense, to "break" these expectations (Draghi, 2012, p. 4).

6. FOUR SCENARIOS FOR THE STUDY OF THE DEBT-GROWTH RELATIONSHIP

On the basis of the previous literature review, it is not possible to reach a univocal conclusion regarding the debt-growth relationship. In fact, it seems that both a positive and a negative relationship are equally possible, as well as the absence of any relationship. Even less is theoretically founded the existence of a general debt-to-GDP threshold above which growth is consistently stifled. More importantly, a consistent, unified theoretical framework underpinning the empirical debt-growth research is still missing.

The remaining part of the chapter exemplifies a possible theoretical framework within which the key issues in the debt-growth problem can be located, and possibly clarified, in a consistent and orderly manner. The ingredients that I pick up from the literature consist of the intertemporal setup of the fiscal models of endogenous growth, on which I graft public debt as a means to finance productive public expenditure. Thus, I will be able to characterise and discuss the debt-growth relationship in the four scenarios centred on the efficiency-sustainability criteria presented in Section 4. As will be seen, the model also embeds some specific debt-growth relationships previously presented.

6.1. A fiscal model of endogenous growth with efficient and sustainable public debt

I propose a fiscal model of endogenous growth freely inspired to Barro (1990) and Diamond (1965). Barro (1990) presents a now standard model of growth sustained by productive public expenditure fully covered by taxation.[11] To introduce debt in this setup, I adopt a sequential economy with two-period

[11] I draw on the version by Barro and Sala-i-Martin (1998, ch. 4).

generations *à la* Diamond (1965)[12] where public expenditure is financed by debt in the first period and the debt burden in covered by taxation in the second period.

The key assumption in the Barro model is that the economy consists of competitive firms producing an aggregate output Y according to a neoclassical (Cobb-Douglas) production function augmented by productive public expenditure G, where productive means a kind of expenditure in public goods that can raise private factors' productivity (typical examples are infrastructures, education, research, health care, etc.). I reformulate the Barro production function in terms of labour L, *private* capital K, and *public* capital K_G (i.e. the stock of public goods mentioned above), with the usual condition $0 < \alpha < 1$:

(1.5) $Y = AL^{1-\alpha}K^{\alpha}{K_G}^{1-\alpha} = A(K_G L)^{1-\alpha}K^{\alpha}$

and public capital is labour enhancing.

It is convenient to introduce a dual technology, one with public capital, like (1.5), and one without it, a conventional Cobb-Douglas. To activate the former, public investment is needed. In order to introduce public debt, I treat the economy as a sequence of two-period generations of equal size. Each generation starting in period (t) is endowed with labour L_t and private capital K_t inherited from the previous generation Labour is supplied inelastically in each period and normalized to 1. Likewise, I set the scale factor $A = 1$ in each period. For simplicity, the depreciation rate of private capital is zero; its gestation time is 1 period. The feasible production in t is given by the private technology, therefore

(1.6) $Y_t = {K_t}^{\alpha}$

With neither private nor public investment in period t, the economy remains at this constant output. If all generations unfold equally, this is also the steady state of the economy.

[12] The difference here is that the generations do not overlap, but I assume that they comply with the intergenerational pact that each generation leaves the same endowment of capital to the next.

If, instead, the private sector invests the amount I_t, the private capital stock $K_{t+1} = K_t + I_t$ will be operative in $t+1$. The government, too, can invest in public capital the amount G_t financed by debt, $D_t = G_t$. Public capital $K_{Gt+1} = G_t > 1$ will also be operative in $t+1$. Therefore, feasible production in $t+1$ will be:

(1.7) $Y_{t+1} = K_{t+1}^{\alpha} K_{Gt+1}^{1-\alpha}$

The government fulfils its intertemporal budget constraint by taxing all incomes in period $t+1$ with the flat rate τ. Incomes include the public debt service (principal and interests). Therefore, the following public budget equality holds:

(1.8) $\tau Y_{t+1} = (1-\tau) D_t {R^D}_{t+1}$

where ${R^D}_{t+1}$ is the unit debt service. Under the efficient capital market hypothesis, the return to capital is equalized, across the private and public sectors, to the marginal product of private capital, given by:

(1.9) ${R'}_{t+1} = \alpha \left(\frac{K_{Gt+1}}{K_{t+1}}\right)^{1-\alpha}$

Consequently, $(1-\tau){R^D}_{t+1} = (1-\tau){R'}_{t+1} = R_{t+1}$ is the after-tax return earned on both forms of capital, the (gross) interest rate for short. Since $D_t = K_{Gt+1}$, the public budget constraint (1.8) can be rewritten $\tau Y_{t+1} = K_{Gt+1} R_{t+1}$, which sets the feasible stock of public capital. Since Y_{t+1} is determined by (1.7), the result is

(1.10) $K_{Gt+1} = \left(\frac{\tau}{R_{t+1}}\right)^{\frac{1}{\alpha}} K_{t+1}$

The complementarity between public and private capital is the first key feature of this economy.

Recalling that $(1-\tau){R'}_{t+1} = R_{t+1}$, and substituting public capital into (1.9), we obtain:

(1.11) $R_{t+1} = [\alpha(1-\tau)]^{\alpha} \tau^{1-\alpha}$

The second notable result is that the interest rate is invariant to the capital stock – a result propaedeutic to endogenous growth. The interest rate is however a concave function of the tax rate, which leads to the peculiar relationship between debt and growth in this economy.

To this end, I first consider the optimal consumption path of the representative household of the t-th generation, which maximises a time separable logarithmic utility function subject to its two-period budget constraints:

$max_{C_t, C_{t+1}}\ U(C_t, C_{t+1}) = \log(C_t) + \beta \log(C_{t+1})$

s.t. $C_t = Y_t - I_t - D_t$

$C_{t+1} = (1 - \tau)Y_{Lt+1} + (K_t + I_t + D_t)R_{t+1}$

where I assume that period 1 production takes place only through private technology and, therefore, Y_t is given by equation (1.6), and where Y_{Lt+1} is labour income, $\beta = (1 + \rho)^{-1} < 1$ is the time discount factor, $\rho > 0$ is the rate of time preference, R_{t+1} is the after-tax net return, and where, to start the analysis,

By combining the first order conditions with respect to C_t and C_{t+1}, one can obtain the Euler equation and the optimal consumption path

(1.12) $\gamma \equiv \frac{C_{t+1}}{C_t} = \frac{R_{t+1}}{1+\rho}$

As usual, an increase in the interest rate rises C_{t+1} with respect to C_t, while an increase in the rate of time preference decreases it. Substitution of the interest rate equation (1.11) into (1.12) yields the growth equation for this economy, namely

(1.13) $\gamma = \frac{(\alpha(1-\tau))^{\alpha}\tau^{1-\alpha}}{1+\rho}$

We thus see the crucial result, namely that growth is a concave function of the tax rate necessary to finance public capital. Concavity reflects the double-edge role of taxation: $\tau^{1-\alpha}$ is the growth-enhancing effect of financing public capital, $(1-\tau)^{\alpha}$ is the growth-depressing effect of taxing capital income. As a consequence, there exists a unique tax rate τ^* that maximises γ, namely

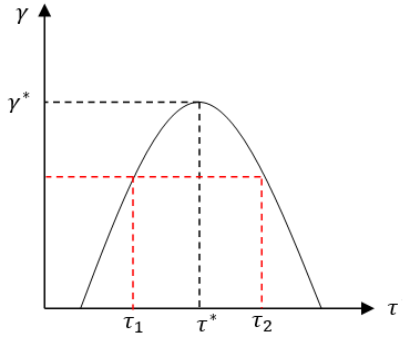
(1.14) $\tau^* = 1 - \alpha$

which is the same result as in the original Barro model (depicted in Figure 1.1), and, since $L = 1$, "the government sets its share in GDP to equal the share it would get if public services were a competitively supplied input of production" (Barro, 1990, p. S109).

The public finance implication is that, given τ^*, each generation has its own optimal public debt which is both sustainable and efficient. In particular, there

is neither "crowding out" when debt is created in t (indeed there is crowding-in)[13] nor is there excess fiscal burden in *t+1*.

Figure 1.1. The optimal level of τ* and the corresponding γ^*.



τ_1 and τ_2 are inefficient because, respectively, too low and too high.

As said above, a notable feature of the economy is the complementarity between public and private capital. Along the optimal growth path, the public/private capital ratio is constant, as can be seen upon substituting the optimal values of τ and R_{t+1} into (1.10):

(1.15) $\frac{K^*_{Gt+1}}{K^*_{t+1}} \equiv k^*_{t+1} = \left(\frac{1-\alpha}{\alpha^2}\right)$

One possible interpretation of this relationship is that the government can expand debt-financed public investment in proportion to the willingness of the private sector to invest.

As to the debt-to-GDP ratio, it can first be noted that the relevant ratio (in terms of debt burden) for the t-th generation is given by the GDP equation (1.7), i.e.

(1.16) $d_{t+1} \equiv \frac{K_{Gt+1}}{Y_{t+1}}$

Developing this expression for optimal values, the result that is obtained is:

(1.17) $d^*_{t+1} = (k^*)^{\alpha}$

That is to say, the optimal debt-to-GDP ratio may be whatever is appropriate for each economy and each generation, given endowment, preferences and technology, so that no generalisation or comparison is meaningful across time

[13] According to equation (1.9), as long as $\tau < \tau^*$, raising public capital increases the marginal product of private capital, which allows for a larger private capital stock, and shifts consumption to the future, which generates more saving for capital accumulation.

or different economies. In other words, *"high" and "low" debt-to-GDP ratios may equally be efficient and sustainable.*

6.2. Sustainable but inefficient debt

The previous model provides an immediate instance of cases in which public debt is sustainable but inefficient in terms of growth. Since the relationship between taxation and growth is concave, the cases in consideration occur whenever public debt, i.e. public capital, is either too low or too high with respect to (1.16). In the former case, the government fails to exploit the full range of growth-enhancing public investment; in the latter excess investment requires excess taxation that depresses growth. Therefore, note in the first place that growth may be sub-optimal not only because debt is "too high". In the second place, even when debt is in fact too high, it remains perfectly sustainable. Indeed, lower growth is due to the fact that the government complies with sustainability by levying excess taxation. This, moreover, need not come as an unexpected event but may be fully anticipated. In other words, inefficiency defines a set of effects of public debt on growth *that do not depend either on unsustainability nor on default risk but, quite the contrary, on the anticipation of the sustainable path of fiscal policy.* Finally, sustainable debt is not synonymous with efficient fiscal policy and optimal growth of the economy. As explained in the previous section, the threshold between efficient and inefficient level of debt is hard to draw in comparisons over time or across different countries.

6.3. Efficient but unsustainable debt: fiscal consolidation

The third case I examine is one where public debt is ex-ante efficient and sustainable whilst it is not ex-post. I model this situation by means of an unanticipated shock that in period 2 of the t-th generation lowers total factor productivity. This simple device may capture different situations: from true recessions, to ex-ante overvaluation of public investment productivity, or misbehaviour of the government that deviates a share of debt to unproductive

uses. In any case, the consequence which I focus on is the necessity of fiscal consolidation in period 2, i.e. a fiscal adjustment that guarantees debt solvency.

The first period of the *t*-th generation is the same as in the base case, except that the coefficient *A* in the production function is now a random variable of unit expected value which in *t*+1 takes the value $A_{t+1} < 1$. Note that, by assumption, the stocks of private and public capital operational in *t*+1, which ere optimal for $A_{t+1} = 1$, have been installed in *t* and are irreversible (denoted by a bar). Consequently,

(1.18) $Y_{t+1} = A_{t+1}(\bar{K}_{t+1})^{\alpha}(\bar{K}_{Gt+1})^{1-\alpha} = A_{t+1}{Y^*}_{t+1}$

where ${Y^*}_{t+1}$ denotes the ex-ante optimal GDP as in the first case. Therefore, the government budget as given by equations (1.8) and (1.9) and the optimal tax rate $\tau^* = 1 - \alpha$ can no longer be satisfied. A fiscal consolidation is necessary, and to this end the government changes the tax rate so that:

(1.19) $\tau_{t+1}A_{t+1}{Y^*}_{t+1} = (1 - \tau_{t+1})\bar{K}_{Gt+1}\bar{R}^{D}_{t+1}$

where $\bar{R}^{D}_{t+1}$ is the unit debt service to which the government is committed from the previous period when $A_{t+1} = 1$ was expected. Therefore,[14]

(1.20) $\bar{R}^{D}_{t+1} = \alpha\left(\frac{\bar{K}_{Gt+1}}{\bar{K}_{t+1}}\right)^{1-\alpha} = \alpha\bar{k}^{1-\alpha}_{t+1}$

From the base model, we know the ex-ante values of ${Y^*}_{t+1}$ and of the optimal public/private capital ratio. Upon substituting these values in the public budget constraint, we find that the new tax rate should satisfy[15]:

(1.21) $\tau_{t+1}A_{t+1}\bar{k}^{-\alpha}_{t+1} = (1 - \tau_{t+1})\alpha\bar{k}^{1-\alpha}_{t+1}$

As a result, the solvency tax rate is

(1.22) ${\tau^s}_{t+1} = \left(1 + \frac{A_{t+1}}{\alpha\bar{k}_{t+1}}\right)^{-1}$

Since ${\tau^s}_{t+1} = \tau^*$ for $A_{t+1} = 1$, the new tax rate is certainly higher than the ex-ante optimal one, and it should be higher the worse the productivity shock.

What are the concomitant effects of fiscal consolidation on the economy? The first is that the growth rate is reduced, *yet this is the direct and exclusive effect of the productivity shock on the GDP path*, not of fiscal consolidation by itself.

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[14] Note that consequently the unit debt service is no longer equal to the actual return to capital which *falls* by $A_{t+1} < 1$.

[15] Check that for $A_{t+1} = 1$ and $\tau_{t+1} = 1 - \alpha$, (1.20) is indeed an identity.

The second effect, directly due to fiscal consolidation, is on households' consumption which necessarily deviates from the optimal path given by (1.12). The increase in the tax rate, in addition to the productivity shock, affects the *t+1* budget constraint as follows

(1.23) $C_{t+1} = (1 - \tau^{s}{}_{t+1})[(1 - \alpha)A_{t+1}Y^{*}{}_{t+1} + (K_t + I_t)R'{}_{t+1} + D_t\bar{R}^{D}_{t+1}]$

where $(1 - \alpha)A_{t+1}Y^{*}{}_{t+1}$ is the gross income share of labour. Likewise, we can write $(K_t + I_t)R'{}_{t+1} = \alpha A_{t+1}Y^{*}{}_{t+1}$, and therefore:

(1.24) $C_{t+1} = (1 - \tau^{s}{}_{t+1})[A_{t+1}Y^{*}{}_{t+1} + D_t\bar{R}^{D}_{t+1}]$

As can be seen, households suffer from lower gross income from the private sector and higher tax rate. Moreover, their consumption is fully constrained by current disposable incomes, so that the economy also displays this "Keynesian" feature.

6.4. Inefficient and unsustainable debt

Debt-financed public expenditure may be *ex-ante* inefficient for a number of reasons, ultimately because the government spends and taxes too much (beyond the optimal level identified in the first scenario) or because the projects are in fact less productive. To simplify the analysis of the fourth scenario, we can note that when the economy is hit by an adverse shock as in the third scenario, public debt observationally results both inefficient and unsustainable *ex post*. Drawing on the political economy literature on the default choice mentioned in section 5, I now examine the point that, since fiscal consolidation is a costly decision for the government, it may consider the option of default. Yet also default is a costly decision.

To address this problem various specifications of the government's decision are available. In this context, it is natural to assume the representative consumer's utility as the welfare function of the government. Consequently, let me consider the post-shock consumption level in *t+1*:

(1.25) $C_{t+1} = (1 - \tau_{t+1})[A_{t+1}Y^{*}{}_{t+1} + (1 - \phi)D_t\bar{R}^{D}_{t+1}]$

where the government has two policy variables, the tax rate τ_{t+1} and the rate of "haircut" of the debt repayment ϕ. Note immediately that the former variable affects consumption via after-tax income, whereas the latter affects

consumption via pre-tax income. Therefore, the government faces the typical trade-off between increasing the consumer utility by lowering τ_{t+1} and decreasing it by raising ϕ. The point is that the two variables are inversely related to the extent that the government lowers τ_{t+1} below the solvency level ${\tau^s}_{t+1}$ given by (1.22). In fact, on the basis of the government's budget, it is possible to see that:

(1.26) $\phi = 1 - \tau_{t+1} \frac{(A_{t+1}{Y^*}_{t+1} + D_t \bar{R}^D_{t+1})}{D_t \bar{R}^D_{t+1}}$

Since ${\tau^s}_{t+1} = \frac{D_t \bar{R}^D_{t+1}}{A_{t+1}{Y^*}_{t+1} + D_t \bar{R}^D_{t+1}}$, $\phi = 0$ if $\tau_{t+1} = {\tau^s}_{t+1}$, and $\phi = 1$ if $\tau_{t+1} = 0$. Upon substituting ϕ into (1.25) it is possible to see that C_{t+1} is a concave quadratic function of τ_{t+1}. The optimal debt policy is the $({\tau^d}_{t+1}, \phi)$ combination that maximises the consumer utility, i.e.

(1.27) ${\tau^d}_{t+1} = \frac{{\tau^s}_{t+1}}{2}, \qquad \phi = 0.5$

where (d) denotes that the tax rate implies partial default.

Interestingly, the optimal debt policy is independent of any other variable except the solvency tax rate ${\tau^s}_{t+1}$, but of course this is due to the utility function that I have assumed. It is however generally true that post-shock consumption is concave in τ_{t+1}, i.e. it reaches a maximum for a specific combination $({\tau^d}_{t+1}, \phi)$. This result prompts two remarks. First, (partial) default is always a policy option for a government facing (unexpectedly) unsustainable debt. Second, the effect of debt on the economy cannot be gauged independently of whether debt is inefficient/unsustainable, and the government chooses the default option.

7. CONCLUSIONS

Research on the relationship between public debt and economic growth has a long history. Interest has been revived by the fiscal consequences of the Great Recession of 2008-09. This new wave of research has been mostly empirical, and largely dominated by the pursuit of "the" debt-to-GDP ratio beyond which debt depresses growth; yet no univocal conclusion has been reached either about the quantification of the critical ratio or even about its existence.

Foundational work is however lacking: why should we expect a negative public debt-growth relationship in the first place? If such a relationship exists, why should it take the specific form of a threshold of the debt-GDP ratio, and why should we expect this threshold to be equally valid across time and space?

In an attempt to address these questions, I have examined a wide range of different literatures concerning public debt and its impact on the economic system. Overall, there is no clear and straightforward theoretical answer to the previous questions. Or, from another perspective, there are many possible answers and many elements affecting them, thus reflecting the complexity of the argument, as well as the variety of the empirical situations. In particular, I have found no theoretical foundation to the existence of a critical debt-to-GDP ratio with general validity.

One main problem in the theoretical literature is that three different analytical approaches are intertwined: static, single-period *vs.* dynamic, intertemporal setup; flow (budget deficits) *vs.* stock (outstanding debt) analysis; expected solvency *vs.* expected default. In each of them, or combination of them, debt has distinct effects on the economy. I have thus completed this chapter with a fiscal model of endogenous growth that may help deal with these features in an orderly and consistent manner along two coordinates of debt assessment: sustainability/unsustainability, and efficiency/inefficiency. The thrust of the model is that no meaningful assessment of debt and its effect on growth at any point in time is possible without reference to the whole debt trajectory and the specific state of the economy along the trajectory. If, for instance, public debt is on a sustainable and efficient trajectory, the debt level, the debt-to-GDP ratio and the growth rate at any point in time may be whatever is consistent with the fundamentals of the economy; the mere comparison between different countries has no informative value. Specific analyses, leading to different predictions, are necessary when public debt is either inefficient or unsustainable, and whether the government wishes to consolidate or not.

If a comprehensive conclusion may be drawn is that *each country's debt history and specific characteristics, circumstances, and events have an overwhelming*

importance that cannot be encapsulated in a single general law. Research should concentrate on the former and abandon the pursuit of the latter.

Chapter 2

Analysing Economic Growth and Debt Relationship in a Panel of European Countries

Abstract

After the large public debts created by the Great Recession 2008-09, the idea that public debt has a negative impact on economic growth has become very popular in the literature, and it has paved the way towards the adoption of policies of debt reduction. Many studies have attempted to provide support for this claim and for the existence of general debt thresholds above which debt would negatively affect growth. However, because of heterogeneous conditions, such thresholds might not be generalised to any country and any period.

Therefore, leaving the estimation of debt-thresholds aside, this chapter aims to deepen the understanding of the relationship between public debt and economic growth by analysing a slightly unbalanced panel dataset including 27 Western and Eastern European countries with quarterly data from 1999Q1 to 2015Q4.

The proposed methodology is divided into two steps. In the first step, I carry out a time-series cointegration analysis that allows for the maximum degree of within-country heterogeneity, to understand if a long-run relationship between GDP and public debt exists, and to find and describe any difference between countries. In the second step, I deal with the between-country dimension by estimating appropriate panel models.

The main findings show that a) a long-run relationship between public debt and GDP exists for some countries but it cannot be generalised; b) such a long-run relationship is not unique and does not always correspond to the debt-to-GDP ratio, the sustainability measure that is commonly adopted to describe the debt burden; and c) the short-run linkage between public debt and GDP is negative, but also weak and heavily influenced by the events that followed the financial crisis. Therefore, country heterogeneity and the role of specific events are overwhelming factors in the debt-growth nexus.

Keywords: economic growth, public debt, debt thresholds, cointegration analysis, panel data dynamic models, coefficient heterogeneity.

1. INTRODUCTION

1.1. The Pursuit of the *debt threshold*

Interest in the debt-growth relationship in the advanced economies has emerged as a consequence of the Great Recession of 2008-09 and the large fiscal stimuli adopted by governments. In the OECD as a whole, the debt-to-GDP ratio escalated from 73.5 percent in 2007 to 122.0 percent in 2015. The Eurozone followed a very similar path, falling into a severe public debt crisis between 2010 and 2012 ignited by Greece. Early in 2010, at the Toronto summit, leading governments, more forcefully those in the Eurozone, decided to cope with this situation by implementing a set of restrictive fiscal policies, whose aim was to reduce public budget deficits and outstanding debts that were considered no longer sustainable and a burden on the future growth of the economies.

Particularly influential both for academic research and the implementation of fiscal corrective measures was the paper by Reinhart and Rogoff (2010), whose main finding is a negative relationship between growth and debt above a general threshold of 90 percent of the debt-to-GDP ratio. Although Reinhart and Rogoff's work was criticized, first by Irons and Bivens (2010) for what regards the applicability of the analysis to the U.S. and the implied causality, and then by Herndon et al. (2013) for the methodology, it has sparked a wave of studies searching for debt thresholds in advanced countries: the pursuit of the *debt threshold* above which growth is definitely jeopardised by public debt, a sort of "extreme limit" beyond which a government should not go.

Taking a step back, before the financial crisis the research focus was essentially on poor and developing countries. This literature was supported by the debate around the debt cancellation programs, that became popular since the 80s (see Chapter 1). In this vein, the empirical analysis of Nguyen et al. (2003) argue that a level of internal debt above 50 percent of GDP (or above 20-25 percent if its net present value is considered) can negatively affect growth in low-income countries because of an inefficient use of the available resources. By employing a large panel dataset of developing countries, Pattillo et al. (2011) have reached similar conclusions: a debt-to-GDP ratio above 35-40 percent

negatively affects growth, but a negative marginal impact of debt on growth arises even at a half of this estimated threshold.

Nowadays, the debt-growth debate has mainly changed perspective by focussing on high-income countries and, in particular, on the Eurozone members. Even though the most popular idea is that there is a negative relationship between debt and growth — and that negative effects arise earlier for poor countries than for rich countries — empirical threshold results can actually be divided into three categories that focus on the consequences of breaching a specific debt threshold: 1) Public debt stifles growth above a specific threshold of the debt-to-GDP ratio; 2) Public debt has no effects on growth above a specific debt-to-GDP threshold; and 3) Public debt has a positive effect on growth above a specific debt-to-GDP threshold. Little is said about what happens below those thresholds.

The first group includes the majority of the threshold-based works, whose methodology and results are indeed quite similar. For instance, Caner et al. (2010) have performed a comparison between developing and developed countries. By employing a large dataset of 99 countries, they have showed that growth is negatively affected above 77 percent of the long-run debt-to-GDP ratio, and above 64 percent if only developing countries are considered. Similar conclusions have been reached by Cecchetti et al. (2012) (who have identified a threshold at 84 percent of GDP and at 96 percent of GDP when a control variable for crisis periods is added) and by Afonso and Jelles (2013) (who have found a negative impact of debt on growth, besides an effect of worsening of financial crises above a threshold of 90 percent of GDP).

A series of papers has attempted to better describe the whole GDP-debt relation. Baum et al. (2012) have demonstrated that, on the basis of a dataset including 12 Eurozone countries from 1980 to 2008, the short-run impact of debt on growth is positive and statistically significant for low levels of debt-to-GDP but decreases and, eventually, has a negative impact above a threshold of 95 percent. They have also pointed out that the long-term bond interest rate is subject to an increased pressure when the debt-to-GDP ratio is above 70 percent. Checherita-Westpahl and Rother (2012) have employed a dataset

extended to the period 1970-2010 to show that the relation linking debt and growth is concave and U-shaped, with a turning point around 90-100 percent of GDP, and the existence of such a relationship has been ascribed to public investments and total factor productivity. Finally, in another paper, Checherita-Westphal et al. (2014) have proposed a theoretical explanation for the U-shaped relationship.[1]

At the same time, other studies reached the conclusion that no relationship seems to link debt and growth. Cordella (2010), Presbitero (2012), and Egert (2015) have suggested that a non-linear relationship exists, but debt becomes irrelevant for high levels of debt-to-GDP ratio. Presbitero (2012) has explained these findings referring to country-specific factors, sample composition and to the fact that "debt overhang is a growth constraint only in countries with sound macroeconomic policies and stable institutions" (Presbitero, 2012, p.1). In another work, Eberhardt and Presbitero (2015) have claimed that, by applying a standard Error Correction Model (ECM) and accounting for heterogeneity, a non-linear relationship between debt and GDP across-countries arises.[2] However, a systematic within-country relationship has not been found and a general debt-to-GDP threshold is unlikely to exist.

The analysis of this chapter is close to that of Eberhardt and Presbitero (2015). Indeed, they share the same starting point, that is, the groundlessness of the assumptions that there is one debt threshold beyond which growth is negatively affected, and that all countries are characterised by the same debt-growth equilibrium relationship. There are, however, differences for what concern the sample of countries: the dataset of Eberhardt and Presbitero (2015) includes yearly data over the period 1961 - 2012 of 118 countries, whereas my dataset includes a relatively more homogenous group of 25 European countries, with quarterly data over the period 1999Q1 - 2015Q4.

[1] Greiner (2012) has criticized this conclusion. Specifically, it claimed that the model was based on a very simple and unrealistic fiscal policy with exogenously fixed deficits, and that "once a more general debt policy is considered, one finds that smaller public deficits and lower public debt always generate a higher growth rate" Greiner (2012, p.6).

[2] In that study, debt has been regarded as exogenous with respect to economic growth.

Given these dissimilarities, the two works follow different developments. The first part of the work of Eberhardt and Presbitero (2015) essentially aims at considering both heterogeneity across countries and the cross-sectional dependence within an error-correction framework, two aspects that, as specified above, were not considered in the previous empirical works. Subsequently, they introduced a non-linear approach which allows to study the short-run and the long-run behaviour around specific thresholds, concluding that the common thresholds of 60% and 90% of the debt-to-GDP ratio do not hold.

The methodology that I adopt is similar, but rather than estimating a heterogeneous error correction model including all countries, I first test for cointegration country by country to estimate the long-run relationships, and then I group the countries according to the detected statistical properties. This methodology allows to compare groups of countries that share the same long-run statistical properties taking, at the same time, heterogeneity into consideration. Moreover, the more recent period of analysis permits to focus on the impact of the austerity period.

Finally, the conclusions of the two works agree in saying that a single debt-threshold is unlikely to exist, because of heterogeneity. While I draw this conclusion implicitly from the cointegration analysis and the subsequent panel group estimation, Eberhardt and Presbitero (2015) draw this conclusion explicitly by analysing the validity of two specific debt-to-GDP thresholds. Then, on the one hand I conclude that a long-run equilibrium relationship is not generalisable and does not always correspond to the debt-to-GDP ratio, a debt burden measure that is commonly adopted. On the other hand, I notice that the sign of the short-run relationship between debt and growth is not constant over time.

Summing up all the previous contributions, it is difficult to derive a unified thinking and to reach a one-way conclusion, especially because of countries' heterogeneity. Most of the studies have supported the view that debt jeopardizes growth above a certain threshold (but there is no agreement on its level and little or nothing is said about what happens below that threshold), whereas other authors have found no evidence about the existence of such a

threshold. Finally, some authors supported the existence of a positive relationship above a certain threshold. See, for instance, Minea et al. (2012): debt reduces growth for values of the debt-to-GDP ratio below a threshold of 115 percent, but this effect disappears and becomes positive above that threshold.

In general, a debt threshold may be useful from a political and institutional perspective, but, because of heterogeneity, it would be optimistic to believe that such a threshold could be applied to any country in any period. This is exactly the conclusion presented in Chudik et al. (2015): based on a dataset of advanced and emerging countries, the research has not found any evidence about a general debt threshold. Nevertheless, authors showed that this conclusion does not compromise the existence of a long-run negative relationship between rising public debt and growth, suggesting that "the debt trajectory can have more important consequences for economic growth than the level of debt-to-GDP itself" (Chudik et al. 2015, p.28). In conclusion, the value of the debt-to-GDP ratio at a given point in time is perhaps too narrow a variable to explain such a complex question as economic growth.

1.2. Beyond thresholds: is there a general causal relationship involving debt and growth?

In retrospect, one may say that the empirical pursuit of the debt-to-GDP threshold harmful to growth lacks deeper foundational work. Why should we expect a negative public debt-growth relationship in the first place? If such a relationship exists, why should it take the specific form of a threshold of the debt-to-GDP ratio, and why should we expect this threshold to be equally valid across time and space? Such research questions have motivated the analysis presented in this chapter.

Pescatori et al. (2014) have argued that a simple debt-to-GDP threshold above which growth is stifled does not exist. Instead, the relationship between debt and growth seems to be highly influenced by the past trajectory of debt. This statement could be used as a synthesis of the findings of that branch of literature that departs from the pursuit of the debt-to-GDP thresholds.

Closely searching for causal channels, Deshpande (1997) has explicitly dealt with the Neoclassical claim that public debt crowds out investments but, unlike Nguyen et al. (2003), he has considered external debt only. With a dataset that includes 13 countries characterized by high debt-to-GDP ratios, external debt is found to exercise a negative impact on investments. In the same vein, Balassone et al. (2011) have used Italian data from 1861 to 2009 to show that the negative relationship between public debt and growth is mainly due to the negative impact of debt on the investment level. Evidence about the existence of a general negative relationship is also supported by Ceh Casni et al. (2014) (whose analysis has been based on Central, Eastern, and Southeastern European countries data) and by Bordo et al. (2010). A different methodology has been proposed by Panizza and Presbitero (2014), who initially confirmed the existence of a negative relationship between debt and growth but, once an instrumental variable for public debt based on the exchange rate was introduced, the linkage between the two variables disappeared. These authors have explicitly excluded causality after the inclusion of the instrumental variable, a conclusion shared by Irons and Bivens (2010), quoted in the previous section.

Another analysis of causality was performed by Kumar and Woo (2015) by adopting a panel dataset of both advanced and emerging economies. This study has accurately considered the intertemporal nature of such a relationship, examining the influence that the public debt has on the growth rate of the subsequent five to twenty years. The analysis has suggested the existence of a negative relationship between the initial debt and the subsequent growth or, using the words of the authors, a 10-percentage point increase in the initial debt-to-GDP ratio is associated with a decrease in real per capita GDP growth of 0.2 percentage points per year, an impact that is smaller in advanced economies.

Finally, Lof and Malinen (2014) have proposed a panel VAR analysis on the stationary growth rates of debt and GDP of 20 advanced countries and have reached opposite conclusions to Woo and Kumar (2015): debt has no statistically significant effects on growth but, in fact, growth has a statistically significant

negative effect on public debt. In other words, the negative correlation between debt and growth is due to the negative impact that growth has on debt.

As before, it is difficult to derive a clear conclusion and it is not easy to solve the causality direction dilemma. Even when it is recognized that a general debt threshold for economic growth is unlikely to exist, results on the nature or the direction of the causal effect do not agree. In any case, the existence of a significant negative relationship between debt and growth is the predominant thinking, although in contrast with the conclusions of a number of other works. Hence, the aim of the present study is to go to the roots of the debt-growth relationship, first to investigate whether debt and growth are linked and, second, to ascertain under what conditions (i.e. specific countries and times) debt has a negative impact on growth. To this end, I have adopted a research methodology that differs from the most common empolyed in the literature on debt-to-GDP thresholds.

First, I have assumed an "agnostic" stance, that is to say, this work does not hinge on any specific theory, and it should not be considered as a validation of a specific theoretical statement. Rather, it is based on the approach outlined by Hoover et al. (2008) and aims at understanding "what the data say" without imposing aprioristic theoretical structures.

A second methodological choice consistent with this approach is to treat the (growth of the) amount of public debt and (the growth of) GDP as the two genuine primitives, without imposing the debt-to-GDP ratio as a primitive itself. In fact, for this to be possible, the two underlying primitives should display well defined statistical properties, namely cointegration and convergence towards a long-term equilibrium value, which are usually not tested in the literature.

Thirdly, I have set time and space limits to the dataset by purpose. My analysis is based on a slightly unbalanced panel dataset including quarterly data for 25 Eastern and Western European countries[3] from 1999Q1 to 2015Q4.

[3] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK.

I believe that the heterogeneity, or non-generality, of results that I have pointed out before should be taken as an intrinsic feature of the problem at hand, so that a viable strategy is to restrict, rather than further expand, the observational field[4]. Indeed, more recent empirical research has also shown that the effects of fiscal policy are space and time-varying in relation to a number of contingent "conditioning factors", for instance the business cycle, the monetary policy and exchange-rate regime, the degree of openness of the economy, and others (e.g. Favero et al. 2011, Hebous 2011, Gechert et al. 2015). In this view, my chosen observational field is Europe at time of the single currency. The majority of countries in my dataset belongs to the Eurozone. It represents a unique "field experiment" of a large number of countries where some key conditioning factors of fiscal policy are common and exogenous, namely fiscal targets and rules, monetary policy, the exchange rate with the rest of the world. The non-Eurozone countries, though not sharing the single currency, present similar structural and institutional features. Alas, time and space boundaries have a cost in terms of observations, and hence the feasibility and reliability of econometric tests, that I have sought to manage at best. Hopefully, the boundaries set are sufficiently well tailored (not too large, not too small) in order for conclusions to be meaningful *in the context of Europe and the Eurozone in particular*.

Within this observational field, the main result is that a long-run equilibrium relationship between GDP and debt exists for some countries − and debt and GDP tend to adjust towards it − but it is not generalisable. Cross-country heterogeneity, and the role of specific occurrences like the financial crisis and austerity, remain substantial and overwhelming factors. Moreover, where a relationship exists, it does not always imply that the debt-to-GDP ratio may be the appropriate variable. Therefore, a unique equation describing the GDP-debt

[4] As is well known, statistical inference of economic data is plagued by various trade-offs. One of these concerns generality vs. specificity. "Hard" scientists seek general laws, which require large amounts of observations. In the economic world, however, maximising observations by spanning across wide time and space coordinates can easily violate the assumption that data come from the same generating process.

relationship does not seem to exist, which entails the impossibility to derive a meaningful general debt-to-GDP threshold.

The rest of the chapter is organized as follows. After introducing my dataset with some descriptive statistics in Section 2, in Section 3 I test whether a long-run relationship between the growth rates of GDP and public debt exists by performing cointegration analysis at the country level. Five groups of countries are identified as rejecting or non-rejecting cointegration, and with different cointegration characteristics. Then, in order to compare such groups of countries, and in an attempt to derive implications about the sign and short-term dynamics of the debt-growth relationship, in Section 4 I present five models estimated by employing panel dynamic techniques. I also provide further extensions to check for robustness, goodness of fit, heterogeneity, and specific events like the financial crisis and austerity. Conclusions follow and close the chapter in Section 5.

2. DATASET DESCRIPTION

The two fundamental variables of the dataset are the real general government outstanding public debt and the real GDP, computed as described in the Data Appendix at the end of this chapter. Real time series are required to leave the effect of inflation aside from the cointegration analysis.

GDP data cover the period from 1999Q1 to 2015Q4 and have been adjusted for seasonality. For the majority of countries, data about public debt cover the period from 2000Q1 to 2015Q4 and have been adjusted for seasonality only when seasonality was previously identified. Overall, the number of GDP observations counts to 1700, while the number of public debt observations counts to 1612. Whenever a strongly balanced dataset is required, I employed a dataset reduced to the interval 2000Q1-2015Q4.

Table 2.1 summarises the structure of my dataset, Figure 2.1 displays the growth rates of GDP and debt, while their summary statistics are shown in Table 2.2, jointly with the correlation coefficients. All countries have experienced a decline in GDP because of the global financial and economic

crisis, while the greatest changes in the debt levels have been experienced by Bulgaria, Germany, Greece, Ireland, Latvia, and Spain during the subsequent time period.

Turning from levels to growth rates, GDP growth rates look more stable than debt growth rates. Furthermore, it is interesting to observe that Pearson's correlation coefficients, in 19 countries out of 27, is strictly greater than 0.1 in absolute value, but the sign is often negative.

The Spearman's rho, less sensitive to outliers and used to capture whether a variable is a monotone function of the other, is almost always negative. Noteworthy, Spearman's coefficients are always far from 1 and -1, thus indicating that a decreasing monotonic trend between GDP and debt may exist but it is rather weak. Finally, the Kendall's tau, which captures the rank ordinal association between the two variables, does not show a strong ordinal correlation between the two variables of interest.

Table 2.1. Dataset structure, seasonal adjustment, and EMU membership.

Country	GDP	Public Debt	Season. Adj.	EMU
1. Austria	1999Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	1999
2. Belgium	1999Q1-2015Q4	1999Q1-2015Q4	GDP, Debt	1999
3. Bulgaria	1999Q1-2015Q4	2000Q1-2015Q4	GDP	-
4. Croatia	2000Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	-
5. Cyprus	1999Q1-2015Q4	2000Q1-2015Q4	GDP	2008
6. Czech R.	1999Q1-2015Q4	2000Q1-2015Q4	GDP	-
7. Denmark	1999Q1-2015Q4	2000Q1-2015Q4	GDP	1999
8. Estonia	1999Q1-2015Q4	2000Q1-2015Q4	GDP	2011
9. Finland	1999Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	1999
10. France	1999Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	1999
11. Germany	1999Q1-2015Q4	2000Q1-2015Q4	GDP	1999
12. Greece	1999Q1-2015Q4	2000Q1-2015Q4	GDP	2001
13. Hungary	1999Q1-2015Q4	2000Q1-2015Q4	GDP	-
14. Ireland	1999Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	1999
15. Italy	1999Q1-2015Q4	1999Q1-2015Q4	GDP, Debt	1999
16. Latvia	1999Q1-2015Q4	2000Q1-2015Q4	GDP	2014
17. Lithuania	1999Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	2015
18. Luxembourg	2000Q1-2015Q4	2000Q1-2015Q4	GDP	1999
19. Malta	2000Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	2008
20. Netherlands	1999Q1-2015Q4	2000Q1-2015Q4	GDP	1999
21. Portugal	1999Q1-2015Q4	2000Q1-2015Q4	GDP	1999
22. Romania	1999Q1-2015Q4	2000Q1-2015Q4	GDP	-
23. Slovak R.	1999Q1-2015Q4	2000Q1-2015Q4	GDP	2009
24. Slovenia	1999Q1-2015Q4	2000Q1-2015Q4	GDP	2007
25. Spain	1999Q1-2015Q4	1999Q1-2015Q4	GDP	1999
26. Sweden	1999Q1-2015Q4	2000Q1-2015Q4	GDP	-
27. the UK	1999Q1-2015Q4	2000Q1-2015Q4	GDP, Debt	-

Source: Eurostat (namq 10 gdp, gov 10q ggdebt)

Figure 2.1. Debt (red) and GDP (blue) growth rates for each country.

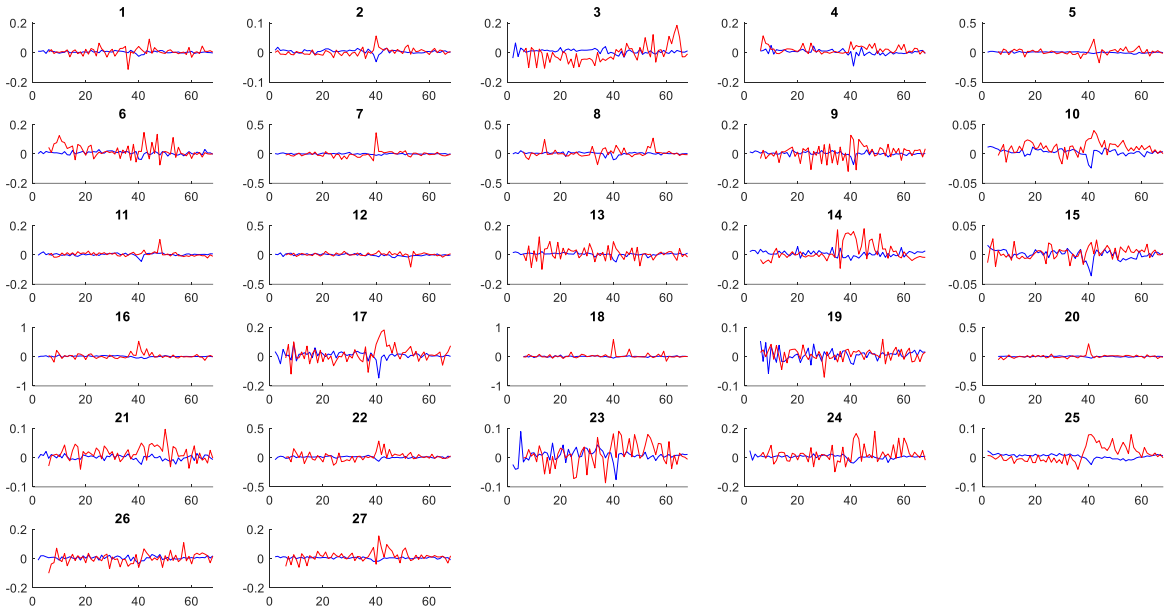
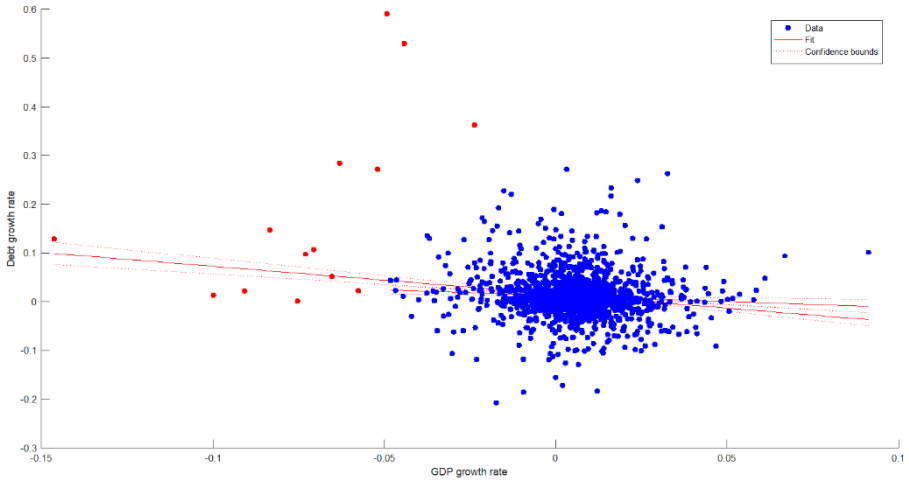


Table 2.2. Means, standard deviations, and correlations between debt and GDP growth rates.

Country	GDP growth rate		Debt growth rate		Pearson's Coefficient	Kendall's Tau	Spearman's Rho
	Mean	SD	Mean	SD			
1. Austria	0,004	0,008	0,007	0,026	-0,061	-0,006	-0,002
2. Belgium	0,004	0,007	0,003	0,011	-0,470	-0,138	-0,186
3. Bulgaria	0,009	0,016	-0,008	0,060	-0,238	-0,196	-0,290
4. Croatia	0.004	0.019	0.021	0.025	-0.065	-0.141	-0.210
5. Cyprus	0,004	0,011	0,015	0,054	-0,284	-0,160	-0,249
6. Czech R.	0,007	0,012	0,022	0,045	0,056	0,057	0,103
7. Denmark	0,002	0,009	-0,003	0,058	-0,319	-0,015	-0,031
8. Estonia	0,009	0,026	0,017	0,069	-0,185	-0,113	-0,182
9. Finland	0,004	0,014	0,008	0,050	-0,203	-0,004	-0,025
10. France	0,003	0,006	0,011	0,010	-0,281	-0,138	-0,187
11. Germany	0,003	0,009	0,005	0,017	0,011	-0,044	-0,064
12. Greece	0,000	0,018	0,009	0,036	0,025	-0,050	-0,074
13. Hungary	0,005	0,011	0,010	0,043	-0,120	0,060	0,079
14. Ireland	0,010	0,019	0,020	0,061	-0,509	-0,368	-0,535
15. Italy	0,001	0,008	0,004	0,010	-0,138	0,005	0,013
16. Latvia	0,009	0,023	0,026	0,100	-0,299	-0,052	-0,069
17. Lithuania	0,010	0,029	0,019	0,055	-0,090	-0,041	-0,057
18. Luxembourg	0,007	0,018	0,027	0,093	-0,151	0,250	0,340
19. Malta	0.006	0.019	0.007	0.021	-0.099	-0.117	-0.178
20. Netherlands	0,003	0,007	0,005	0,034	-0,258	-0,013	-0,029
21. Portugal	0,001	0,008	0,015	0,024	-0,152	-0,107	-0,151
22. Romania	0,008	0,017	0,020	0,071	-0,342	-0,116	-0,184
23. Slovak R.	0,009	0,022	0,011	0,039	-0,013	0,035	0,058
24. Slovenia	0,006	0,014	0,025	0,055	-0,264	-0,157	-0,220
25. Spain	0,005	0,008	0,012	0,027	-0,734	-0,478	-0,675
26. Sweden	0,006	0,012	0,001	0,036	-0,006	-0,026	-0,052
27. the UK	0,005	0,007	0,017	0,036	-0,358	-0,149	-0,213

In order to examine whether a general conclusion can be derived for the whole panel, I have represented the pooled scatter-plot in Figure 2.2. In line with the graphs proposed by Eberhardt and Presbitero (2015) or by Herndon et al. (2013), no clear relationship emerges from it. The regression line is slightly downward sloping, but this result is clearly determined by few outliers. As a matter of fact, when these observations are removed, the linear regression line becomes flatter.

Figure 2.2. Debt and GDP quarterly growth rates, scatter-plot with linear regression line.



The same graph is depicted in Figure 2.3, but now a regression line has been added for each country. What clearly stands out is a high degree of heterogeneity, as shown in Eberhardt and Presbitero (2015), with regression slopes that assume both positive, negative, and non-significant values. This result is confirmed by Figure 2.4, where the two series are combined into the widespread debt-to-GDP ratio; obviously, they are different from the well-known yearly values. The distributions of the debt-to-GDP ratio across countries differ both in terms of level and in terms of overall dispersion, but what arises is a general positive skewness, with the right tail longer than the left tail for almost every country.

Recapitulating, by looking at the correlation coefficients, the two variables appear to be correlated but, by looking at the scatter-plots of the growth rates, no clear general relationship arises. In addition, the boxplots representing the distributions of the debt-to-GDP ratio and the individual scatter-plots lead to

identify a high degree of heterogeneity. In the following paragraphs I attempt to identify a long-run relationship between debt and GDP.

Figure 2.3. Debt and GDP quarterly growth rates, scatter-plot with regression lines for each country.

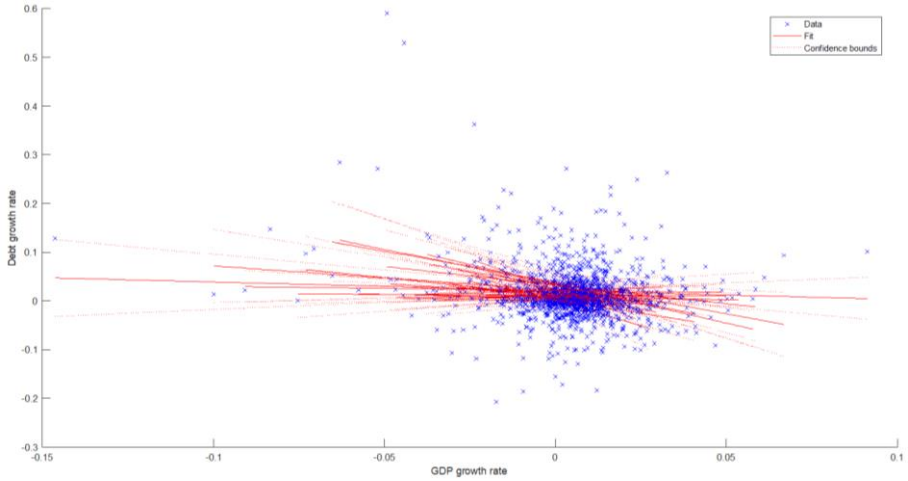
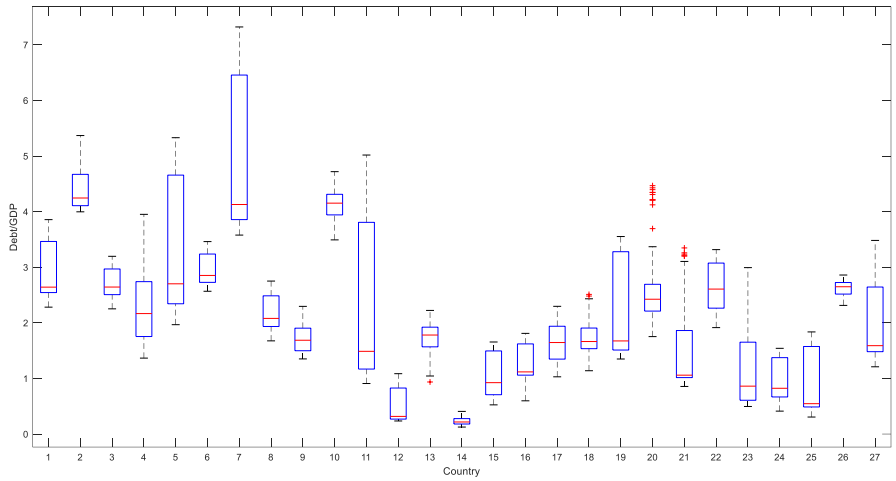


Figure 2.4. Quarterly debt-to-GDP ratio, boxplots by country.



3. A GENERAL SPECIFICATION FOR THE EMPIRICAL ANALYSIS

The general empirical specification for the analysis in this Chapter is an Equilibrium Correction model representation (ECM) of the unrestricted Vector Autoregression (VAR) that I assume to model the stochastic process generating the dataset. Denoting with z_{it} the vector of I(1) observed variables, the ECM representation is as follows:

(2.1) $\Delta z_{it} = \mu_i + \Pi_i z_{it-1} + \sum_{l=1}^{k_i-1} \Gamma_{il} \Delta z_{it-l} + \Phi_i x_{it}^{*} + \varepsilon_{it}$

where the specification has been augmented to include control or exogenous stationary variables denoted by the vector x_{it}^{*}.

If the observed I(1) variables are cointegrated, with r_i cointegrating vectors, the matrix Π_i has rank r_i and can be written as $\Pi_i = \alpha_i \beta_i'$, and model (2.1) can also be written as a Cointegrated VAR (CVAR):

(2.2) $\Delta z_{it} = \mu_i + \alpha_i \beta_i' z_{it-1} + \sum_{l=1}^{k_i-1} \Gamma_{il} \Delta z_{it-l} + \Phi_i x_{it}^{*} + \varepsilon_{it}$

where $\beta_i' z_{it-1}$ represent the r_i cointegrating relations that are I(0) and can be considered as long-run equilibrium relationships. According to model (2.2), these equilibrium relationships are assumed to differ across countries: they represent heterogeneous stationary relations which enter the model in the form of disequilibrium errors determining the short-run behaviour of the system of variables, jointly with the other stationary variables.

If the observed I(1) variables do not cointegrate, $\Pi_i = 0$ and a VAR in first differences would be the appropriate model.

In order to simplify the application of model (2.2), I assume no between-countries cointegration: this is quite reasonable, since finding stationary linear relations across countries is very hard, particularly over the period of observation, and I reckon that any cross-sectional dependence, in terms of common factors, could be dealt with when estimating the dynamic panel data model (2.2).

In the following, my focus will be, first, on within country cointegration, in order to determine whether any long-run stationary relationship between the I(1) variables of interest can be detected at country level. The estimated stationary variables representing the long-run relationships will then be inserted into model (2.2) before estimating it using the appropriate panel data procedure.

Therefore, the following question has the priority over any further discussion: does a long-run relationship between debt and GDP exist at country level? As a matter of fact, the existence of such a relationship determines the econometric model to be estimated.

In summary, the proposed methodology is developed in two steps. In the first step, I carry out a time-series cointegration analysis that allows for the

maximum degree of heterogeneity across countries: as emerged above, heterogeneity cannot be ignored even within my dataset of European countries. In the second step, I deal with the panel dimension of my dataset by estimating appropriate panel models.

3.1. Within-country time series analysis

3.1.1. Methodology

The existence — within the single country — of a long-run relationship between the two main variables of interest would imply that their data generating process can be modelled using an adaptation of the CVAR model represented in (2.2), which "provides a simple linear system that can characterize the probability distribution of a set of variables" (Hoover, 2008, p. 253).

The following long-run relation between the log transformed variables[5] is assumed:

(2.3) $\beta_1 \, ln(Debt_t) + \beta_2 \, ln(GDP_t) = f(t) + u_t$

where $f(t)$ denotes a deterministic function of time, or a constant, and u_t represents a stationary stochastic process for debt (Debt) not to diverge with respect to GDP. If both debt and GDP are non-stationary I(1) variables sharing a common stochastic trend, then the relation (2.3) can be embedded within the CVAR model emphasising it. Therefore, defining $ln(Debt) = y_t$ and $ln(GDP) = x_t$, the adaptation of model (2.1) for the determination of the 2×1 vector $z_t = (y_t, x_t)'$ for any country i is given by:

(2.4) $\Delta z_t = \Pi z_{t-1} + \sum_{l=1}^{k-1} \Gamma_l \Delta z_{t-l} + M D_t + \varepsilon_t$

where Δ is the difference operator; Π and Γ_l are 2×2 matrices containing the dynamic coefficients relating Δz_t to the lagged values of z_t and to its past values; k is the order of the autoregressive process; M is a $2\times d$ matrix of coefficients on the d deterministic variables, including the constant, contained in D_t, and ϵ_t is a 2×1 vector of disturbances, assumed to be serially uncorrelated with zero means and a positive definite covariance matrix Ω.

[5] An advantage of specifying the relation in terms of log transformed variables is that, when it is embedded in a CVAR model, the estimated short-run dynamics show how the rate of growth of debt and GDP adjust to any disequilibrium.

Detection of a stationary relation like (2.3) implies that the z_t variables share a common stochastic trend, which means that the matrix Π is of reduced rank r and may be rewritten as $\Pi = \alpha\beta'$, where α and β are 2×1 vectors, with β being the cointegrating vector containing the cointegration coefficients, and α the vector of adjustment coefficients. In the present study there is cointegration if $r=1$; otherwise, if $r=0$, it means that no stationary relation between debt and GDP exists and, if $r=2$, it means that debt and GDP are already stationary variables. Being $r=1$ the case of interest for the existence of a long-run relationship like (2.3), the identification of the long-run structure will be just straightforward in this case.

Using the Johansen (1995) approach, it is possible to determine the rank r of Π and test restrictions[6] on β and restrictions[7] on α once the deterministic function $f(t)$, which makes u_t stationary in (2.3), has been specified. Given that the sample period does not cover many decades but just less than two decades including the recent crisis period, it is reasonable to allow for a more elaborate specification of the deterministic function $f(t)$ including, if necessary, structural changes like shifts in the mean of the differenced variables, or broken linear trends in the levels of the variables, instead of a simple linear trend which takes a longer period of time to converge to the mean. As Juselius (2006, p.293) points out, "an I(1) stochastic trend around a broken linear deterministic trend, can in some cases avoid the I(2) analysis altogether by allowing for sufficiently many breaks in the linear trend", a strategy that considers also the implications of the well-known Lucas' critique. In fact, looking at the graphs of the data in levels and first differences, for many countries it is possible to observe behaviours similar to the ones of I(2) variables, with growth rates

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[6] A case of particular interest is when the cointegrating vector satisfies the restriction $\beta = (1,-1)'$ that describes the log of the debt-to-GDP ratio in the long-run.

[7] Restrictions on α have important implications on the CVAR specification of the model. Given the two variables of interest, when $r=1$ the test of a zero coefficient in α is equivalent to testing whether the associated variable can be considered as weakly exogenous for the long-run parameters β, or, in other words, whether it can be considered as a "long-run" forcing variable for the determination of the other variable, in the sense that its changes affect the other variables but it is not affected by any changes in the cointegration relation.

changing over the sample period and with significant mean reversions. Thus, starting from a more general specification for $f(t)$, I can test whether these structural changes are significant. In formal terms, if the deterministic variables D_t are just a constant and a linear trend, the CVAR model (2.4) can be rewritten as:

(2.5) $\Delta z_t = \alpha\tilde{\beta}'\tilde{z}_{t-1} + \sum_{j=1}^{k-1}\Gamma_j\Delta z_{t-j} + \mu_0 + \mu_1 t + \varepsilon_t$

where $\tilde{\beta}' = (\beta', \beta_0, \beta_1)$ and $\tilde{z}_{t-1} = (z'_{t-1}, 1, t)'$ show the double role that the constant and the trend play in the model, both in the cointegration relation and in the equation for Δz_t. When $\beta_1 = 0$ and $\mu_1 = 0$, the linear trend cancels in the cointegration space but, given the unrestricted constant, there can be linear trends in the variables in levels. When $\beta_1 \neq 0$ and $\mu_1 \neq 0$, the linear trend does not cancel in the cointegration space but there are no linear trends in the differenced variables. Within this case, if we allow for broken linear trends in the cointegrating relation, to the trend component must be added interaction terms of the form $(t - t^*)D_{st^*}$, where t^* is the time of the break and D_{st^*} stands for a shift dummy taking value 1 for $t \geq t^*$ and 0 for $t < t^*$, while D_t will contain also the differenced broken trend.

Because of different times for the breaks and different results emerging from the testing procedures, the CVAR model (2.5) specification will change for each country. This means that different findings are possible, and that the countries in my dataset can be grouped according to the econometric properties that they show.

3.1.2. Estimation results

I initially applied two sets of tests: unit-root tests, to determine whether the time series represent realizations of non-stationary I(1) variables, and cointegration tests, to find out whether a long-run relationship between them exists. The analyses have been performed with Matlab R2016b and CATS 2.0 within RATS 6.2.

The unit-root analysis has been used to establish the order of integration of debt and GDP for each country. Since the time period covered by the analyses

is undoubtedly characterised by one or more breaks, the Lee-Strazicich (2003) unit-root test[8] with two endogenous breaks has been adopted. The test statistics has confirmed that both GDP and public debt can be considered as non-stationary I(1) series[9] with breaks (see Table 2.3 and Table 2.4).

Table 2.3. Public debt, Lee-Strazicich unit-root test with two structural breaks, results.

Level	Break 1	Break 2	t-test	Difference	Break 1	Break 2	t-test
1. Austria	2009Q2	2013Q2	-4.617	Austria	2004Q1	2008Q2	-10.161***
2. Belgium	2007Q2	2009Q1	-5.477*	Belgium	2008Q2	2012Q4	-8.747***
3. Bulgaria	2007Q1	2012Q2	-2.137	Bulgaria	2007Q4	2010Q4	-8.047***
4. Croatia	2006Q3	2010Q1	-4.093	Croatia	2008Q2	2011Q2	-8.067***
5. Cyprus	2008Q3	2012Q1	-2.137	Cyrpus	2003Q2	2008Q3	-7.381***
6. Czech R.	2009Q1	2012Q1	-3.808	Czech R.	2008Q3	2012Q4	-10.961***
7. Denmark	2008Q3	2011Q3	-3.544	Denmark	2005Q2	2009Q1	-9.406***
8. Estonia	2007Q3	2012Q2	-1.979	Estonia	2007Q3	2011Q4	-7.624***
9. Finland	2008Q3	2012Q1	-1.331	Finland	2004Q3	2009Q3	-13.660***
10. France	2003Q2	2009Q1	-3.650	France	2006Q1	2009Q4	-7.942***
11. Germany	2004Q1	2010Q3	-4.209	Germany	2007Q2	2011Q1	-9.066***
12. Greece	2003Q3	2010Q2	-1.840	Greece	2008Q3	2011Q3	-9.644***
13. Hungary	2008Q1	2011Q1	-1.146	Hungary	2004Q1	2012Q3	-13.667***
14. Ireland	2003Q1	2009Q3	-2.614	Ireland	2006Q1	2009Q1	-10.913***
15. Italy	2004Q4	2008Q3	-4.572	Italy	2004Q4	2008Q3	-9.798***
16. Latvia	2003Q4	2008Q3	-2.257	Latvia	2006Q3	2009Q3	-8.701***
17. Lithuania	2005Q1	2008Q2	-2.044	Lithuania	2008Q3	2012Q2	-9.463***
18. Luxembourg	2004Q1	2008Q3	-0.860	Luxembourg	2007Q3	2010Q3	-9.794***
19. Malta	2005Q4	2008Q3	-4.334	Malta	2005Q4	2008Q2	-10.791***
20. Netherlands	2003Q2	2009Q1	-1.050	Netherlands	2004Q1	2008Q2	-7.922***
21. Portugal	2008Q3	2011Q3	-0.588	Portugal	2006Q1	2011Q2	-9.376***
22. Romania	2005Q1	2008Q4	-3.227	Romania	2008Q3	2011Q3	-10.803***
23. Slovak R.	2003Q2	2007Q4	-1.650	Slovak R.	2008Q2	2011Q3	-8.403***
24. Slovenia	2008Q4	2011Q4	-1.351	Slovenia	2008Q4	2012Q2	-11.063***
25. Spain	2006Q4	2010Q2	-4.801	Spain	2008Q2	2011Q3	-8.172***
26. Sweden	2008Q4	2012Q4	-1.763	Sweden	2006Q4	2009Q4	-10.732***
27. the UK	2007Q4	2011Q1	-3.946	the UK	2005Q3	2010Q1	-10.366***

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10% level respectively.
For critical values see Lee and Strazicich (2003), p. 1084, Table 2.

8 The advantage of Lee-Strazicich test is that it allows for endogenously determined breaks in the level and in the trend under both the null and the alternative hypotheses, increasing the power of the test function in the presence of structural breaks in the deterministic components of the series, which appear to be the case.

9 The test includes a time trend and a number of lags automatically chosen from 0 to 4; results show that the null-hypothesis (unit-root) cannot be rejected at 5 percent level. This test allows me to deal with the loss of power from ignoring one or more breaks, but in fact some countries may require the inclusion of a third break, in particular for the debt series. These countries are, indicatively: Cyprus, Denmark, Estonia, Italy, Romania, Slovakia, Sweden, and the UK. It seems plausible and useful to consider all the time series as I(1), also because the application of the same test has excluded a sheer I(2) behaviour. In any case, as a robustness check, I carried out the unit-root analysis also by employing panel techniques. Both the Harris-Tzavalis unit-root test with the small-sample correction and the Breitung test with the correction for the cross-sectional dependence confirms the I(1) nature of the time series of the analysis.

Table 2.4. GDP, Lee-Strazicich unit-root test with two structural breaks, results.

Level	Break 1	Break 2	t-test	Difference	Break 1	Break 2	t-test
1. Austria	2006Q1	2009Q4	-4.180	Austria	2008Q1	2009Q3	-7.082***
2. Belgium	2006Q2	2009Q3	-4.331	Belgium	2008Q1	2009Q4	-6.560***
3. Bulgaria	2003Q4	2008Q4	-4.861	Bulgaria	2007Q3	2009Q2	-9.026***
4. Croatia	2008Q3	2011Q2	-5.399	Croatia	2007Q4	2009Q2	-12.87***
5. Cyprus	2007Q1	2012Q3	-4.328	Cyrpus	2008Q2	2012Q4	-8.139***
6. Czech R.	2003Q4	2008Q2	-3.609	Czech R.	2008Q3	2011Q2	-8.111***
7. Denmark	2005Q3	2008Q4	-4.192	Denmark	2007Q4	2009Q2	-8.526***
8. Estonia	2008Q2	2011Q3	-4.592	Estonia	2007Q3	2009Q3	-9.172***
9. Finland	2008Q3	2011Q4	-4.168	Finland	2007Q4	2009Q2	-9.086***
10. France	2008Q2	2011Q3	-3.764	France	2007Q2	2009Q2	-6.150**
11. Germany	2003Q3	2008Q3	-4.004	Germany	2008Q2	2009Q4	-7.064***
12. Greece	2007Q3	2011Q3	-4.068	Greece	2008Q1	2010Q1	-9.773***
13. Hungary	2005Q4	2009Q2	-4.368	Hungary	2008Q2	2010Q2	-7.760***
14. Ireland	2008Q2	2012Q2	-4.065	Ireland	2006Q3	2008Q4	-12.643***
15. Italy	2002Q4	2007Q4	-4.026	Italy	2007Q4	2009Q2	-6.125**
16. Latvia	2006Q1	2009Q2	-4.353	Latvia	2007Q1	2009Q3	-11.278***
17. Lithuania	2007Q3	2010Q4	-4.524	Lithuania	2007Q3	2009Q2	-12.151***
18. Luxembourg	2002Q4	2008Q3	-4.822	Luxembourg	2006Q4	2009Q1	-9.235***
19. Malta	2002Q2	2013Q1	-4.989	Malta	2005Q2	2008Q2	-12.164***
20. Netherlands	2002Q4	2008Q2	-3.723	Netherlands	2007Q4	2009Q2	-7.044***
21. Portugal	2009Q3	2011Q4	-4.344	Portugal	2008Q1	2010Q4	-7.551***
22. Romania	2007Q1	2009Q3	-4.047	Romania	2008Q4	2010Q2	-7.249***
23. Slovak R.	2003Q1	2008Q3	-4.025	Slovak R.	2008Q3	2010Q1	-9.377***
24. Slovenia	2006Q4	2011Q4	-4.969	Slovenia	2001Q4	2008Q1	-5.262***
25. Spain	2006Q1	2011Q4	-3.742	Spain	2002Q2	2008Q2	-4.890***
26. Sweden	2005Q1	2008Q2	5.049	Sweden	2008Q3	2010Q4	-10.401***
27. the UK	2008Q1	2010Q3	-4.992	the UK	2007Q3	2009Q1	-9.420***

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10% level respectively.
For critical values see Lee and Strazicich (2003), p. 1084, Table 2.

Given these results, I have carried out a cointegration analysis; detailed results are reported in Table A2.2 in the Cointegration Appendix, to which I refer in the following part. The columns corresponding to the heading "Model Specification" show the number of lags, whether there are one or more breaks, and whether exogenous variables have been considered. This piece of information relates to the specification chosen by selecting the maximum number of lags and then adjusting it by looking at the tests on residuals ("Autocorrelation" − LM(1) test − and "Normality" columns) and by including, eventually, appropriate dummy variables and time breaks. The columns "Test on restricted model" show the p-values and the corrected p-values associated to the test for the imposed restriction on β, while the columns labelled "Variable Exclusion" confirm that no variable can be excluded from the relation within the cointegration framework. Finally, the p-values in the last column, labelled "Stationarity", confirm that neither GDP nor debt are stationary, in line with the results of the unit-root test presented above.

The fundamental results of the analysis are represented by the two columns labelled with "Cointegration rank", where the p-values and the corrected p-

values[10] of the Johansen trace test are reported. At the significance level of 5 percent, 19 countries show no cointegration: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Finland, Germany, Greece, Ireland, Latvia, Lithuania, Luxembourg, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK.

However, on the basis of the values of the roots of the companion matrix, four countries have been classified as showing cointegration: Romania, Slovenia, Sweden, and the UK.[11] For the remaining countries, one cointegration relationship has clearly been detected: Austria, Belgium, Denmark, France, Hungary, Italy, Malta, and Netherlands.

Therefore, countries can be divided into at least two groups, those that show cointegration and those that do not show cointegration, though on the basis of different specifications for the lags and the deterministic components.

In a first attempt to identify and statistically interpret the cointegration relationship for each country in the dataset, the coefficients of $ln(Debt)$ and $ln(GDP)$ have been restricted to take the values to 1 and -1 respectively, in order to find evidence of the debt-to-GDP ratio,[12] i.e. $ln\left(\frac{Debt}{GDP}\right)$, perhaps the most widespread and commonly adopted measure of debt burden. Therefore, this restriction allows to check whether the debt-to-GDP ratio corresponds to the long-run stationary relationship between government debt and GDP, and thus whether the debt-to-GDP ratio can be appropriately applied to describe and evaluate public debt.

Nevertheless, as shown in Table A2.2, this restriction is rejected[13] at the usual 5% significance level for all countries showing evidence of cointegration. Accordingly, the long-run relationship cannot be generally described as the

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[10] The p-values based on the Bartlett correction for small sample sizes. See Johansen (2002).

[11] The two greatest roots for Romania are 0.9 and 0.596; for Slovenia 0.997, 0.525; for Sweden 0.941, 0.392; and for the UK 0.99, 0.694. Therefore, the roots of the companion matrix suggest the presence of cointegration beyond the results of the Johansen test.

[12] In other words, whenever the corrected p-values do not allow to reject the imposed restriction on the cointegration vector, the cointegration relationship can be interpreted as the debt-to-GDP ratio; on the contrary, whenever this restriction is statistically rejected, the debt-to-GDP ratio does not correspond to the long-run relationship between debt and GDP.

[13] By considering the Bartlett correction, it is not rejected at 5 percent level for Austria, Italy, Romania, and Sweden, and at 1 percent level for Belgium, Denmark, and Slovenia.

"pure" debt-to-GDP ratio, with noticeable implications in terms of the applicability of such a measure to the historical evaluation of the debt burden: if the long-run relationship between debt and GDP does not correspond to the debt-to-GDP ratio, any implication derived from it should be interpreted with due caution.

Finally, I have considered whether either public debt or GDP can be considered as weakly exogenous variables. Though weak exogeneity has emerged for some countries, public debt cannot be considered as an independent (exogenous) variable for each country.[14]

Even at this point in the analysis it can be noted that the existence of a cointegration relationship between debt and GDP cannot be generalised for every country in my dataset, as well as the existence of a unique model describing it. In fact, on the basis of the Johansen test[15] and without relying upon the debt-to-GDP thresholds, it is possible to identify five groups of countries:

- Group 1, cointegration, debt is weakly exogenous: Belgium, France;
- Group 2, cointegration, GDP is weakly exogenous: Denmark, Malta, Netherlands, Sweden, the UK;
- Group 3, cointegration, neither GDP nor debt is weakly exogenous: Austria, Hungary, Italy, Romania, Slovenia;
- Group 4, no cointegration, debt is weakly exogenous: Bulgaria, Czech Republic, Estonia;
- Group 5, no cointegration, neither GDP nor debt is weakly exogenous: Croatia, Cyprus, Finland, Germany, Greece, Ireland, Latvia, Lithuania, Luxembourg, Portugal, Slovakia, Spain.

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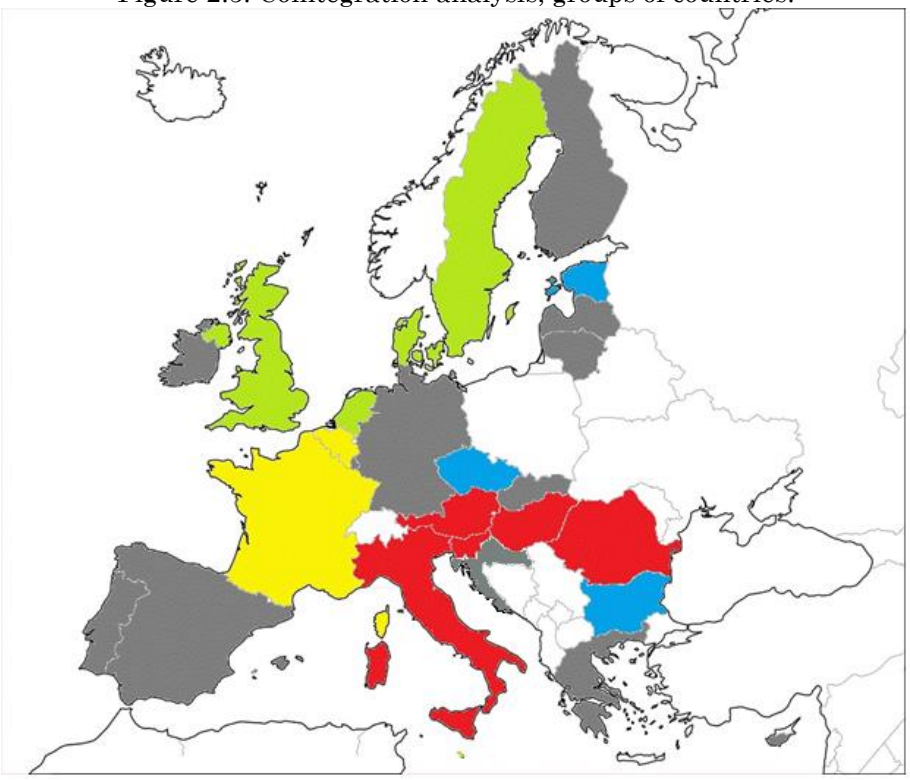
[14] At the 5 percent significance level, debt can be considered as weakly exogenous for Belgium, Bulgaria, Czech Republic, and France, while GDP is weakly exogenous for Denmark, Netherlands, Sweden, and the UK. For the remaining countries, neither debt nor GDP can be considered as weakly exogenous.

[15] I also employed the Gregory and Hansen (1996) test, which extends the ADF test to the cointegration analysis allowing for the inclusion of one level shift in the intercept and one regime shift in the cointegration coefficient and in the time trend. However, while some breakpoints coincided with the breaks reported in Table A2.2, this cointegration test, in general, was unable to confirm the results of the Johansen test and to detect cointegration. This is probably a consequence of the fact that it does not allow for the same level of details of the Johansen test and, in particular, for more than one break.

Figure 2.5. Cointegration analysis, groups of countries.



Group 1 (yellow), Group 2 (green), Group 3 (red), Group 4 (blue), Group 5 (grey).

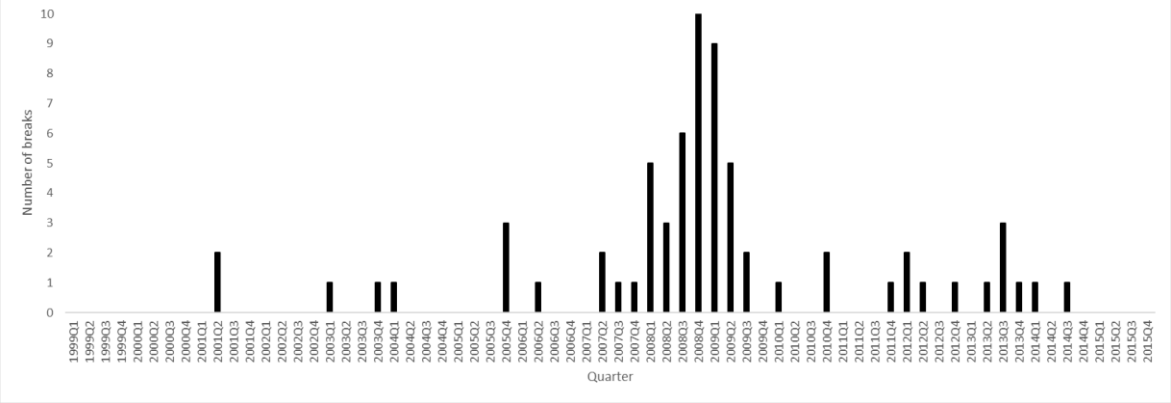
It seems possible to give groups a geographical and a historical interpretation. In fact, Group 1 includes two close EMU countries; Group 2 includes four North European countries, three of them outside the EMU; Group 3 includes bordering countries, with strong economic relationship, though with clear different histories and traditions; Group 4 includes three Eastern European countries that, however, do not have any border in common; and, finally, Group 5 includes three sub-groups of countries, i.e. three central European countries that did not heavily suffered the Sovereign Debt Crisis (Finland, Luxembourg, Germany), three Eastern European countries with two Baltic Republics (Latvia, Lithuania, Slovakia), and five countries that experienced a harsh period of debt crisis and austerity, beyond Italy (Cyprus, Greece, Ireland, Portugal, Spain). These groups of countries are geographically depicted in Figure 2.5. Therefore, groups from 1 to 4 include comparable and/or geographically close countries, while countries in group 5 are remarkably heterogeneous, thus suggesting further differentiation.

Three aspects deserve particular attention. First, the time breaks have not been exogenously chosen but they are the result of a preliminary analysis of the

time series and of the cointegration residuals, country by country. Therefore, it is possible to say that I have let the data speak and that the breaks reflect the behaviour of the time series and the impact of exogenous occurrences. The distribution of the selected breaks, depicted in Figure 2.6, shows that most of them occurred between 2008Q1 and 2009Q2 and are due to the 2008 financial crisis. Several breaks are located after 2010 and they are scattered between 2010Q4 and 2014Q3, during the Greek crisis and the subsequent sovereign debt crisis and austerity period. Finally, 9 breaks are located before the financial crisis.

As a result, whilst the majority of breaks is clearly due to worldwide shocks and in particular to the financial crisis, a number of them cannot be connected to worldwide phenomena. Moreover, even the time of the reaction to the financial crisis, a worldwide shock that affected all countries, is not identical for all countries, thus highlighting further that a homogenous cointegration analysis would be inadequate.

Figure 2.6. Distribution of the time breaks.



Second, for countries showing cointegration, special attention must be paid to whether an equation is equilibrium correcting or not with respect to the cointegration relation; or, in other words, whether the variables of interest reacts with respect to the disequilibrium long-run relationship. Table A2.3 in the Cointegration Appendix reports the estimates of β_i and α_i with the corresponding t values for each country.

It is to be noted that the statistical non-significance of the α_is directly reflects the weak exogeneity of the corresponding variables. Therefore, the α_i associated to public debt for the countries within the group "cointegration, debt is weakly exogenous" is not significant, while, within the group "cointegration, GDP is weakly exogenous", the non-significant α_i is the one associated to GDP. Similarly, both α_is are not significant for the group "cointegration, neither debt nor GDP is weakly exogenous". In addition, to interpret the results one should consider that if the estimated α_i and β_i show opposite signs, the variable of interest behaves in an equilibrium-correcting manner; otherwise, it is not equilibrium correcting.

Considering the first group of countries, the long-run relationship can be interpreted as a GDP relationship. Indeed, the $\hat{\alpha}_i$s suggest that GDP rather than public debt can be considered as equilibrium correcting to the cointegration relationship. This also means that the public debt variable has been pushed by GDP (the pulling variable), rather than adjusting to it. On the contrary, the long-run relationship of the second group of countries can be defined as a debt relationship: the GDP has been pushed to the long-run relationship, instead of adjusting to it. Finally, for the third group of countries that show cointegration, both public debt and GDP adjust to the equilibrium relationship in an equilibrium-correcting manner.

All in all, the estimated equations are definitely equilibrium correcting but they differ in terms of pulling and pushing forces, along which the long-run relationship can be categorised.

Finally, a comment on the interpretation of cointegration is necessary. First of all, cointegration is not informative *per se* for what concern debt sustainability. The evidence of cointegration between public debt and GDP is undoubtedly the preliminary requirement for any subsequent analysis based on the relationship between the two variables, but it does not provide any information about past, current or future debt sustainability. The evaluation of debt sustainability on the basis of cointegration should be carried out, instead, by following Trehan and Walsh (1991) and Greiner and Fincke (2016) according

to which sustainability requires the quasi-difference stationary[16] of the government debt and the presence of cointegration between public debt and primary surpluses. Therefore, the attention should be on the primary surpluses and not on GDP, an element that further limits inference that can be drawn from the debt threshold literature about sustainability.

In the following part I will exploit this result to consider the panel dimension of the data.

3.2. Pooled dynamic panel data analysis

3.2.1. Methodology

Having determined, on the basis of the time series properties of data, the five groups within which countries can be considered as forming a homogeneous panel with respect to the model for their data generating process, we can go ahead with the second step of the analysis.

What I estimated in the preceding section for those countries in which cointegration between the variables of interest emerged was a stationary variable measuring the disequilibriums from the long-run relation. More precisely, this stationary variable is defined as $CR_{it} = \beta_i' R_{it}$, where R_{it} are found by concentrating out the short-run effects Δz_{it-1} and the determinist effects, from z_{it-1}. The panel data CVAR specification described by equation (2.2) can thus be rewritten as follows:

$$(2.6)\ \Delta z_{it} = \mu_i + \alpha_i CR_{it-1} + \sum_{l=1}^{k_i-1} \Gamma_{il} \Delta z_{it-l} + \Phi_i x_{it}^{*} + \varepsilon_{it}$$

where, at first, I consider α_i, Γ_i and Φ_i as homogeneous coefficients ($\alpha_i = \alpha$, $\Gamma_i = \Gamma$, and $\Phi_i = \Phi\ \forall i$), and thus heterogeneity between countries is accounted for the fixed-effect component μ_i only. This homogeneity restriction will then be relaxed in Section 3.5.

Considering the composition of the vector z_{it} given above, model (2.6) for those countries showing cointegration can extensively be written as:

$$(2.7)\ gY_{it} = \mu_{1i} + \gamma_{11} gD_{it-1} + \gamma_{12} gY_{it-1} + \phi_1 Euro_{it} + \alpha_1 CR_{it-1} + \varepsilon_{it}$$

[16] Denoting by D_t public debt and r the interest rate on government bonds, quasi-difference stationarity implies the stationarity of $D_t - \vartheta D_{t-1}$, with $0 \leq \vartheta < (1 + r)$.

$$gD_{it} = \mu_{2i} + \gamma_{21} gY_{it-1} + \gamma_{22} gD_{it-1} + \phi_2 Euro_{it} + \alpha_2 CR_{it-1} + \varepsilon_{it}$$

while, for those countries that do not show cointegration, it becomes:

$$(2.8)\ gY_{it} = \mu_{1i} + \gamma_{11} gD_{it-1} + \gamma_{12} gY_{it-1} + \phi_1 Euro_{it} + \varepsilon_{it}$$

$$gD_{it} = \mu_{2i} + \gamma_{21} gY_{it-1} + \gamma_{22} gD_{it-1} + \phi_2 Euro_{it} + \varepsilon_{it}$$

All the estimated models include the lagged GDP growth rate (gY_{it-1}) and the lagged debt growth rate (gD_{it-1}),[17] a constant, a dummy variable $Euro_{i,t}$ that captures the entrance in the monetary union, and the stationary cointegration variable CR_{it-1} when countries show cointegration.

Since my dataset is characterised by a limited number of countries and a much longer number of time periods,[18] equation (2.6) cannot be estimated with the usual GMM techniques adopted for dynamic panel models (i.e. Arellano-Bond and Arellano-Bover estimators). For this reason, the estimation procedures will be based on the fixed-effect estimator, which is biased but consistent for $T \to \infty$. Estimation results are presented in the next section.

3.2.2. Estimation results

The existence of a cointegration relationship implies a long-run relationship between debt and GDP but it does not say anything about the nature of such a relationship and about the sign of the short-run adjustments. To compare the groups of countries and in an attempt to derive general implications, five models have been estimated on a set of stationary variables.

With respect to the within-country analysis, the panel analysis introduces a problem of cross-sectional dependence that may arise as a result of worldwide events affecting all countries contemporaneously (like the financial crisis, as observed in the previous section). Therefore, I have also introduced a common risk factor, the natural logarithm of the CBOE VIX Index (see the Data Appendix for further details). The dynamics of such a variable, depicted in Figure 2.7, shows a slow mean-reverting process that can be considered stationary for the given frequency and time horizon according to both the KPSS

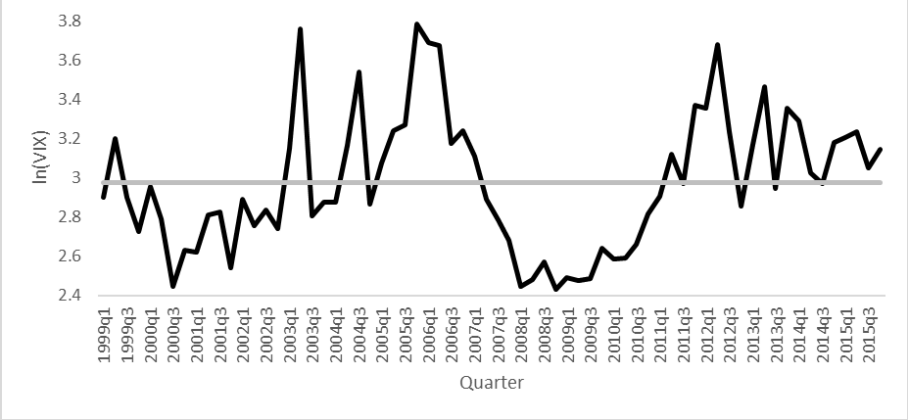
[17] More lags did not lead to any improvement in the empirical analysis.

[18] This situation depicts a panel of time-series data.

unit root test (with and without trend) and the Phillips-Perron unit root test (with and without trend).

Estimation results are displayed in Table 2.5. Panel (a) reports the estimation results of those groups of countries that show cointegration between debt and GDP (Group 1, Group 2, and Group 3 respectively), while panel (b) reports the estimation results of those groups of countries that do not show cointegration (Group 4 and Group 5).

Figure 2.7. The logarithm of the VIX Index (black) and its mean (grey).



By focussing on panel (a) of Table 2.5, two coefficients are particularly significant for the analysis. First, the statistical significance of the homogeneous coefficient α associated to the cointegration variable implies the relevance of the disequilibrium errors in explaining the dependent variable. This can be observed for all groups with the only exception of the second specification of Group 2, which, however, is characterised by a very limited number of countries. Indeed, it must be remarked that causation cannot be inferred from CVAR estimation, therefore the significance of such a coefficient does not imply causality.

Second, the sign of the short-term relationship between the GDP growth rate and the debt growth rate is always negative, as (intuitively) expected since it reflects the negative correlations found at the beginning of this chapter, besides the findings of all those works that describe a negative relationship between debt and GDP. However, it should be noted that these terms are not always statistically significant, thus implying that the short-term effect vanishes. In

particular, it seems that *gD* adjusts towards *gY* (a reduction in *gD* is followed by a reduction in *gY*) in Group 1, Group 2, and Group 4, that both adjustments (gD towards gY and gY towards gD) in Group 5, but also that no adjustment occurs in Group 3.

Finally, for each group the dummy Euro — that captures the effect of being part of the monetary union — is statistically significant, highlighting the presence of significant differences between countries inside and outside EMU.

Table 2.5. Panel estimation: basic specifications.

(a) Groups of countries that show cointegration.

Group	**1**		**2**		**3**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**	**gD**	**gY**
gY(-1)	-0.3313*	-0.1662	-0.5523*	0.3855***	-0.4792	0.2897***
	(0.1574)	(0.1555)	(0.0613)	(0.0030)	(0.2368)	(0.0449)
gD(-1)	-0.0261	-0.0273	0.1276	-0.0493	-0.1130	-0.0078
	(0.0231)	(0.0196)	(0.1140)	(0.0250)	(0.0801)	(0.0105)
CR(-1)	0.0288***	-0.0008***	-0.0064**	0.0095	-0.2411**	0.0500**
	(0.0014)	(0.0001)	(0.0005)	(0.0019)	(0.0637)	(0.0169)
Euro	0.0036***	0.0056***	-	-	0.0199***	-0.0060***
	(0.0005)	(0.0004)	-	-	(0.0039)	(0.0004)
Const.	0.0421*	-0.0157**	0.0232**	-0.0024	0.0269	0.0020
	(0.0188)	(0.0037)	(0.0017)	(0.0014)	(0.0237)	(0.0033)
LnVIX	Yes	Yes	Yes	Yes	Yes	Yes
#Countries	5	5	2	2	5	5
#Obs	320	320	128	128	320	320
Overall R^2	0.2696	0.0412	0.2322	0.3204	0.1419	0.3111
CD test (p-value)	0.1820	0.0000	0.093	0.0000	0.7680	0.0000
AR(2) (p-value)	0.1950	0.2827	0.6457	0.1654	0.0985	0.6178

(b) Groups of countries that do not show cointegration.

Group	**4**		**5**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**
gY(-1)	-0.6619*	0.1789***	-0.8077**	0.0478
	(0.1696)	(0.0168)	(0.2752)	(0.0731)
gD(-1)	0.1431	-0.0368	-0.0043	-0.0572***
	(0.0833)	(0.0139)	(0.0625)	(0.0167)
CR(-1)	-	-	-	-
	-	-	-	-
Euro	0.0164	-0.0036	0.0009	-0.0095***
	(0.0045)	(0.0014)	(0.0100)	(0.0014)
Const.	0.0142	-0.0265	0.0810*	-0.0081
	(0.0330)	(0.0153)	(0.0244)	(0.0059)
LnVIX	Yes	Yes	Yes	Yes
#Countries	3	3	12	12
#Obs	192	192	768	768
Overall R^2	0.0953	0.1198	0.0794	0.0864
CD test (p-value)	0.9940	0.0020	0.0000	0.0000
AR(2) (p-value)	0.2600	0.1301	0.6655	0.0481

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

3.2.3. Model validity: robustness and goodness of fit

First of all, the results of the previous section could be affected by the omitted factors bias. In order to check the robustness of the previous results, the

following variables have been added to the estimations of models (2.7) and (2.8): the lagged inflation rate (*infl(-1)*), the lagged growth rates of the general government revenues (*gR(-1)*), and the lagged first differences of the long-term average bond yield[19] (*Dr(-1)*), maintaining the logarithm of the VIX Index. Results are shown in Table 2.6 and they do support the previous results. In fact, the sign and the significance of the cointegration variable do not change, while the magnitude of the estimated coefficients of CR_{it-1} changes only slightly. In general, it is also confirmed the negative relationship between the growth rates of debt and GDP for cointegrated countries (Table 2.6, panel (b)), whereas the short-run adjustment completely disappears in cointegrated countries (Table 2.6, panel (a)). This is no surprise since the relationship was already weak in Table 2.5.

Moreover, the added explanatory variables do not consistently improve the explanation of the dependent variables, i.e. gY and gD: they are almost always not statistically significant, they do not consistently improve the explanatory power of the model (in two cases the R^2 is lower while in the other cases it is comparable to Table 2.5), and there are no improvements in terms of cross-sectional dependence. Given these results and in order to keep the specifications as simple as possible, I will use and develop the five basic specifications for the rest of the analysis.[20]

Second, the Arellano-Bond panel test has been applied to test for the presence of second order serial correlation in the residuals, which may bias the standard errors and affect the other statistical tests. Though the asymptotic distribution of this test statistic requires $N \to \infty$, which is evidently not satisfied in this analysis, the application of the test might still give an indication of the presence of serial correlation. Nevertheless, at a significance level of 5 percent, the null hypothesis of no serial correlation cannot be rejected for all groups of countries.

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[19] These variables are treated as exogenous and they have been individually tested for stationarity.

[20] Models in Table (2.5) and Table (2.6) have also been reestimated by using the maximum-likelihood estimator and, though inadequate in term of standard errors, the Arellano-Bond estimator. No substantial differences have been detected, thus confirming the consistency of the estimations.

Table 2.6. Panel estimation, alternative specifications.

(a) Groups of countries that show cointegration.

Group	**1**		**2**		**3**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**	**gD**	**gY**
gY(-1)	-0.3201	-0.0412	-0.6269	0.3836*	-0.5437	0.2900***
	(0.2499)	(0.0809)	(0.1161)	(0.0243)	(0.2886)	(0.0547)
gD(-1)	-0.0218	-0.0272	0.1444	-0.0538	-0.1319	0.0029
	(0.0256)	(0.0182)	(0.0913)	(0.0388)	(0.0787)	(0.0112)
CR(-1)	0.0288***	-0.0008	-0.0065***	0.0092	-0.2087**	0.0512*
	(0.0018)	(0.0002)	(0.0000)	(0.0021)	(0.0603)	(0.0188)
infl(-1)	0.6229	-0.4761	0.5123	-0.1905	-0.0665	0.1797
	(0.6275)	(0.1750)	(0.1886)	(0.2379)	(0.4817)	(0.1372)
gR(-1)	-0.0659	0.0249	0.0653	0.0079	-0.1464	0.0379
	(0.1149)	(0.0226)	(0.0467)	(0.0089)	(0.1666)	(0.0292)
Dr(-1)	-0.0030	0.0026	-0.0010	0.0019	-0.0029	0.0007
	(0.0200)	(0.0041)	(0.0050)	(0.0031)	(0.0119)	(0.0020)
Euro	0.0059***	0.0054	-	-	0.0168*	-0.0052***
	(0.0006)	(0.0004)	-	-	(0.0066)	(0.0006)
Const.	0.0362*	-0.0124	0.0230**	-0.0020	0.0384	0.0004
	(0.0169)	(0.0032)	(0.0018)	(0.0012)	(0.0308)	(0.0033)
LnVIX	Yes	Yes	Yes	Yes	Yes	Yes
#Countries	5	5	2	2	5	5
#Obs	320	320	128	128	320	320
Overall R^2	0.2724	0.0389	0.2483	0.3240	0.1541	0.3308
CD test (p-value)	0.1280	0.0000	0.1210	0.0000	0.6480	0.0000
AR(2) (p-value)	0.2165	0.0850	0.6796	0.1604	0.1197	0.6961

(b) Groups of countries that do not show cointegration.

Group	**4**		**5**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**
gY(-1)	-1.0930**	0.1229	-0.7712	0.0754
	(0.0654)	(0.0839)	(0.2742)	(0.0806)
gD(-1)	0.1890	-0.0246	-0.0162**	-0.0505***
	(0.1874)	(0.0234)	(0.0683)	(0.0118)
CR(-1)	-	-	-	-
	-	-	-	-
infl(-1)	-0.3593	0.4546	-0.6609	-0.0773
	(2.3332)	(0.0936)	(0.5768)	(0.1052)
gR(-1)	0.1251***	-0.0080	-0.1134	0.0255
	(0.0000)	(0.0162)	(0.0644)	(0.0191)
Dr(-1)	0.0015	-0.0019	0.0295*	-0.0129**
	(0.0232)	(0.0130)	(0.0149)	(0.0058)
Euro	-	-	-0.0021	-0.0094***
	-	-	(0.0105)	(0.0013)
Const.	0.0406	-0.0204*	0.0937**	-0.0082
	(0.0477)	(0.0017)	(0.0300)	(0.0063)
LnVIX	Yes	Yes	Yes	Yes
#Countries	3	3	12	12
#Obs	192	192	768	768
Overall R^2	0.1527	0.1125	0.1013	0.1423
CD test (p-value)	0.4100	0.0210	0.0000	0.0000
AR(2) (p-value)	0.1892	0.2393	0.8790	0.1608

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

Third, since macroeconomics time series are often characterized by contemporaneous correlation, residuals have been tested for cross-sectional dependence with the panel test proposed by Pesaran (2015), and cross-sectional dependence has in fact been detected. I will deal with this problem in Section 3.5.

In conclusion, differences in the specifications and in the results for the cointegration analysis and differences in the estimated coefficients, and in the behaviour of the residuals of the dynamic panel models, fully reflect the heterogeneity of the country in each group: a unique model would be inadequate. Therefore, even if it is possible to derive general conclusions, it is also possible to claim that they cannot be applied to any country. In next section, I will include the impact of the crisis and of the austerity periods in the basic specifications.

3.3. Financial crisis and austerity: development of the basic specification

It is undeniable that the financial crisis has represented an important change in the macroeconomic regime of many countries, a change that is fully reflected in the dynamics of both public debt and GDP and that has been followed by the widespread implementation of austerity measures. In order to account for these aspects, the econometric models described by equations (2.7) and (2.8) have been extended to incorporate the following variables, and the estimation results are shown in Table 2.7[21]:

- $Crisis_{it}$, a dummy equal to 1 from 2008Q3 to 2009Q4, whose aim is to capture the impact of the financial crisis.
- $Austerity_{it}$, a dummy equal to 1 from 2010Q1 to 2015Q4. The timing and intensity of the application of the austerity measures in Europe varies from country to country (see Chapter 4), but this temporal dummy should capture the effect of the post-crisis period, which coincides with the generalized austerity period that affected all countries.
- Two interaction terms between the previous dummy variables and the main explanatory variables (gY(-1) and gD(-1)).

Considering at first Group 1, the estimated coefficients of CR_{it-1} are comparable to those in Table 2.5, but gY(-1) in the gD-equation is no more

[21] Tests for serial correlation and normality have been carried out again; results are similar to the basic models.

significant. Instead, the interaction term between $gY(-1)$ and *Austerity* is negative and significant, so that it is possible to state that the feedback of $gY(-1)$ on gD is now incorporated by this variable and is negative. In addition, the coefficients of the variables $Crisis$ and $Austerity$ are significant and positive, thus implying that both time periods are characterised, on average, by higher debt growth rates with respect to the previous period.

As regards the gY-equation, both the interaction terms are not significant, as well as the estimated coefficient of *Austerity*, whereas the coefficient of *Crisis* is significant and negative, underlying that this time period is characterised by lower GDP growth rates with respect to the previous and subsequent periods.

Turning to Group 2, the inclusion of the dummy variables and of the interaction terms has made the short-run relationship between the growth rates of debt and GDP no more significant. Moreover, the significance level of the CR's coefficients have changed and, at the same time, none of the included dummy variables and interaction terms are significant. As ntoed above, this group is formed by two countries only and results may be affected by this.

For the first equation of Group 3, *Crisis*, *Austerity*, and the interaction terms are not significant, but the coefficient of the $gY(-1)$ becomes statistically significant. At the same time, the CR's coefficients are not fundamentally affected. Considering the gY-equation, the coefficients of *Crisis* and *Austerity* are both significantly negative, reflecting the impact of the two sub-periods on the growth rate of the GDP; at the same time, the interaction term between *gD(-1)* and Crisis is positive and slightly significant, therefore offsetting the negative short-run relationship observed during the crisis period.

For what regards Group 4, all coefficients are not significant within the gD-equation, with the only exception of the interaction term between *gY(-1)* and *Crisis*, that captures the negative relationship between the debt growth rate and the lagged GDP growth rate. Conversely, the estimated coefficients of *Crisis* and *Austerity* are negative and significant for the gY-equations as well as the short-run adjustment, but no interaction term is significant.

Table 2.7. Panel estimation, extended basic specifcations: crisis and austerity.

(a) Groups of countries that show cointegration.

Group	**1**		**2**		**3**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**	**gD**	**gY**
gY(-1)	-0.0208	-0.2721**	-0.1579	0.2799*	-0.3754**	0.1783***
	(0.1203)	(0.0942)	(0.5006)	(0.0370)	(0.1043)	(0.0371)
gD(-1)	-0.0951**	-0.0137	-0.0498	0.0095	-0.1283	-0.0190
	(0.0219)	(0.0293)	(0.2260)	(0.0381)	(0.0648)	(0.0129)
CR(-1)	0.0286***	-0.0007**	-0.0056	0.0105**	-0.2417**	0.0426*
	(0.0012)	(0.0002)	(0.0025)	(0.0006)	(0.0646)	(0.0155)
Euro	-0.0475**	0.0217***	-	-	0.0128	-0.0023
	(0.0133)	(0.0018)	-	-	(0.0113)	(0.0016)
Crisis	0.0446**	-0.0167***	0.0185	-0.0031	0.0032	-0.0140**
	(0.0114)	(0.0028)	(0.0063)	(0.0038)	(0.0152)	(0.0044)
Austerity	0.0161**	-0.0010	0.0054	-0.0027	0.0080	-0.0054*
	(0.0054)	(0.0015)	(0.0065)	(0.0020)	(0.0109)	(0.0019)
gD(-1)*Crisis	-	0.0053	-	-0.1022	-	0.0472*
	-	(0.0417)	-	(0.1375)	-	(0.0218)
gY(-1)*Crisis	0.2183	-	-0.2169	-	-0.4841	-
	(0.2363)	-	(0.7591)	-	(0.3824)	-
gD(-1)*Austerity	-	0.0367	-	0.0619	-	0.0382
	-	(0.0423)	-	(0.1677)	-	(0.0254)
gY(-1)*Austerity	-0.6423**	-	-0.0782	-	0.7883	-
	(0.2316)	-	(0.3958)	-	(0.7269)	-
Const.	0.0331	-0.0069	0.0075	0.0011	0.0281	0.0087**
	(0.0181)	(0.0057)	(0.0032)	(0.0037)	(0.0261)	(0.0023)
LnVIX	Yes	Yes	Yes	Yes	Yes	Yes
#Countries	5	5	2	2	5	5
#Obs	320	320	128	128	320	320
Overall R^2	0.2192	0.0390	0.3053	0.3583	0.1920	0.3942
CD test	0.2670	0.0230	0.6370	0.0000	0.4730	0.0000
AR(2)	0.1330	0.7286	0.3470	0.1643	0.0896	0.4805

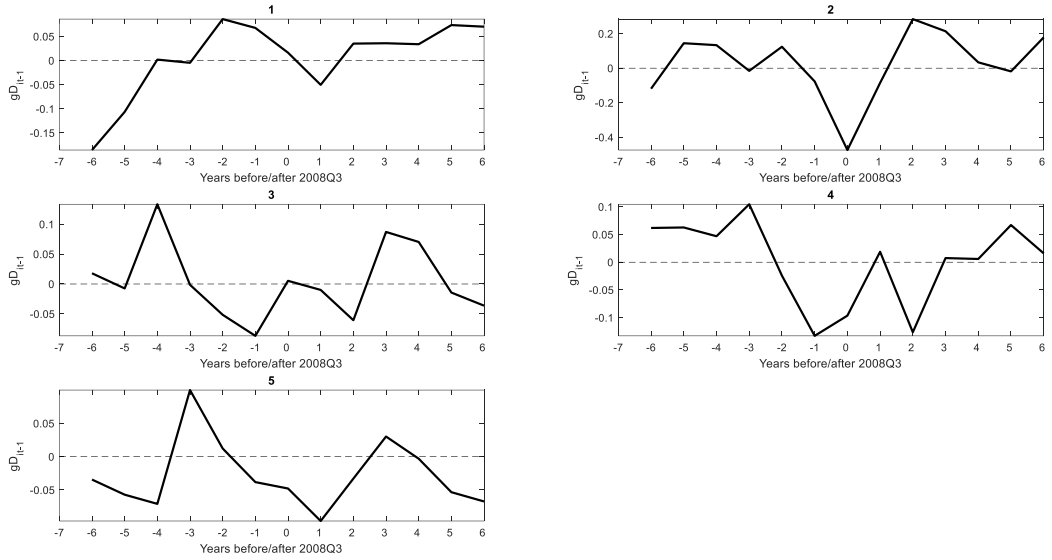
(b) Groups of countries that do not show cointegration.

Group	**4**		**5**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**
gY(-1)	-0.2830	0.0192	-0.5939***	-0.0845
	(0.4818)	(0.0721)	(0.1656)	(0.0697)
gD(-1)	0.1223	-0.0245*	-0.0449	-0.0273
	(0.0468)	(0.0083)	(0.0671)	(0.0285)
CR(-1)	-	-	-	-
	-	-	-	-
Euro	0.0050	0.0015	-0.0037	-0.0050**
	(0.0261)	(0.0030)	(0.0084)	(0.0017)
Crisis	0.0041	-0.0271**	0.0257*	-0.0184***
	(0.0296)	(0.0031)	(0.0120)	(0.0041)
Austerity	0.0163	-0.0077**	0.0046	-0.0060**
	(0.0330)	(0.0016)	(0.0057)	(0.0020)
gD(-1)*Crisis	-	0.0322	-	-0.0255
	-	(0.1853)	-	(0.0393)
gY(-1)*Crisis	-0.8162**	-	-0.4242	-
	(0.1529)	-	(0.4275)	-
gD(-1)*Austerity	-	-0.0132	-	0.0033
	-	(0.0228)	-	(0.0374)
gY(-1)*Austerity	0.2023	-	0.4952*	-
	(0.0559)	-	(0.2356)	-
Const.	0.0112	-0.0030	0.0551**	0.0040
	(0.0559)	(0.0098)	(0.0190)	(0.0051)
LnVIX	Yes	Yes	Yes	Yes
#Countries	3	3	12	12
#Obs	192	192	768	768
Overall R^2	0.1136	0.2551	0.1149	0.1932
CD test	0.8890	0.1670	0.0000	0.0000
AR(2)	0.2972	0.1690	0.5832	0.2831

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

Considering, eventually, Group 5, the short-run coefficients within the gD-equation remain highly significant, but the negative effect is diminished by the positive effect of the interaction term between *gY(-1)* and *Austerity*. The negative short-run relationship that has emerged in Table 2.5 disappears, instead, in Table 2.5, in which only the dummies *Crisis* and *Austerity* are significant.

Figure 2.8. Short-term temporal dynamics of *gD*(-1) for the five basic specifications with *gY* as dependent variable.



Indeed, the short-run component seems severely affected by the new added variables. In order to better describe the temporal dynamics of this component, a dummy variable for each year before and after[22] 2008Q3 and its interaction with the lagged value of the debt growth rate have been added to the five gY-equations.[23] In such a way, it is possible to depict the dynamics of the *gD(-1)*'s coefficient.

Evidently, the short-run adjustment has followed a cyclical dynamics, similar in the five groups, with a decrease around the gloabl crisis that has lasted a period going from one to three years and that reflects the negative sign emerged

[22] For many countries in my dataset, it represents the first quarter of economic crisis.
[23] Thus, 1 indicates the year 2008Q3-2009Q2, -1 indicates the year 2007Q3-2008Q2, and so on. Euro has been excluded from the estimations. See Figure 2.6.

in the previous analysis, while the period before and, above all, after the crisis, are primary characterised by higher and sometimes positive coefficients.

Finally, it must be noticed that residuals are still affected by cross-sectional dependence: the new variables have not overcome this problem. I will return to this aspect in Section 3.5.

Recapitulating, the inclusion of temporal dummies variables and appropriate interaction terms to account for the financial crisis and the subsequent austerity period has changed the conclusions reached in the previous section on the basis of models (2.7) and (2.8): the negative short-run relationship between public debt and GDP has been considerably revisited.

Furthermore, the distinction between "crisis" and "austerity" periods allows seeing that in both periods some groups experienced a fall in their GDP growth rates and a positive (or, at least, non-significant) impact on their debt growth rates. This is confirmed by the detailed temporal dynamics that shows a downturn around 2008Q3 and for the subsequent two-three years. A possible explanation for this fact may be found in the adopted fiscal policies and, in particular, in the expansionary and then austerity measures implemented in those periods. Nevertheless, a causal linkage cannot be assumed and would require further research.

3.4. Group 5, accounting for countries' heterogeneity

Group 5 is formed by a considerable number of different countries, a fact that undoubtedly introduces a high degree of heterogeneity. This finding suggests that this classification is perhaps not sufficient to comprehensively include all the aspects determining the debt-GDP relationship. Indeed, it is implausible that countries like Greece, Ireland, and Portugal, that experienced heavy debt crises, share the same properties of, for instance, Finland.

To account for the countries' diversity and to observe if any difference emerges between core and peripheral countries, the effects of the three core-countries of Group 5, i.e. Germany, Finland, and Luxembourg, have been captured by a dummy variable used to construct an interaction term (CC) with either the lagged growth rate of debt or GDP. Such a term has been included in both the

basis model for Group 5 and in their extended versions in order to account for the crisis and austerity periods (see Table 2.8). In both cases, estimation results do not dramatically change. Two aspects should be remarked: a) the interaction term is significant in three cases and is borderline non-significant in only one case, and b) its sign is always positive, thus indicating that the short-run negative adjustment in Table 2.5 is significantly lower or even positive for these countries.

Table 2.8. Panel estimation, Group 5 models with core-European countries interaction term.

Group	**5**		**Group**	**5**	
Dep. Var.	**gD**	**gY**	**Dep. Var.**	**gD**	**gY**
gY(-1)	-0.9475**	0.0437	gY(-1)	-0.7487***	-0.0886
	(0.3269)	(0.0751)		(0.2122)	(0.0712)
gD(-1)	-0.0037	-0.0737***	gD(-1)	-0.0438	-0.0357
	(0.0611)	(0.0212)		(0.0644)	(0.0311)
Euro	-0.0005	-0.0094***	Euro	-0.0046	-0.0050**
	(0.0102)	(0.0015)		(0.0087)	(0.0017)
CC	0.7740*	0.0507**	Crisis	0.0266*	-0.0179***
	(0.3919)	(0.0202)		(0.0126)	(0.0040)
Const.	0.0806**	-0.0076	Austerity	0.0037	-0.0059**
	(0.0236)	(0.0057)		(0.0059)	(0.0020)
LnVIX	Yes	Yes	gD(-1)*Crisis	-	-0.0349
#Countries	12	12		-	(0.0344)
#Obs.	768	768	gY(-1)*Crisis	0.0266	-
R^2	0.0878	0.0941		(0.0126)	-
CD	0.0000	0.0000	gD (-1)*Austerity	-	-0.0014
AR(2)	0.7367	0.0597		-	(0.0352)
			gY(-1)*Austerity	0.4979*	-
				(0.2581)	-
			CC	0.7784	0.0403**
				(0.4391)	(0.0141)
			Const.	0.0534*	0.0042
				(0.0190)	(0.0051)
			LnVIX	Yes	Yes
			#Countries	12	12
			#Obs.	768	768
			R^2	0.1230	0.1961
			CD	0.0000	0.0000
			AR(2)	0.6519	0.4057

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All standard errors are in parentheses.

On the one hand it is possible to say that the new sub-group of core-countries is characterised by a different short-run coefficient, which reflects a weaker negative relationship between debt and GDP, and, on the other hand, that the same conclusion can potentially be reached for the other sub-groups of countries. In fact, repeating this analysis to account for further differences would lead to consider each country individually, a fact that should remark the key role played by heterogeneity and the improbability of observing one general debt-GDP relationship. When cointegration arises, the debt-to-GDP ratio may

represent the long-run relationship between the two variables, but there is no evidence that suggests the existence of a general debt-to-GDP threshold. When, instead, cointegration is not detected, the debt-GDP relationship is more severely affected by heterogeneity; hence, a unique threshold is even less justified. The analysis in the next section will consider heterogeneity in depth.

3.5. Heterogeneity, cross-sectional dependence, and small-samples correction

This last section is devoted to the analysis of three aspects that have emerged above: the relatively limited number of countries in the groups, the presence of cross-sectional dependence not solved by adding the logarithm of the VIX to the previous specifications, and the heterogeneity of countries; I have dealt with all these aspects by adopting the Dynamic Common Correlated Effects estimator in Stata 13 (see Ditzen, 2016). In particular, for what concern the first point, the package developed by Ditzen (2016) allows to exploit the jackknife small sample bias corrections, the mean-group estimator that considered heterogeneity, and it allows to implement the technique initially proposed by Pesaran (2006) consisting in the approximation of the unobserved common factors responsible for the unobserved dependencies and the contemporaneous correlation between countries with the cross-section means of the dependent and independent variables. Moreover, results are robust to non-stationarity of such common factors.[24]

Results are reported in Table 2.9, from which three facts emerges. First, the CD test shows no cross-sectional dependence in the residuals. Second, all the short-run adjustments are not significant, and also the significance of the CR coefficients is reduced. Third, the results are in line with Section 3.3: the negative short-run adjustments are captured by the interaction terms, which give rise to more complex interaction effects between the growth rates of debt and GDP.

Therefore, accounting for heterogeneity has reduced the significance of many estimated coefficients but has not diminished the validity of the previous

[24] Further details about this methodology are presented in Chapter 3, Section 5.1, p. 120.

conclusions, i.e. that the debt-growth relationship is to some extent determined by the time period of the analysis.

Table 2.9. Panel estimation, Dynamic Pooled Common Correlated Effects, extended basic models.

(a) Groups of countries that show cointegration.

Group	**1**		**2**		**3**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**	**gD**	**gY**
gY(-1)	0.0518	-0.2373	-0.5842	-0.0216	1.0029	-0.1328
	(0.2817)	(0.1853)	(0.8361)	(0.0624)	(0.8373)	(0.3258)
gD(-1)	0.0760	-0.0215	-0.3268	0.2470	-0.1800*	-0.0592
	(0.1666)	(0.0206)	(0.3549)	(0.3313)	(0.1015)	(0.0657)
CR(-1)	-0.2939*	0.0211	-0.0422	0.0633*	-0.2190*	0.0667
	(0.1560)	(0.0384)	(0.0249)	(0.0385)	(0.1226)	(0.0469)
Euro	-	-	-	-	-0.0137	0.0059
	-	-	-	-	(0.0127)	(0.0053)
Crisis	0.0607***	-0.0439**	0.0173	-0.0064***	0.0073	-0.0354***
	(0.0218)	(0.0187)	(0.0132)	(0.0007)	(0.0234)	(0.0086)
Austerity	0.0371***	-0.0115**	0.0046	-0.0043	0.0262	-0.0145*
	(0.0116)	(0.0058)	(0.0046)	(0.0062)	(0.0188)	(0.0084)
gD(-1)*Crisis	-	-0.0834	-	-0.3222	-	-0.0375
	-	(0.3265)	-	(0.7040)	-	(0.1352)
gY(-1)*Crisis	0.6736	-	-0.3049	-	-0.1697	-
	(1.7242)	-	(1.1175)		(0.2708)	-
gD(-1)*Austerity	-	-0.2118	-	0.0785	-	0.1257
	-	(0.1434)	-	(0.3646)	-	(0.1206)
gY(-1)*Austerity	-3.8397*	-	0.2802	-	-0.1883*	-
	(2.1215)	-	(0.1051)	-	(0.0890)	-
Const.	-0.0109	0.0056**	0.0016	0.0057	0.0491***	0.0411*
	(0.0066)	(0.0024)	(0.0097)	(0.0035)	(0.0189)	(0.0242)
#Countries	4	4	2	2	5	5
#Obs.	244	244	126	126	309	309
CD Test	0.8279	0.8191	0.4429	0.1525	0.2965	0.3143

(b) Groups of countries that do not show cointegration.

Group	**4**		**5**	
Dep. Var.	**gD**	**gY**	**gD**	**gY**
gY(-1)	-0.5179	-0.1275	0.1621	-0.1586*
	(0.8565)	(0.2002)	(0.3432)	(0.0913)
gD(-1)	-0.0118	-0.0215	-0.1189*	0.0261
	(0.2110)	(0.0280)	(0.0691)	(0.0240)
CR(-1)	-	-	-	-
	-	-	-	-
Euro	-0.0410	-	-0.0749	0.0101
	(0.0410)	-	(0.1310)	(0.0079)
Crisis	-0.0308	-0.0246**	0.1887	-0.0120
	(0.0645)	(0.0106)	(0.1440)	(0.0122)
Austerity	0.0386	-0.0160***	0.3033	-0.0085
	(0.0555)	(0.0051)	(0.1882)	(0.0055)
gD(-1)*Crisis	-	-0.3896	-	0.0792
	-	(0.2656)	-	(0.1516)
gY(-1)*Crisis	-1.3566	-	-2.9819**	-
	(2.9710)	-	(1.1863)	-
gD(-1)*Austerity	-	0.0319	-	-0.0767*
	-	(0.0989)	-	(0.0430)
gY(-1)*Austerity	-0.0321	-	-1.6596	-
	(1.3957)	-	(1.6423)	-
Const.	0.0203	0.3058***	0.0059	0.0024
	(0.0467)	(0.0109)	(0.0107)	(0.0027)
#Countries	3	3	11	11
#Obs.	183	183	675	675
CD Test	0.6536	0.2406	0.8705	0.0247

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

4. CONCLUSIONS

In this chapter, I have implemented a two-steps methodology aiming at finding and describing a long-run relationship between public debt and GDP by analysing a slightly unbalanced panel dataset including 27 Western and Eastern European countries with quarterly data from 1999Q1 to 2015Q4.

In the first step, I have carried out a time-series cointegration analysis that allowed for the maximum degree of heterogeneity across countries, to ascertain whether a long-run relationship between (the growth rate of) public debt and (the growth rate of) GDP growth exists. On the basis of my findings, I can conclude that a long-run equilibrium relationship exists for some countries, but it is not generalisable. Moreover, such a relationship does not always entail the debt-to-GDP ratio, thus suggesting that the use of this measure might not be always appropriate.

In the second step, I have divided the countries in my dataset according to a search for the proper econometric model to be estimated, and I have exploited this strategy to compare the five identified groups. Results show that there is a negative short-run relationship between public debt and GDP, but this is weak, not always significant, and changes over the period of the analysis.

Moreover, the cointegration analysis and the subsequent panel estimations highlight that, despite the limited number of observations, a high degree of heterogeneity remains as an overwhelming feature of the phenomena in consideration. Because of heterogeneity, a unique equation describing the GDP-debt relationship may not be appropriate, thus sustaining the impossibility to derive a meaningful general debt-to-GDP threshold.

The econometric models that I have estimated in this chapter are the starting point towards future analyses. Following the approach "specific-to-general" described in Juselius (2006), the cointegration space could be extended to incorporate other variables that may lead to more comprehensive long-run relationships — even when cointegration has not been found — thus capturing other peculiarities of the relationship between public debt and economic growth.

The conclusions reached in this chapter should, in my view, redirect the debt-growth analysis from the pursuit of universal debt-to-GDP thresholds to indepth investigation that may explain why, when and how accumulation of public debt is associated to a decline in economic growth. This line of research is still undeveloped.

APPENDIX

Data Appendix

The primary data source for my analysis is the Eurostat Database, from which I take the quarterly time series of the nominal GDP at current prices; the price index (GDP implicit deflator, 2010=100); the general government gross debt i.e. the sum of liabilities, at the end of year, of all units classified within the general government sector; the inflation rate, based on the Harmonised Index of Consumer Prices (HICP, 2010=100); the general government expenditure; the interest rates for long-term government bonds denominated in national currencies.

By dividing the nominal GDP at current prices by the price index, I obtain the real GDP, which corresponds to the chain linked volumes (2010=100) time series available on Eurostat. Likewise, I obtain the real general government gross debt and the real general government expenditure. I subsequently deseasonalise these time series by applying the X-13 ARIMA technique.

This methodology allows me to obtain fully comparable real time series, avoiding the data availability (the "seasonally but not calendar adjusted" and the "seasonally and calendar adjusted" data on Eurostat are not available for all quarterly variables and all countries, though the unadjusted time series are usually available).

A second and last database is Thomson Reuters Eikon, from which I take the quarterly time series of the VIX i.e. the CBOE market volatility index derived from real-time, mid-quote prices of S&P 500 Index call and put options. According to the CBOE website (http://www.cboe.com/vix), the VIX Index "is a calculation designed to produce a measure of constant, 30-day expected volatility of the U.S. stock market, derived from real-time, mid-quote prices of S&P 500® Index (SPXSM) call and put options. On a global basis, it is one of the most recognized measures of volatility, widely reported by financial media and closely followed by a variety of market participants as a daily market indicator." Moreover, the VIX Index "is designed to reflect investors' consensus

view of future (30-day) expected stock market volatility. The VIX Index is often referred to as the market's fear gauge".

The final sample, slightly unbalanced, contains approximately 1700 observations for each variable from 1999Q1 to 2015Q4 from 27 countries, thus on average 68 quarters per country. I limit my analysis to countries with GDP and debt data available from at least 2000Q1 (a minimum of 64 observations for the cointegration analysis), and for this reason Poland is excluded.

Table A2.1 summarises the data sources of the mentioned variables.

Table A2.1. Employed variables and data sources.

Variable	**Source**	**Type of variable**
CBOE volatility index (VIX)	Thomson Reuters	Quarterly data
GDP at current prices	Eurostat	Quarterly data
Government consolidated gross debt	Eurostat	Quarterly data
Government revenues	Eurostat	Quarterly data
Inflation rate	Eurostat	Quarterly data
Long-term government bond yield	Eurostat	Quarterly data, average of monthly data
Price index (GDP implicit deflator)	Eurostat	Quarterly data

Cointegration Appendix

Table A2.2. Johansen trace test with Bartlett Correction (BC), tests on residuals, for weak exogeneity, for variable exclusion and for stationarity.

Country	Cointegration rank		Cointegration rank (BC)		Autocorrelation	Normality	Weak exogeneity		Restriction	Restriction (BC)
	r=0	r=1	r=0	r=1	LM(1)		GDP	Debt		
Austria	0.000	0.087	0.000	0.088	0.93	0.89	0.000	0.000	0.031	0.098
Belgium	0.001	0.049	0.002	0.077	0.30	0.12	0.000	0.883	0.003	0.020
Bulgaria	0.000	0.000	0.000	0.000	0.19	0.94	0.000	0.236	-	-
Croatia	0.000	0.000	0.000	0.000	0.52	0.10	0.000	0.000	-	-
Cyprus	0.000	0.000	0.000	0.002	0.13	0.24	0.000	0.000	-	-
Czech R.	0.000	0.005	0.000	0.01	0.44	0.19	0.000	0.248	-	-
Denmark	0.000	0.032	0.000	0.033	0.98	0.28	0.224	0.000	0.006	0.027
Estonia	0.000	0.000	0.000	0.000	0.40	0.00	0.000	0.001	-	-
Finland	0.000	0.000	0.000	0.002	0.17	0.26	0.001	0.000	-	-
France	0.001	0.588	0.003	0.612	0.12	0.17	0.000	0.186	0.000	0.000
Germany	0.000	0.000	0.000	0.000	0.22	0.45	0.000	0.000	-	-
Greece	0.000	0.005	0.000	0.006	0.12	0.87	0.004	0.000	-	-
Hungary	0.007	0.985	0.015	0.987	0.20	0.19	0.000	0.000	0.000	0.000
Ireland	0.000	0.024	0.000	0.034	0.63	0.19	0.000	0.000	-	-
Italy	0.004	0.773	0.005	0.775	0.41	0.10	0.000	0.000	0.018	0.051
Latvia	0.000	0.000	0.000	0.000	0.99	0.17	0.000	0.000	-	-
Lithuania	0.000	0.000	0.000	0.000	0.19	0.72	0.000	0.000	-	-
Luxembourg	0.000	0.000	0.000	0.000	0.45	0.20	0.001	0.000	-	-
Malta	0.001	0.346	0.002	0.350	0.33	0.66	0.195	0.000	0.000	0.000
Netherlands	0.000	0.505	0.000	0.508	0.50	0.35	0.088	0.000	0.000	0.003
Portugal	0.000	0.008	0.000	0.008	0.56	0.96	0.017	0.009	-	-
Romania	0.000	0.053	0.000	0.054	0.43	0.86	0.018	0.000	0.471	0.589
Slovak R.	0.000	0.002	0.000	0.004	0.57	0.55	0.002	0.012	-	-
Slovenia	0.000	0.000	0.000	0.000	0.16	0.43	0.000	0.042	0.026	0.047
Spain	0.000	0.001	0.000	0.001	0.69	0.10	0.000	0.000	-	-
Sweden	0.000	0.001	0.000	0.001	0.91	0.72	0.194	0.000	0.019	0.052
the UK	0.097	0.786	0.106	0.788	0.15	0.11	0.596	0.000	0.000	0.007

Continue on next page.

Country	Model Specification				Variable Exclusion								Stationarity	
	#L	Model	Breaks	Exog. V.	GDP	DGG	Dummy	B1	B2	B3	B4	Trend	GDP	DGG
Austria	1	Drift	2007Q4, 2009Q1	2009Q4	0.000	0.000	0.034	0.000	0.000	-	-	-	0.000	0.000
Belgium	2	Drift	2008Q4, 2009Q2	-	0.002	0.004	-	0.000	0.000	-	-	-	0.004	0.002
Bulgaria	1	Cidrift	2008Q1, 2009Q2, 2014Q3	-	0.000	0.003	-	0.000	0.000	0.027	-	0.000	0.003	0.000
Croatia	2	Drift	2008Q1, 2009Q1, 2013Q4	2009Q4	0.000	0.000	0.000	0.000	0.004	0.001	-	-	0.000	0.000
Cyprus	2	Drift	2009Q1	-	0.058	0.000	0.051	0.001	0.001	0.000	0.000	-	0.000	0.058
Czech R.	2	Cidrift	2008Q4, 2012Q1	-	0.000	0.003	-	0.003	0.100	-	-	0.000	0.003	0.000
Denmark	1	Drift	2008Q3, 2009Q1	2006Q2	0.001	0.015	0.064	0.000	0.000	-	-	-	0.015	0.001
Estonia	1	Drift	2004Q1, 2007Q2, 2008Q4, 2012Q2	-	0.000	0.000	-	0.000	0.000	0.000	0.000	-	0.000	0.000
Finland	2	Cidrift	2008Q3, 2009Q2, 2011Q4	-	0.001	0.000	-	0.000	0.000	0.001	-	0.002	0.000	0.000
France	2	Drift	2005Q4, 2008Q4	-	0.000	0.000	-	0.017	0.002	-	-	-	0.000	0.000
Germany	1	Cidrift	2005Q4, 2008Q3, 2009Q1, 2010Q4	-	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Greece	2	Cidrift	2008Q1, 2010Q1, 2012Q1	-	0.000	0.000	-	0.000	0.000	0.000	-	0.000	0.000	0.000
Hungary	2	Drift	2007Q2, 2009Q1	-	0.000	0.000	-	0.008	0.001	-	-	-	0.000	0.000
Ireland	2	Drift	2003Q4, 2007Q3, 2008Q2, 2013Q3	-	0.002	0.004	-	0.001	0.006	0.001	0.007	-	0.037	0.002
Italy	1	Drift	2008Q2, 2009Q2	-	0.000	0.000	-	0.000	-	-	-	0.000	0.000	0.000
Latvia	1	Drift	2001Q2, 2008Q4, 2013Q3	2008Q3	0.038	0.000	0.087	0.024	0.015	-	-	-	0.000	0.038
Lithuania	1	Cidrift	2008Q1, 2009Q1	2000Q4	0.000	0.000	0.024	0.001	0.039	-	-	0.000	0.000	0.000
Luxembourg	1	Drift	2001Q2, 2008Q4, 2013Q3	-	0.000	0.000	-	0.061	0.000	0.000	-	-	0.000	0.000
Malta	1	Cidrift	2006Q2	-	0.001	0.000	-	0.001	-	-	-	0.000	0.000	0.001
Netherlands	1	Cidrift	2008Q4, 2009Q2, 2014Q1	-	0.026	0.000	-	0.000	0.000	0.041	-	0.03	0.000	0.026
Portugal	1	Cidrift	2008Q4, 2010Q4	-	0.000	0.000	-	0.000	0.000	-	-	0.000	0.000	0.000
Romania	1	Drift	2003Q1, 2008Q3, 2009Q3	-	0.054	0.000	-	0.003	0.000	0.000	-	-	0.000	0.054
Slovakia	2	Cidrift	2008Q4, 2013Q2	2009Q1	0.007	0.008	0.013	0.001	0.003	-	-	0.000	0.008	0.007
Slovenia	1	Drift	2008Q1, 2009Q1	2012Q2	0.002	0.000	0.013	0.000	0.000	-	-	-	0.000	0.002
Spain	2	Cidrift	2008Q2, 2009Q1, 2012Q4	-	0.040	0.000	-	0.000	0.000	0.000	-	0.000	0.000	0.04
Sweden	1	Drift	2005Q4, 2008Q3	2009Q3	0.032	0.000	0.015	0.000	0.000	-	-	-	0.000	0.032
the UK	1	Drift	2008Q3, 2009Q3	-	0.000	0.000	-	0.002	0.002	-	-	-	0.000	0.000

Table A2.3. β structures for countries showing cointegration.

Country	Par.	GDP	DGG	Dummy	B1	B2	B3	Trend
Austria	β	1.000	-0.739	0.102	0.055	-0.053	-	-
		(NA)	(-9.128)	(2.216)	(5.864)	(-5.556)		
	α	-0.088	0.467	-	-	-	-	-
		(-3.891)	(7.518)					
Belgium-	β	1.000	1.967	-	-0.338	0.324	-	-
		(NA)	(9.871)		(-5.499)	(5.273)		
	α	-0.114	-0.006	-	-	-	-	-
		(-6.389)	(-0.186)					
Denmark	β	1.000	0.161	-0.092	-0.582	0.582	-	-
		(NA)	(5.572)	(-1.987)	(-13.321)	(13.318)		
	α	0.020	-0.787	-	-	-	-	-
		(1.236)	(-14.955)					
France	β	1.000	-0.322	-	-0.003	0.004	-	-
		(NA)	(-12.011)		(-3.142)	(4.983)		
	α	-0.360	0.158	-	-	-	-	-
		(-8.128)	(1.483)					
Hungary	β	1.000	-0.467	-	0.012	-0.015	-	-
		(NA)	(-16.951)		(2.829)	(-3.570)		
	α	-0.235	0.884	-	-	-	-	-
		(-4.916)	(5.112)					
Italy	β	1.000	-1.778	-	0.101	-0.087	-	-
		(NA)	(-6.013)		(6.549)	(-5.628)		
	α	-0.096	0.146	-	-	-	-	-
		(-4.857)	(4.227)					
Malta	β	1.000	1.155	-	-0.007	-	-	-0.010
		(NA)	(6.241)		(-5.731)			(-5.277)
	α	-0.108	-0.397	-	-	-	-	-
		(-1.525)	(-6.343)					
Netherlands	β	1.000	1.241	-	0.286	-0.299	0.016	-0.005
		(NA)	(5.777)		(3.751)	(-3.959)	(2.168)	(-6.323)
	α	-0.021	-0.339	-	-	-	-	-
		(-1.770)	(-10.978)					
Romania	β	1.000	-0.627	-	-0.030	0.216	-0.180	-
		(NA)	(-5.050)		(-7.961)	(5.259)	(-4.650)	
	α	-0.059	0.547	-	-	-	-	-
		(-2.542)	(5.902)					
Slovenia	β	1.000	-1.475	0.445	0.287	-0.234	-	-
		(NA)	(-9.235)	(2.850)	(6.057)	(-4.873)		
	α	-0.057	0.099	-	-	-	-	-
		(-10.431)	(2.367)					
Sweden	β	1.000	-2.300	0.407	-0.060	0.082	-	-
		(NA)	(-6.549)	(2.698)	(-5.334)	(5.808)		
	α	-0.028	0.254	-	-	-	-	-
		(-1.555)	(6.108)					
The UK	β	1.000	-0.466	-	0.074	-0.073	-	-
		(NA)	(-7.925)		(3.777)	(-3.769)		
	α	-0.012	0.608	-	-	-	-	-
		(-0.573)	(5.673)					

Notes: t-values are in parenthesis.

Chapter 3

Analysis of the Determinants of Austerity in a Panel of European Countries

Abstract

This chapter aims at explaining what has driven the adoption of austerity policies within a panel of 28 European countries, both members and non-members of the Eurozone, and over the period 2010-16. Determinants of austerity can be brought back to four main sets of variables: fiscal discipline, market discipline, fiscal consolidation, and macroeconomic stabilisation.

The first part of the chapter develops a correlation analysis that describes the relationship between austerity — measured as the first difference of the cyclically adjusted structural primary balance — and each considered explanatory variable, whereas the second part implements a panel econometric analysis. I first employ principal component factor analysis (PCFA) to reduce the number of explanatory variables and to retain the aggregate factors that might affect austerity, and second I estimate a panel model adopting the pooled common-correlated effect estimator (PCCE). Results show that the more important contributions to austerity are provided by the Excessive Deficit Procedure and by the Euro dummy. This effect is partially counterbalanced by the cyclical position of the economy. Nonetheless, the considered variables and common factors are not able to comprehensively explain austerity.

Keywords: austerity, fiscal reaction functions, correlation analysis, principal component factor analysis, dynamic panel data analysis.

1. INTRODUCTION

Austerity, the word that indicates the adoption of fiscal consolidation measures, has become part of everyday language. After the adoption of such measures within the European Monetary Union (EMU) with the aim to curb government budget deficits and outstanding debts with respect to the GDP, newspapers, policymakers, and common people have begun to talk daily about austerity, often with a negative meaning. In fact, it is indubitable that a great number of people within the most affected countries still see it in the same way as a "punishment" imposed by an external ruler, and whose effects on the economic system are definitely negative.[1]

Research on the relationship between fiscal consolidations and economic activity is vast, varied, and still unsettled. On the other hand, what has determined the adoption and the intensity of austerity policies in Europe has not yet been thoroughly investigated: were austerity policies primarily driven by European rules or were they the necessary answer to excessive and increasing public debts and deficits? Moreover, were they influenced by market and fiscal pressures or by the cyclical position of the economy? In other words, was their adoption and intensity dictated by the economic and financial circumstances? These questions describe the purpose of this chapter, in which I aim to find what has driven austerity in Europe from 2010 to 2016.

Specifically, I will assess the impact of four sets of explanatory variables that are introduced and described below: fiscal discipline, market discipline, fiscal consolidation, and macroeconomic stabilisation. Because of the limited time span of the analysis, I will first inspect each variable individually through a correlation analysis, and then I will consider a dynamic pooled-panel setting. The econometric analysis, aiming at formally finding and comparing the determinants of austerity, consideres both the variables of interest detected through the correlation analysis, and four aggregate common factors (one for

[1] See, for instance, the debate arose in Italy in 2017 between the two former Prime Ministers Matteo Renzi and Mario Monti:
http://www.ilsole24ore.com/art/notizie/2016-09-23/pil-renzi-ripresa-fatto-oggettivo-austerity-dannosa-162328.shtml?uuid=ADtnU5PB&refresh_ce=1

each set of explanatory variables) identified by employing the Principal Component Factor Analysis (PCFA).

The chapter is organised as follows. Section 2 introduces and describes the employed austerity measure; Section 3 presents the four sets of explanatory variables; Section 4 performs a correlation analysis for each variable, while Section 5 briefly outlines the econometric methodology and presents the estimation results. Finally, Section 6 concludes.

2. A MEASURE OF AUSTERITY

The main variable of my analysis should be a measure of fiscal consolidation, but several different alternatives are available in the literature. The relevant fiscal variables are usually corrected by taking out the cyclical component and the interest payments, as for the "cyclically adjusted primary balance" (CAPB) and the "cyclically adjusted structural primary balance"[2] (STPB). This is the case of the ratio between STPB and potential GDP (PGDP), which is the official measure adopted by the European Commission (EC) to assess member countries' underlying fiscal position for fiscal surveillance and for the adoption of a formal Excessive Deficit Procedure[3] (EDP).

[2] To understand the difference, consider that the components of the primary budget can be classified into two broad categories: those that are somehow related to the business cycle and those that are not. The former can in turn be distinguished between the automatic stabilisers (e.g. unemployment subsidies) and discretionary counter-cyclical measures (e.g. one-off changes in tax rates). Those unrelated to the business cycle are instead the result of discretionary and "structural" interventions in the sense that they are taken in view of other policy objectives and are, at least ex-ante, meant to be permanent (e.g. a change in the pension transfers). Thus, the STPB is obtained by subtracting form the CAPB also the discretionary counter-cyclical measures and other one-off operations.

[3] Defined as "an action launched by the European Commission against any European Union (EU) Member State that exceeds the budgetary deficit ceiling imposed by the EU's Stability and growth pact legislation." For further details, see the website of the European Commission (https://ec.europa.eu/info/index_en) and the Eurostat Glossary: http://ec.europa.eu/eurostat/statistics-xplained/index.php/Glossary:Excessive_deficit_procedure_(EDP)

In light of these considerations, I have measured the fiscal adjustment – or austerity, A_{it} — in year t as the positive change in the STPB/PGDP over the previous year *t-1*, that is:

(3.1) $$A_{it} = \Delta \frac{STPB}{PGDP} > 0$$

Yet the STPB has been adopted, and the official EC data are available, from 2010, which implies that A_{it} is calculable only from 2011. Therefore, whenever it is necessary to consider the period before 2011, I will resort to the CAPB and I will denote this measure of austerity[4] as A'_{it} (further details are presented in the Data Appendix).

The analysis is performed on a balanced panel dataset containing yearly data over the period 2010–2016 of 28 European countries,[5] both members and non-members of the Eurozone, and four groups are considered. The primary distinction is between the Eurozone countries[6] (EZ henceforth), namely the countries that adopted the single currency before 2017, and the non-Eurozone[7] countries (NoEZ), the countries that have never adopted the Euro. Additionally, a qualitative preliminary analysis allows to distinguish between two subgroups: the first includes the most fiscally sound countries[8] (EZ7), while the second includes the countries that undoubtedly experienced either debt or bank crises and programmes of financial assistance[9] (EZ5).

I will now proceed to examine the characteristics, analogies and differences in austerity in the sample of countries under consideration, with particular focus on the timing and intensity of the adopted policies. As will emerge, austerity has been most severely enacted in the EZ5 countries.

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4 As can be expected, the two indicators follow similar paths, but CAPB is quite more variable than STPB.

5 Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, the UK.

6 Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain.

7 Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Poland, Romania, Sweden, and the UK.

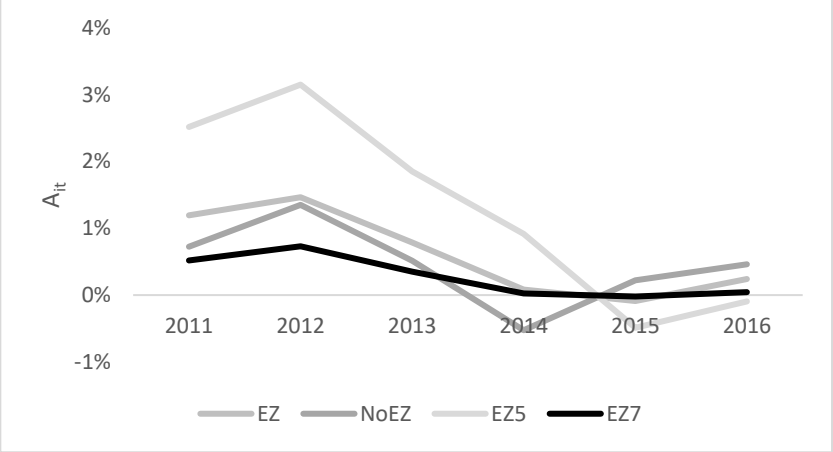
8 Austria, Belgium, Finland, France, Germany, Luxembourg, and Netherlands.

9 Cyprus, Portugal, Greece, Ireland, and Spain.

2.1. Timing and intensity

Within the austerity literature, the first two critical characteristics are timing and intensity, that should go hand in hand. The first key ingredient in the recipe for successful austerity is an "ambitious", front-loaded restoration of sustainable public finances that stops speculative attacks, regenerates investors' confidence, and regains access to the debt market at lower interest rates. According to the evidence analysed by Buti and Pench (2012), gradual consolidations seem more likely to be successful, but gradualism may be harmful for countries starting with high debt levels and major financial distress. From this point of view, the austerity indicator given by equation (3.1) and depicted in Figure 3.1 allows for the following considerations.

Figure 3.1. Average A_{it} dynamics by group of countries, 2011-16.



As to timing, almost all the countries in my dataset took the austerity stance in 2011 which peaked in 2012. The adoption of these fiscal adjustments was in part due to the 2010 generalized partial recovery that followed the massive fiscal stimuli of 2009; it was, however, a short-lived spring followed by further slowdown in the subsequent years. Nonetheless austerity was continued after 2012, though at a declining pace which petered out in 2014-15. Looking at groups of countries, it is worth noting that the EZ and the NoEZ groups enacted roughly the same average amount of austerity in 2011 (1.20% and 0.72%), but they followed a slightly different time path: the EZ group shows a "front-loading" pattern peaking in 2011-2012, whereas the NoEZ group displays a

smoother pattern with austerity between 2012 and 2013 which was abruptly reversed in 2014.

Nevertheless, there are other interesting differences within the groups. In the EZ group, the austerity turn was largely driven by the most financially distressed group (EZ5, and notably Greece and Portugal) averaging around 3.19% of GDP in 2011. The EZ7 group (0.52% in 2011) of the more fiscally sound countries followed a smoother path. Therefore, large and "front-loaded" austerity within the Eurozone has been concentrated in the EZ5 countries.

Table 3.1. Means, standard deviations, and the coefficients of variation of A_{it} for groups of countries, 2011-16.

Group	EZ	NoEZ	EZ5	EZ7
Mean	0.61%	0.46%	1.35%	0.27%
SD	0.63%	1.25%	1.86%	0.57%
CV	2.06	2.73	1.37	2.07

Table 3.1 reports the means, the standard deviations (SD), and the coefficient of variation (CV) of A_{it} for each group in order to quantify the heterogeneity of policies. By looking at the coefficient of variation, i.e. the ratio between the standard deviation and the mean, heterogeneity appears not surprisingly lower in the EZ group, where each government may pursue a fully independent policy, and higher in the NoEZ group, where governments share the same fiscal regulations. Nonetheless, it is true that the differences within the group are between the five countries under either financial or economic assistance on the one hand, and those under no external treatment on the other. In fact, the EZ5 group is characterised by a lower coefficient of variation than the EZ7 group, thus underlying that the first has experienced less variability in the implementation of the austerity programmes than the latter.

To complete this first overview of the data with the intensity of austerity, it should be considered that austerity is usually viewed as a medium-term policy. Hence, I also take into consideration an additional indicator, the *cumulated austerity* from 2011 to 2016, that is:

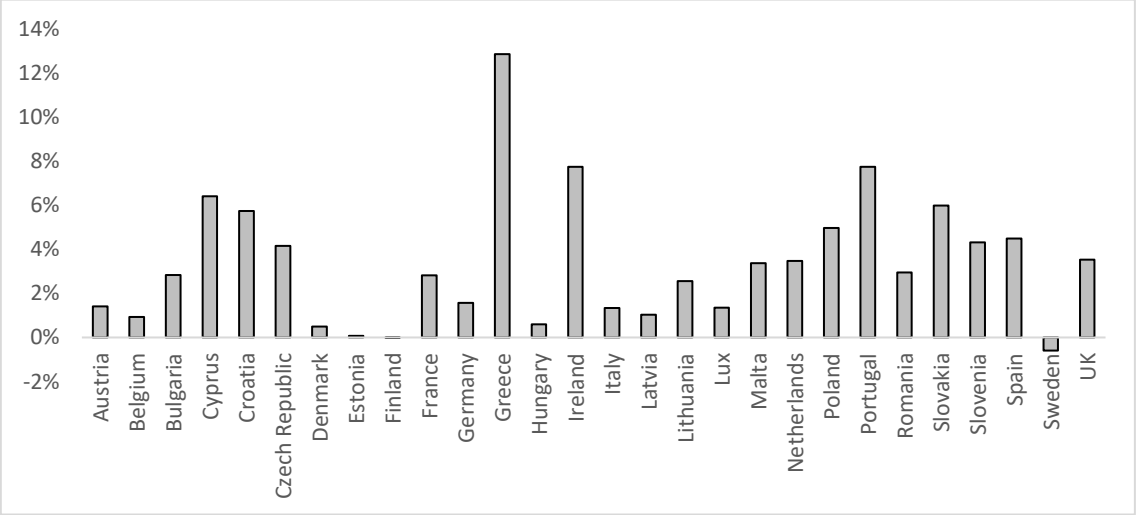
(3.2) $CA_{it} = \sum_{t=2011}^{2016} A_{it}$

This indicator represents the overall intensity of the successive austerity injections whether front- or back-loaded. 26 countries have cumulated a fiscal

restriction from 2011 to 2016 ($CA_{it} > 0$ — see Figure 3.2). Only Sweden and Finland have cumulated a zero or negative fiscal adjustment. Moreover, for 22 countries, CA_{it} has been larger than 1%, and the EZ group has been more restrictive than the NoEZ group (2.98% and 2.08% respectively). Yet it is already known that the most severe restrictions have been realized in the EZ5 group (7.85% on average, which includes the countries on the top of the list: Greece 12.86%, Portugal 7.74%, Ireland 7.5%, Cyprus 6.40%, and Spain 4.49%). This is equivalent to say that the average EZ5 country has cut its STPB at a year pace of about 2% of GDP for four years. Among the other EZ countries, one case stands out: Slovakia, involved in a debt crisis and asked to adopt large fiscal consolidations.

The EZ7 group, instead, has cumulated substantially less austerity (1.59%, with France, however, reaching 2.81% and Netherlands 3.47%). Within the NoEZ group there are no significant differences on average, but it is worth pointing out a few exceptions of countries with CA_{it} well above the average like Croatia (5.75%), Czech Republic (4.15%), and Poland (4.98%).

Figure 3.2. CA_{it} indicators by country over the period 2011-16.



In the light of this first overview of the data, I may draw two conclusions. First, the "Euro dummy" *per se* does appear important, but austerity has been "freely" pursued across the whole European area. Are there common cogent reasons or maybe that austerity has been perceived, or advertised, as the right policy for

the aftermath of the crisis throughout the developed Western countries (see e.g. Blyth, 2013)? Second, austerity has been implemented and then relaxed in different ways as to its timing and overall intensity. This holds true especially among EZ countries, despite their being subject to the same rules and to common surveillance institutions. As argued by EC officials, diversification and flexibility have in fact been actively pursued in application of the recent modifications of the relevant fiscal rules (Buti and Carnot, 2013, p. 3).

Under all dimensions, austerity has been most severely enacted in the EZ5 group under the worst public finance distress, which clearly stands out as the epicentre of the European austerity. On the one hand, this evidence may appear justified by their financial threats; on the other hand, one may wonder why almost all other countries were also pushed into austerity to a non-negligible extent. Thus, I would qualify the EZ experience as one of "uncoordinated austerity", which may have created unfavourable conditions for the countries facing stronger pressure for fiscal consolidation.[10]

In historical perspective, the presented figures depict a unique sequence of large, simultaneous fiscal restrictions across the whole Western and Eastern Europe. However, significant differences have also emerged, and it is therefore important to try to characterize them. Therefore, a deeper analysis is required to find out what has driven the adoption of austerity measures between 2011 and 2016.

3. IN SEARCH OF EXPLANATORY VARIABLES

In search of explanatory variables of A_{it}, I have sorted out four groups that can be found, whether positively or normatively, in the literature.

The first relates to "*fiscal consolidation*" and includes public deficits and debt stocks, two variables that are commonly adopted for fiscal sustainability analyses. The relationship between budget policy and sustainability is the main purpose of the estimation of the so-called "fiscal reaction functions" (FRFs

[10] On the problem of uncoordinated fiscal adjustment plans in the Eurozone, see Tamborini (2013), Berti et al. (2013), in't Veld (2013).

henceforth) introduced by the seminal works of Bohn (1995, 1998).[11] For instance, Afonso and Jelles (2011) employ FRFs in a set of OECD countries showing that primary balances have been increased to deal with the raise in public debt levels. This result is in line with Berti et al. (2016), who shows that most of the European countries included in their analysis positively adjusted their fiscal balances to rising levels of public debt, though with great variability,[12] and with Gosh et al. (2013), who shows evidence of fiscal fatigue within a set of 23 advanced countries.[13] Another application is provided by D'Erasmo et al. (2016), who adopts, among other techniques, FRFs to assess debt sustainability in USA and Europe, rising some concern about fiscal sustainability, while Legrenzi and Milas (2013) find clear evidence of fiscal fatigue for Greece, Ireland, Portugal and Spain. In addition, it seems that all countries adjusted fiscal imbalances only in the higher debt regime.

In contrast with these findings, more recent works have found that the fiscal fatigue hypothesis may not hold or may not hold for all countries (see, among others, Checherita-Westphal and Žďárek, 2017; Everaert and Jansen, 2017; Weichenrieder and Zimmer, 2014), thus casting some doubts on the validity of the previous results.

The second group relate to "*market discipline*", which includes the interest rate spread and the sovereign bond rating. Indeed, yield spreads and credit ratings are commonly considered as procyclical devices that can incentivise the adoption of sound fiscal policies. However, departures from this idea have been found in the literature: Zuccardi (2015), for instance, observes that, within the Eurozone, the relationship of spreads with the economic fundamentals (fiscal

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11 Bohn (1995, 1998) introduced the analysis of the response of primary balance to changes in the public debt caused by economic shocks. According to Proposition 1 in Bohn (2008), the basic FRF equation consists of the following linear relationship between the two variables:

$s_t = \rho \cdot d^*{}_t + \varepsilon_t$

where s_t is the primary balance of period t as a fraction of GDP, ρ is a constant, $d^*{}_t$ is the initial debt-to-GDP ratio, and ε_t is a composite of other determinants. If ε_t is bounded as a share of GDP and the present value of GDP is finite, then $\rho > 0$ satisfies the economy's intertemporal budget constraint and the no-Ponzi game condition, thus indicating fiscal sustainability.

12 This fact, as the authors suggest, highlights the advantages of estimating country-specific FRFs.

13 According to Gosh (2013), fiscal fatigue is the situation in which the increase in public debt is not compensated by an equivalent growth in the primary balance.

balance, public debt, and GDP growth rate) is weaker than in other areas, a fact that is also recognised by Ullrich (2006) who claims that "the confidence that financial markets are able to discipline the debt behaviour of governments is not very high" and that "the EU's Stability and Growth Pact has replaced market discipline". In the same line, Favero and Missale (2012) justify the issuing of Eurobonds on the basis of the fact that the role played by the government bond spreads on domestic bonds as a fiscal discipline device is weakened when contagion effects and market irrationality are more relevant than the fiscal fundamentals of the countries. All in all, the role of government bond spreads and credit ratings as discipline devices seem week for the EZ countries, but they may have played a role for the adoption and the intensity of the austerity policies between 2011 and 2016.

The third group, EZ "*fiscal discipline*", comprises, beyond the EZ membership, the excessive deficit procedures and the public finance forecasts of the EC. These variables capture the actions of the EC in its role to safeguard sound public finances within the framework devised by the EU's Stability and Growth Pact, and the macroeconomic forecasts that the EC makes available for the EU and its member countries concerning the STPB. The excessive deficit procedure and the Stability and Growth Pact have attracted much attention in the literature — into which I do not enter — aiming at assessing their impact and evaluating the possible alternatives (see, for instance, Eichengreen, 1997; Artis and Winkler, 1998; Blanchard and Giavazzi 2004; Giudice and Buti, 2017).

Finally, the fourth and last group, "*macroeconomic stabilisation*", includes the GDP growth rate, the output gap, and the unemployment rate as counterbalancing factors derived from the literature about countercyclical macroeconomics policies (see, among others, Gordon and Leeper, 2005; N'Diaye, 2009) and from the debate about the macroeconomic stabilisation (see, among others, Cooper and Kempf, 2000; Tamborini, 2003; Agénor and Montiel, 2015).

Hence, for each country, I will denote with

- DEF_{it}: the current (year t) total deficit-to-GDP ratio of country i; given the 3% ceiling of the deficit-to-GDP ratio, the variable of interest is $EDEF_{it} = (DEF_{it} - 3\%)$, used by the EC;

- D_{it}: the current gross debt-to-GDP ratio, whose growth rate is indicated by gD_{it};
- S_{it}: the current year average of monthly spreads of long-term government bonds relative to German bonds[14]. The first difference will be indicated with dS_{it};
- RA_{it}: the average Standard and Poor's rating of government bonds. The first difference will be indicated with dRA_{it}.
- $Euro_{it}$: a dummy variable for the Eurozone membership;
- EDP_{it}: a dummy variable for the presence of an Excessive Deficit Procedure;
- $FF_{it|t-1}$: the EC average fiscal forecast in period $t-1$ of the cyclically adjusted primary balance of period t[15];
- OG_{it}: the current output gap;
- gY_{it}: the current real GDP growth rate;
- UR_{it}: the current unemployment rate. The first difference will be indicated with dUR_{it}.

Data sources and employed variables are described in detail in the Data Appendix at the end of this chapter.

Since the aim of this analysis is to extract austerity drivers from the data, and at the same time ascertain their explanatory role of differences in austerity, the empirical methodology develops in two steps. First, I will run a statistical correlation analysis for each explanatory variable and for each group of countries. Then, I will present the results of a panel dynamic estimation with austerity as the dependent variable and by adopting the Principal Component Factor Analysis for the independent variables.

[14] Ratings are translated from letters to numbers between 0 and 1. See the Data Appendix for further details.
[15] See below Section 4.4 for further details.

4. STEP 1: CORRELATION ANALYSIS. WHAT EXPLAINS DIFFERENCES IN AUSTERITY?

In the following, each explanatory variable is analysed individually, and two indicators are presented: the interpolation function and the R^2 statistics. These indicators are sufficient for my purpose, that is to quantify 1) the correlation between the austerity indicator and the explanatory variable to justify the subsequent analysis, and 2) how much of within-group differences in A_{it} are explained by differences in the explanatory variable. At the same time, by comparing the results across groups, I can gain insight where each explanatory variable has exerted its effect more significantly.

4.1. Fiscal consolidation: public deficits and debts

In the first place, let me examine the evolution of the deficit-to-GDP ratios.

Figure 3.3. Deficit-to-GDP ratios, groups of countries, 2010-16.

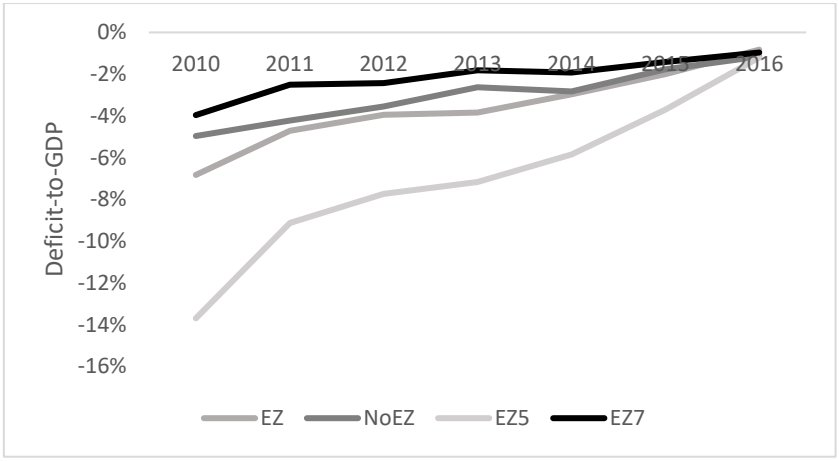


Figure 3.3 reports the dynamics of the deficit-to-GDP ratio for each group of countries from 2010 to 2016. As austerity has been a generalized policy, so all countries have progressively brought their deficit-to-GDP ratio under control. In the EZ group, the average indicator has fallen from 6.83% to 0.83% in 2016. While in 2010 all EZ countries (except Finland, Malta, and Luxembourg) were above the 3% ceiling, in 2016 only two (France and Spain) were above that threshold. Interestingly, even countries with no formal deficit-to-GDP target

have moved in tandem with the EZ group: the average NoEZ deficit has been cut from 4.96% to 1.16% in 2016, though the UK and Romania still have deficits three times larger than the average.

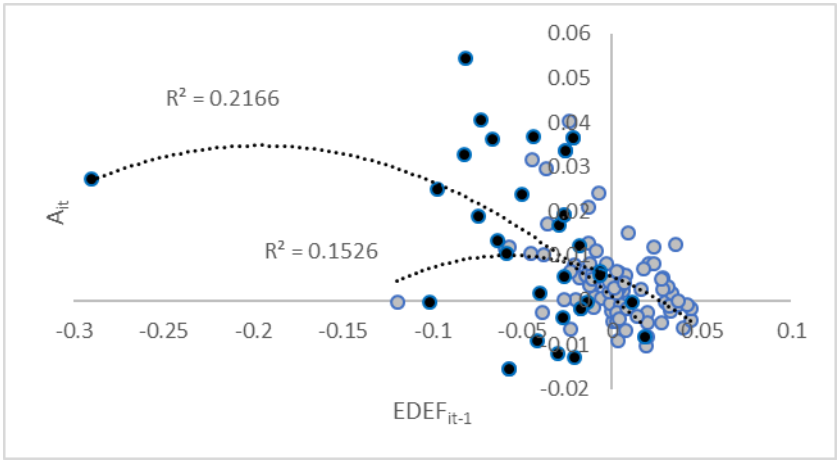
In order to examine the effect of previous deficits on austerity, or the "budget smoothing principle", I investigate two hypotheses. The first is that deficits are promptly corrected year by year. The second is that the adjustment takes a medium-term perspective.

The two panels of Figure 3.4 display the correlation graphs of A_{it} *vis-à-vis* $EDEF_{it-1}$ for the EZ and the NoEZ groups. Both present a negative correlation (though very weak for the NoEZ group), which is consistent with the budget-smoothing principle. This principle, however, has been applied with different strength in different countries and groups. As a matter of fact, the NoEZ countries' austerity measures appear largely disconnected from their deficits. On the other hand, the EZ countries display a stricter correlation between their respective austerity measures and deficits, as one may expect given the fiscal rules of the EMU.

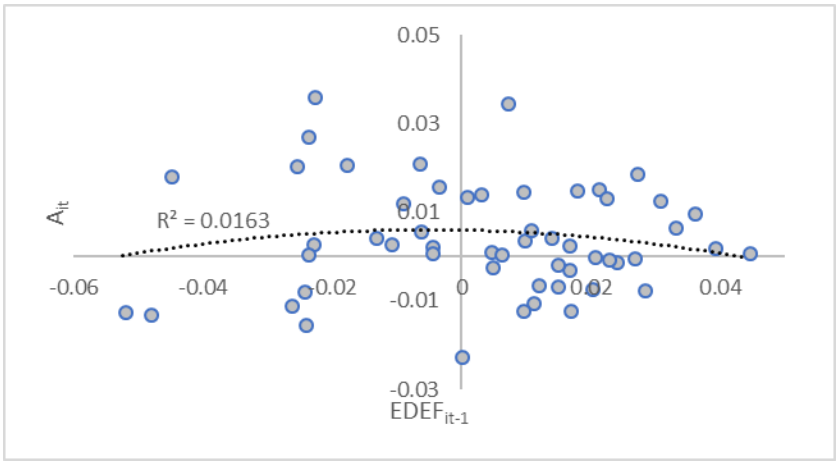
Interestingly, the best interpolation functions are quadratic and concave to the origin (even with the exclusion of the single outlier referred to Ireland in panel (a) of Figure 3.4). This pattern indicates that the restrictive fiscal consolidations have been *decreasingly* correlated to the deficit's dimension. This evidence supports the so-called "fiscal fatigue" hypothesis that I have introduced in Section 3, according to which the government reactiveness decreases as the required adjustment grows (in fact, it should be observed a convex function). Moreover, as can be seen from the correlation graph, there are significant differences *within* the EZ group. Actually, in the EZ7, A_{it} is not strongly correlated with deficits, and differences in deficits explain a small amount of differences in A_{it}. The bulk of the correlation between A_{it} and deficits — and its concavity — in the EZ group is due to the EZ5 countries, which may not be a surprise given their worse public finances and the "Troika" treatment for three of them.

Figure 3.4. Correlation between A_{it} and deficit-to-GDP ratios.
EZ (panel a) and NoEZ (panel b) groups, 2011-16.

(a) EZ5 (black) and other EZ countries (grey)



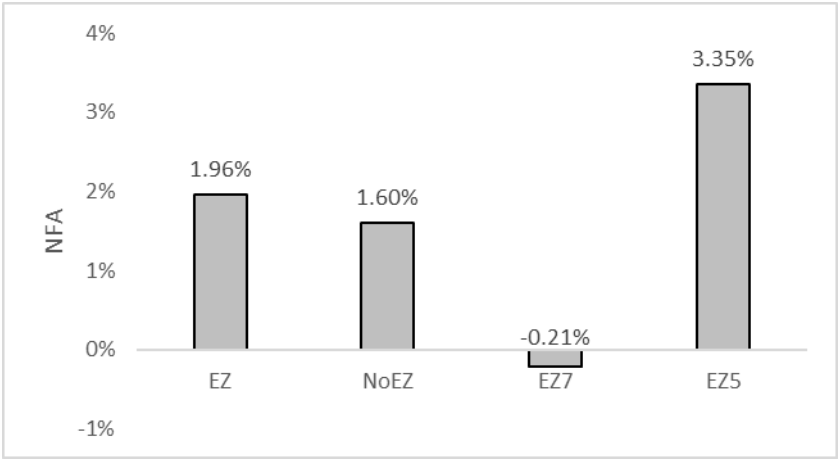
(b)



The second hypothesis is that budget smoothing has taken place over the whole period 2008-2016, in particular that the cumulated austerity 2010-2016 has been activated to rebalance progressively the expansions of 2008-09. Since the STPB data are not available for 2008-09, I have adopted the CAPB-based measure of austerity, A'_{it}, obtaining $CA'_{i08-09} = A'_{i08}+A'_{i09}$. The result is negative for most of countries, indicating a cumulated fiscal stimulus in response to the Great Recession. The same calculation for the years 2010-16 yields the subsequent cumulated fiscal adjustment CA'_{i10-16}. The result is consistent with the analogous STPB-based indicator presented in Figure 3.2, i.e. positive for almost all countries. With these data, two evaluations can be made in terms of the budget smoothing principle.

The first concerns the net overall entity of the fiscal manoeuvres, i.e. $NFA'_{i08\text{-}16} = CA'_{i08\text{-}09} + CA'_{i10\text{-}16}$. Budget smoothing would imply $NFA'_{i08\text{-}16} \approx 0$, whereas $NFA'_{i08\text{-}16} > 0$ indicates over-adjustment, i.e. cumulated austerity in 2010-16 exceeding the initial cumulated stimulus, and vice versa $NFA'_{i08\text{-}16} < 0$.

Figure 3.5. *NFA* indicator over the period 2008-2016, groups of countries.



From Figure 3.5, it is possible to discover essential differences among the groups of countries: whereas both the NoEZ group (1.60%) and the EZ group (1.96%) have slightly over-adjusted, the higher NFA indicator for the EZ group can be explained by looking at the EZ5 countries, which have largely over-adjusted by a cumulated 3.35% of GDP, whereas the EZ7 countries have remained in line with budget smoothing (-0.21%). These data shed further light on a result that underlying the strong and prolonged austerity that Ireland, Greece, Spain, and Portugal have experienced.

A second evaluation of these data can be offered by correlation analysis between $CA'_{i08\text{-}09}$ and $CA'_{i10\text{-}16}$. Under budget smoothing, $CA'_{i08\text{-}09} < 0$ should trigger $CA'_{i10\text{-}16} > 0$ by almost equal amount tracing a correlation line with negative unit coefficient. As Figure 3.6 shows, the sign of the relationship across countries is consistent with this principle, but statistically the differences in initial fiscal stimuli provide a limited account (about 34%) of differences in subsequent cumulated austerity.

Figure 3.6. Correlation between $CFA_{08\text{-}09}$ and $CFA_{10\text{-}16}$, all countries.

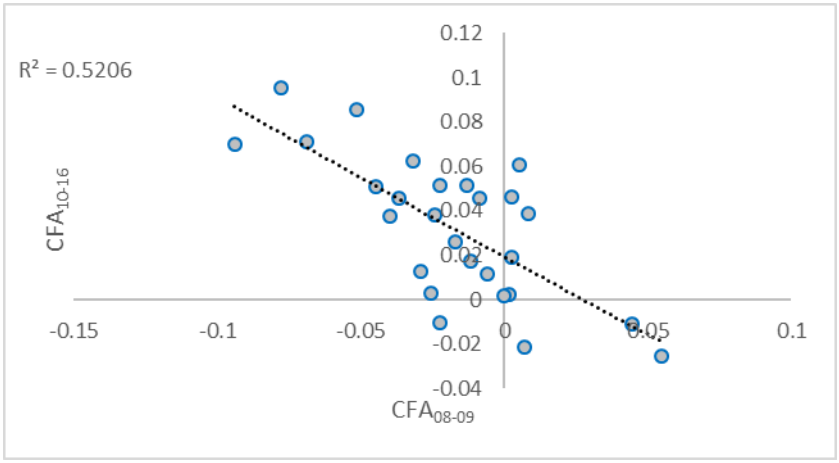
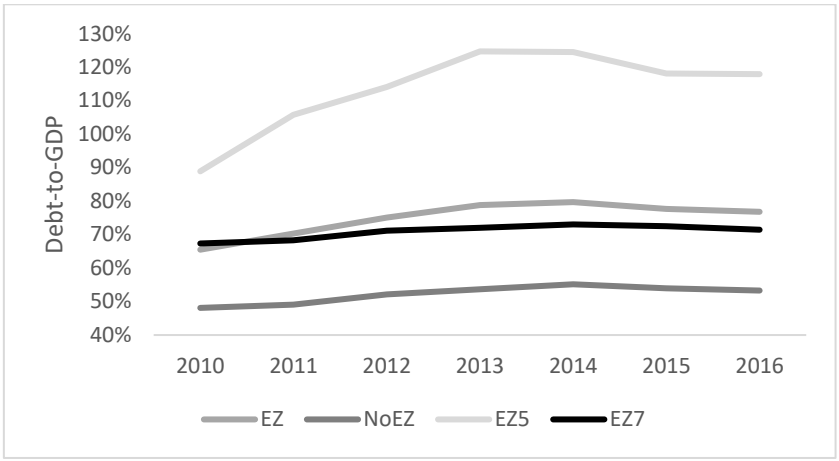


Figure 3.7. Debt-to-GDP ratios, groups of countries, 2010-16.

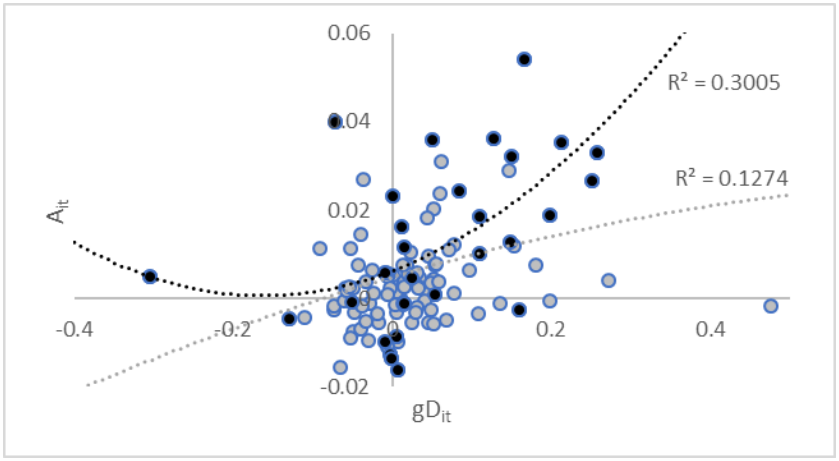


The other key variable for fiscal consolidation is the evolution of the debt-to-GDP ratio. As depicted in Figure 3.7, on this front the austerity effects have been poorer than in the case of deficits in all groups of countries. Starting from 2010, debt-to-GDP ratios have consistently been rising everywhere. The EZ and NoEZ groups have followed very similar paths, but it should be noted that the EZ includes the strongest debt accumulators, that is EZ5 (in particular, Greece). For this group of countries, a considerable decrease in the average debt-to-GDP ratio can be observed starting from 2014, but this tendency has reversed again in 2016.

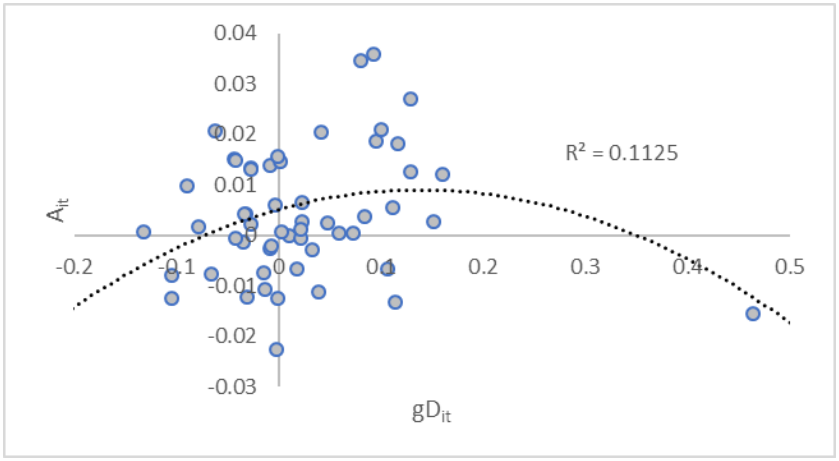
In spite of the increasing policy pressure on public debt consolidation, its evolution does not seem to provide much information about fiscal adjustments.

Figure 3.8. Correlation between A_{it} and the growth rate of the debt-to-GDP ratio. EZ (panel a) and NoEZ (panel b) groups, 2011-16.

(a) EZ5 countries (black) and other EZ countries (grey)



(b)



Consider Figure 3.8. On the one hand, larger A_{it} are associated with larger variations in the debt-to-GDP ratios, but in both the EZ group (12.74%) and NoEZ group (11.25%) the correlation is very weak, and differences in gD_{it} account for a thin fraction of differences in A_{it}. On the other hand, for the EZ5 group only, the R^2 does reach 36.35%, in line with the idea that most severe fiscal adjustments in these countries have been dictated by debt crises.

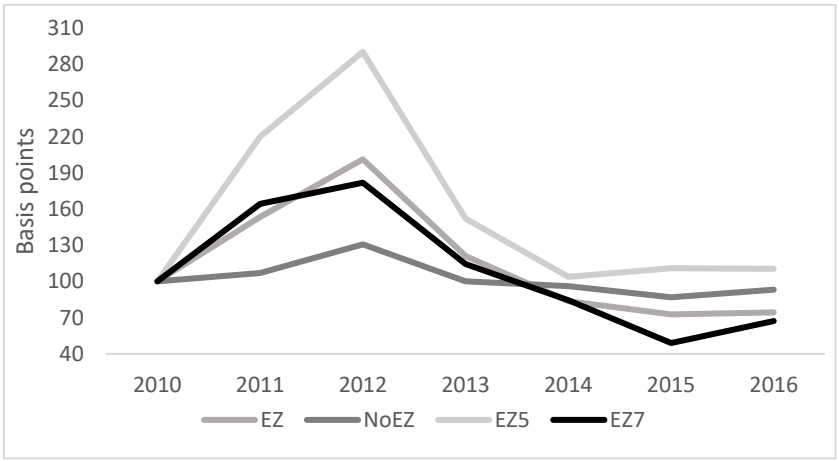
Moreover, the EZ5 group itself — particularly Greece and Ireland — contributes to the largest dispersion of A_{it} *vis-à-vis* debt-to-GDP growth rates, and this fact may have different explanations. One may be that the A_{it} in the EZ5 group have characterised by large over-reactions with respect to the entity of these countries' debt-to-GDP growth rates relative to those of the others. A

reason may be that the governments, and the EMU authorities, have been caught by surprise by the violence of the debt crisis in the transition from fiscal rules almost entirely focused on current deficits rather than to medium-term debt control. Or, otherwise, that for most countries the fiscal adjustment required by curbing the evolution of debt was deemed unsustainable.[16]

4.2. Market discipline: government bonds, ratings and spreads

After the outbreak of the Greek crisis, "market discipline", exerted by means of widening sovereign risk premia, has been a predominant concern for most governments. It is therefore reasonable to consider the evolution of risk premia as a major driver of austerity policies.

Figure 3.9. Year average of monthly spreads of yields of government long-term bonds, groups of countries.



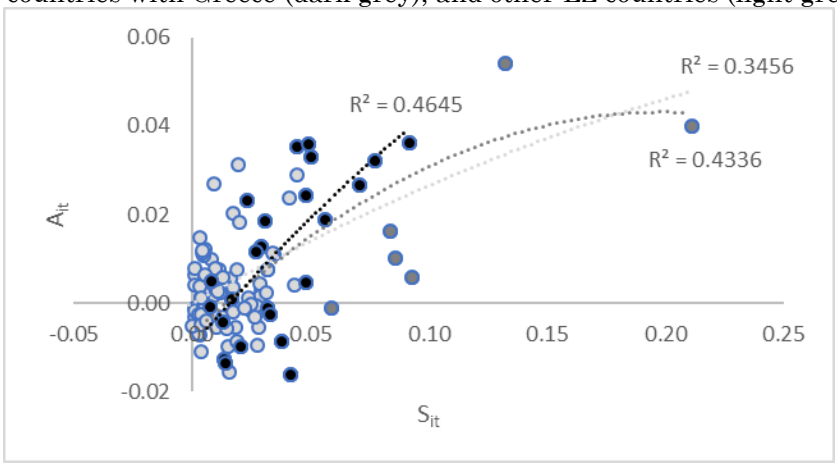
Risk premia are usually measured as the spread S_{it} of a specific interest rate over the benchmark interest rate. In this context, the benchmark is the yield rate of the German ten-year government bond[17]. As shown in Figure 3.9, the surge of spreads has been confined within the EZ group; outside the Eurozone,

16 This hypothesis has been tested by Passamani et al. (2015).

17 As described in the Data Appendix at the end of this chapter, the spread is obtained from the yield on the government bonds denominated in national currency, and it inevitably reflects the expected depreciation of the domestic currency of the NoEZ countries against the euro. Even so, it captures the sovereign risk premia (and thus the market pressure) to which the government is expected to react and is suitable for the purposes of the current analysis.

only a few European countries have recorded spreads above say 300 basis points (remarkably Bulgaria, Hungary, and Romania), a fact that De Grauwe and Ji (2012) ascribe to the "Euro dummy". However, the truly dramatic escalation of spreads has occurred within the EZ5 group of countries under public debt attack, and in particular in Greece, the absolute outlier reaching 13.1% in 2011 and 21% in 2012. The EZ7 group (Germany excluded) show a limited impact of spreads, whereas higher average spread of the EZ group is mainly due to EZ5 and a few cases such as Estonia and Slovakia.

Figure 3.10. Correlation between A_{it} and spreads, 2011-16.
EZ5 countries without Greece (black), Greece and the interpolation function of EZ5 countries with Greece (dark grey), and other EZ countries (light grey),

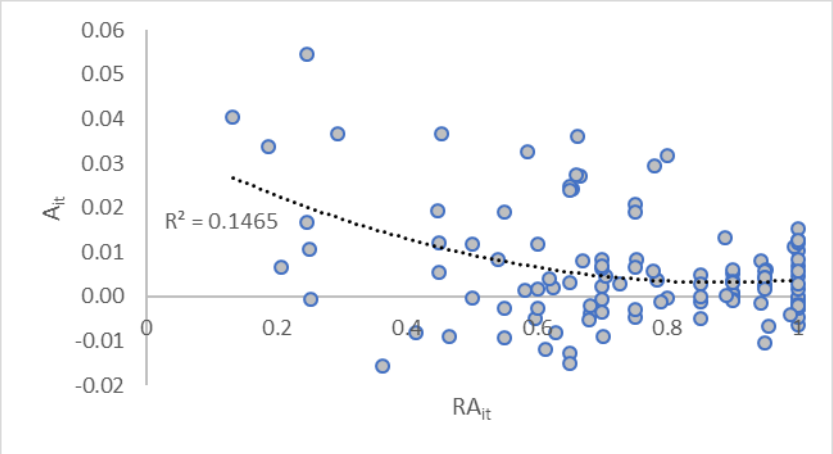


Consistently with this picture, the correlation analysis in Figure 3.10 shows a co-movement of A_{it} with spreads, particularly for the EZ5 countries. For these countries, the best interpolation function is quadratic with differences in spreads being associated with 43.36% of differences in A_{it}, against the 34.56% of the NoEZ countries. The convexity of the interpolation function suggests the presence of fiscal fatigue, that is decreasing correlation of A_{it} with spreads as the latter increases above a certain level (about 5%).

Since Greece is a large outlier, and has undergone debt restructuring and forced fiscal consolidation, it may be interesting to restrict the analysis to the remaining four countries. In fact, the explanatory power of their spreads improves (46.45%) whereas the fiscal fatigue effect is weaker. It should be noted that, if R^2 indicators should be taken at face value, spreads so far provide the

highest explanatory power of differences in A_{it} together with deficit-to-GDP ratios. To some extent, this finding may also explain the poor explanatory power of the debt-to-GDP growth rates in that the latter have actually affected fiscal policies, not so much through formal rules, but in force of the market discipline of risk premia. This hypothesis, however, leaves the question open whether risk premia have in turn been driven by correct fiscal fundamentals or by other non-fundamental or irrational factors.

Figure 3.11. Correlation between A_{it} and S&P ratings 2011-16, EZ countries.



Spreads go hand in hand with another variable in my dataset: government bond ratings. I have employed the annual weighted average of the Standard and Poor's ratings, converted into numbers between 0 and 1 so that the highest rating (AAA) corresponded to the highest value (1), and the lowest rating (D - default) corresponded to the lowest value (0). Ratings, as spreads, capture the market pressure on sovereign yields: the negative correlation between the two variables (-0.26) states that the higher the rating, the lower the spread. This fact reflects into the negative relationship between A_{it} and ratings for EZ countries depicted in Figure 3.11, which has the opposite sign of the relationship shown in Figure 3.10. Nevertheless, ratings account for a lower amount of austerity (14.65%) than spreads, in line with the fact that ratings usually include other elements that affect solvency, beyond the risk premia.

4.3. Fiscal discipline

As mentioned above, the European Commission has the task and the responsibility to monitor the application of the Preventive Arm included in the Stability and Growth Pact, a set of rules that, according to the website of European Commission itself, aim to "prevent fiscal policies from heading in potentially problematic directions" and "to correct excessive budget deficits or excessive public debt burdens".[18] Whenever a member State breaches the deficit threshold of 3% of GDP, or is going to breach it, or has a public debt level above 60% of GDP that is not diminishing at a satisfactory pace[19], the EC can first send an Early Warning and then it can open an Excessive Deficit Procedure (EDP). Early Warnings are recommendations that the European Commission can send to a country when a deviation from the established objectives is detected. It gives the authorities the opportunity to take corrective actions in advance. If actions are not taken or are insufficient to reverse the situation, a formal EDP is opened. In particular, the Commission imposes a sanction to the member State — a non-interest-bearing deposits in percentage of the GDP — and sets a deadline within which the government should take appropriate actions. Once the deadline has passed, the Commission and the Council assess the actions taken, and they can either stop it if they are enough, or they can speed them up if the member State has not done enough. In case of exceptional conditions, the country can ask for an extension of the deadline. Finally, when the excessive deficit is corrected in a "durable manner", the non-interest-bearing deposits are returned to the member States and the EDP is abrogated.

In order to account for this circumstance, I have introduced a dummy variable that is equal to 1 from the year of the EDP opening to the year of its abrogation. According to the European Commission website, only three States have an

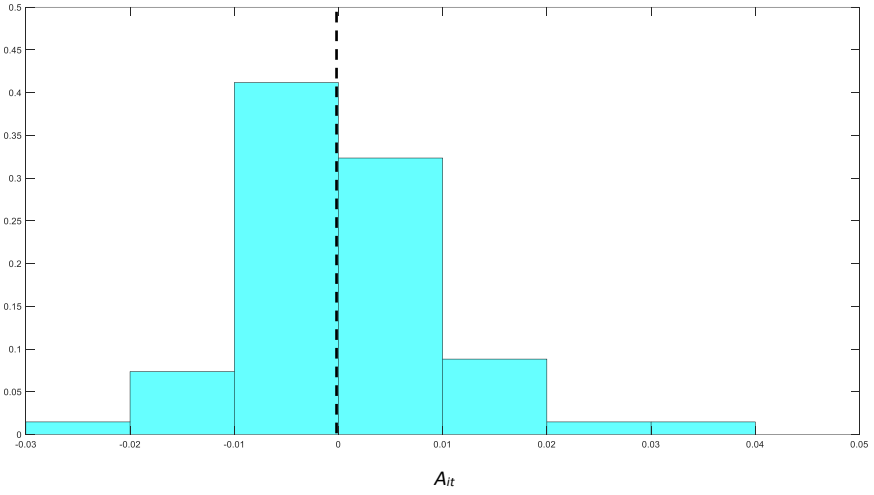
[18] See:
https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/stability-and-growth-pact/applying-rules-stability-and-growth-pact_en

[19] This means that the gap between a country's debt level and the 60% threshold needs to be reduced by 1/20th annually (on average over a perio d of three years).

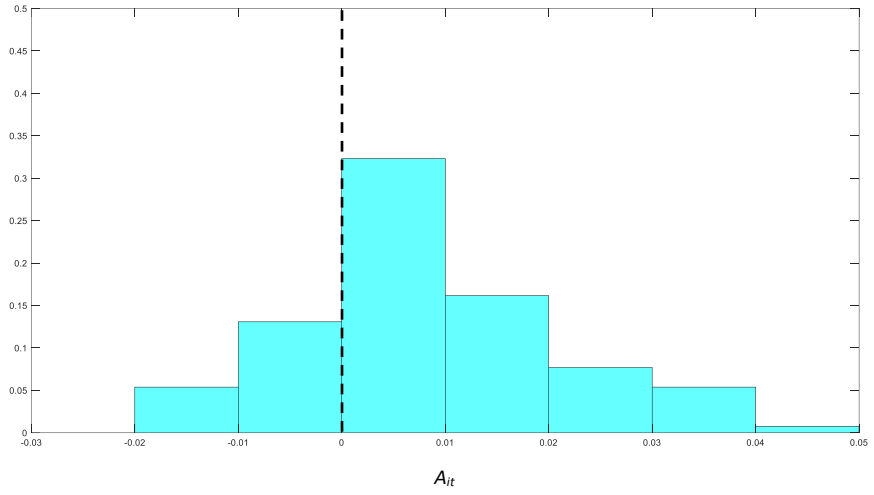
ongoing EDP in 2017 (Spain, France, and the United Kingdom), but between 2009 and 2014 almost every country in my dataset has experienced such a procedure (the only exceptions are Sweden and Estonia). Of course, EDPs might have a positive impact on austerity, and Figure 3.12 sustains this hypothesis.

Figure 3.12. Distributions for A_{it} over the period 2011-2016.
EPD=0 (panel a) and EDP=1 (panel b)

(a)



(b)



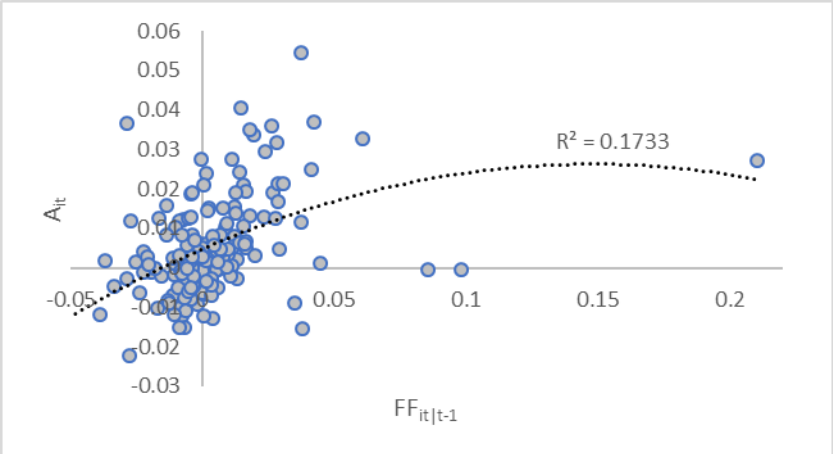
A second variable that I have considered whereby the EZ governments can perceive pressure for fiscal adjustment is the forecast by the EC of the ongoing evolution of their budget. In Spring and Autumn each year the EC releases forecasts on the main budget items relevant to the EDP. Suppose that forecasts predict a deterioration of the budget deficit, hence the government may

implement a correction in order to prevent the EDP.[20] Therefore, I have constructed the following fiscal forecast variable:

(3.3) $FF_{it|t-1} = \left(\frac{STPB}{PGDP}\right)_{it|t-1} - \left(\frac{STPB}{PGDP}\right)_{it-1}$

where $\left(\frac{STPB}{PGDP}\right)_{it|t-1}$ is obtained from the average of the two EC forecasts presented in Spring and Autumn. For some years/countries, the STPB is not available and is replaced by the CAPB. Recall that $A_{it} = \left(\frac{STPB}{PGDP}\right)_{it} - \left(\frac{STPB}{PGDP}\right)_{it-1}$, i.e. the actual fiscal adjustment between *t* and *t-1*. Hence if A_{it} is conditioned by $FF_{it|t-1}$ as explained above, a negative correlation between the two variables should be expected. Figure 3.13, however, shows neither a strong correlation nor the expected sign. The positive sign of the correlation may suggest a good fit of the forecasts, but it also suggests that the governments are insensitive to them.[21]

Figure 3.13. Correlation between A_{it} and $FF_{it|t-1}$.



Finally, I consider an "Euro dummy", a dummy variable that captures the effect of being (*Euro* = 1) or not being (*Euro* = 0) part of the Eurozone.

[20] The most recent literature argues that in measuring the effect of fiscal policy on other macroeconomic aggregates, most researchers do not take into account the effects on the same aggregates due to potential news anticipating future fiscal actions (e.g. Leeper et al. 2013, Auerbach and Gorodnichenko 2012, Fragetta and Tamborini 2017). The same principle may then be extened to governments themselves.

[21] Paradoxically, if governments were sensitive to forecats, these would appear poor ex-post.

4.4. Macroeconomic stabilisation

To complete the analysis, let me now turn to the factor that may countervail the other pressures towards austerity, namely the cyclical position of the economy. Though central to modern macroeconomics, the measurement of the business cycle remains difficult and controversial. I consider here two basic measures. The first is simply the year growth rate of GDP (gY_{it}) this measure can be justified for being simple, "objective", widely adopted and, therefore, of direct concern of governments as they should decide their policies. The other measure is the official output gap (OG_{it}). Though controversial as to their measurement, official output gaps, inherited from the theoretical framework of New Keynesian Macroeconomics, are meant to capture the deviations of GDP from its potential level. In that framework, potential output is dictated by structural supply-side factors (such as factor endowments, technology, and relative prices), whereas output gaps are mostly driven by aggregate demand factors. Output gaps are therefore used as indicators of the need for active stabilisation policies on the demand side.[22] However, they are non-observable directly, and have more a "normative" content, hence one may expect that fiscal policy decisions are less connected with them than with actual GDP fluctuations.

To begin with, Figure 3.14 recalls the evolution of the two business cycle indicators. As regards GDP fluctuations, all groups of countries show a similar pattern. The recession of 2008-09 was followed by rather sustained recovery in 2010. Alas, the latter was short-lived and was followed by either stagnation or a "double dip" recession altogether.

There are, however, notable quantitative differences across groups. The impact on the EZ and NoEZ groups was of equal and intermediate intensity. The GDP paths of the early Euro-members begun to diverge afterwards, when also their fiscal policies became divergent. Indeed, the EZ5 group has been the

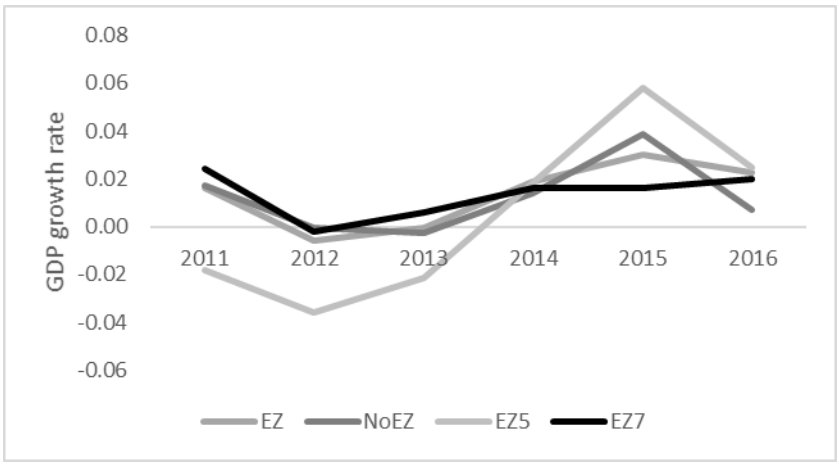
[22] It is important to recall this basic notion because a widespread narrative on austerity blurs this distinction and tends to convey the idea, inherited from the neoclassical Real Business Cycle theory, that low or falling GDP is always and exclusively a supply-side structural problem about which little can be done from the demand side.

worst GDP performer since 2010, whereas the fall is relatively small for the EZ7 group.

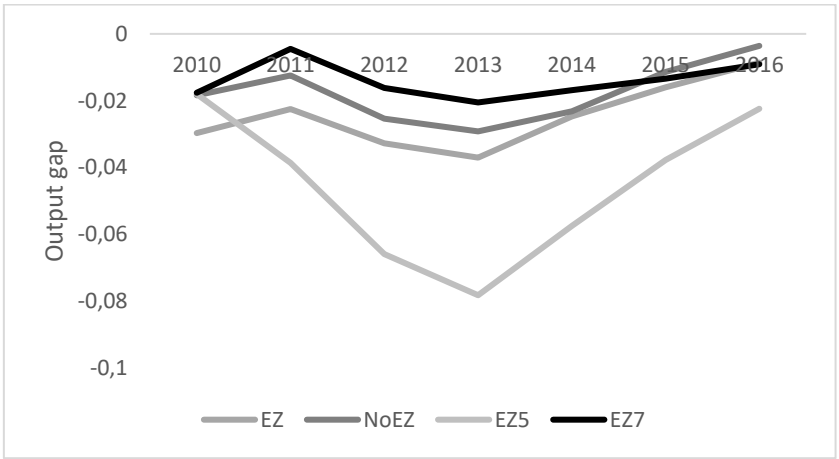
As regards output gaps, on average all groups have been able to close negative output gaps (very low before 2014) with the exception of EZ5 countries. This indicates a global lack of aggregate demand stabilisation (also confirmed by low, and tendentially decreasing, inflation rates). The epicentre of this phenomenon is again in the EZ5 group.

Figure 3.14. Year rate of change of GDP (panel a) and official output gap (panel b), 2011-16, groups of countries.

(a)



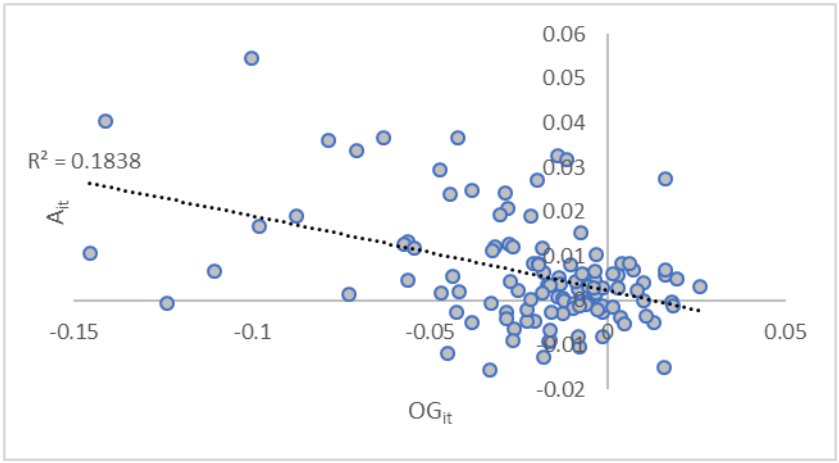
(b)

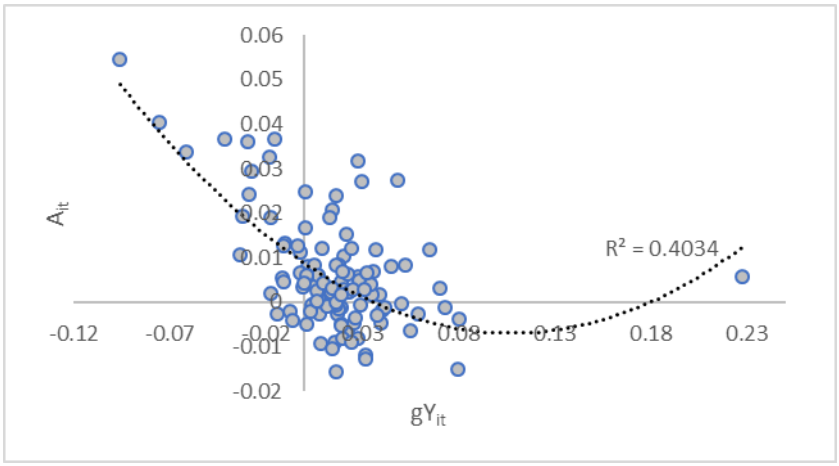


How do austerity policies correlate with the two measures of business cycle? In the first place, Figure 3.15 provides the correlation graphs between A_{it} and gY_{it} and between A_{it} and OG_{it} for the EZ and the NoEZ groups of countries separately.

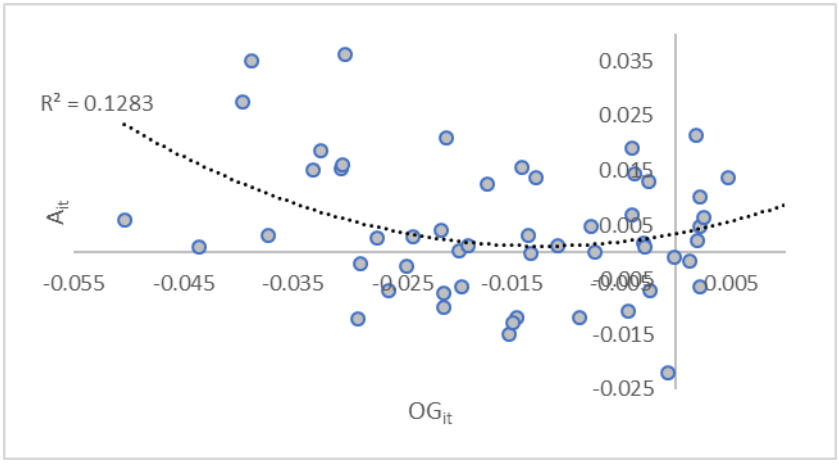
Figure 3.15. Correlation graphs between A_{it} and gY_{it} and OG_{it}, 2011-16. EZ (panel a) and NoEZ (panel b) groups

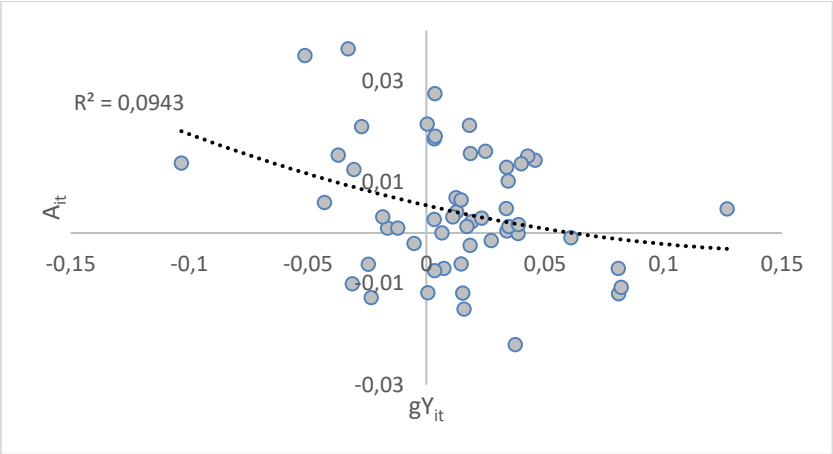
(a)





(b)





Overall, the correlation sign is negative, but most of all the R^2 indicator is rather limited. These data suggest that differences in A_{it} have occurred with little connection with the business cycle, though the negative correlation sign indicates a tendency to procyclicality, that is, the association of fiscal restrictions ($A_{it}>0$) with recessions ($gY_{it}<0$) and negative output gaps[23] ($OG_{it}<0$) (90 observations out of 168). Hence, though correlation is not causation, it is possible to say that austerity has been procyclical in 53.6% of cases, in the sense that it occurred in negative cyclical conditions.

It is also possible to notice that the interpolation function of A_{it} with gY_{it} for EZ countries, and the interpolation function of A_{it} with OG_{it} for NoEZ countries are quadratic and convex to the origin. The countries entrapped in the south-west region below the curve are France, Italy and Spain in various years.

Furthermore, it is worth considering this evidence in greater detail (see the group frequency data of procyclical occurrences of fiscal restrictions in Table 3.2). Of the global 168 A_{it} observations, 110 (65.5%) are restrictions, $A_{it} > 0$. Of these, 29.1% are concomitant with $gY_{it} < 0$, and 52.7% with $OG_{it} < 0$. Hence, globally, fiscal restrictions have been realized during actual recessions in a minority of cases, whereas the signal given by output gaps has been systematically ignored. However, this global result covers sharp differences across groups with regard to the actual GDP. The frequency of fiscal restrictions has been slightly lower in the EZ group (64.9%) than in the NoEZ group (66.7%).

[23] Negative output gaps do not necessarily indicate a recession, but they are nonetheless official indicators of cyclical downturn.

Though the frequency of fiscal restrictions of the EZ7 group (66.7%) is equal to the EZ5 group (66.7%), it is possible to claim that in the EZ5 group, more than elsewhere, austerity has been pursued ignoring the business cycle almost totally: 65.0% percent of observations has been concomitant with $gY_{it} < 0$, and 95.0% of observations has been concomitant with $OG_{it} < 0$.

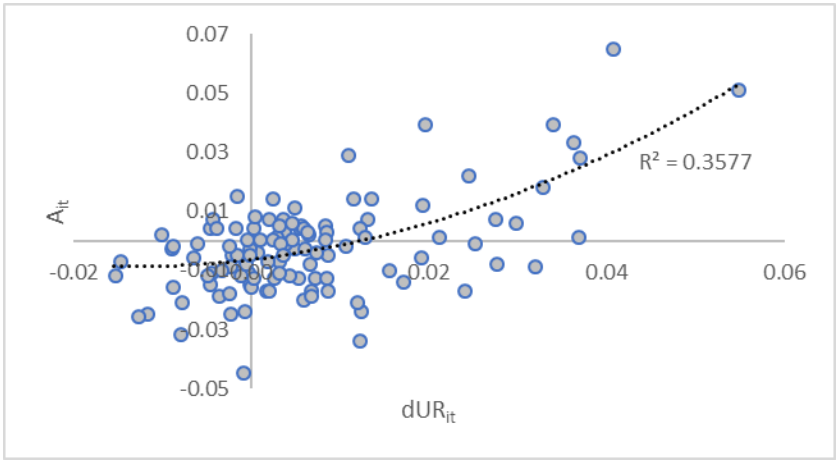
Table 3.2. Group frequency of procyclical occurrences of A_{it}.

	# observations $A_{it} > 0$	of which concomitant with (%):	$gY_{it} < 0$	$OG_{it} < 0$
All data	65.5%		29.1%	52.7%
EZ	64.9%		19.3%	53.5%
NoEZ	66.7%		27.8%	80.6%
EZ5	66.7%		65.0%	95.0%
EZ7	66.7%		17.9%	85.7%

A last variable that I consider in this analysis is the unemployment rate (UR_{it}). Commonly employed in the FRF literature, unemployment is one of the main concerns for governments, and policies are usually adjusted according to its level. Unemployment can also be an indicator of the business cycle; in my dataset is negative correlated both with the output gap (-0.71) and the GDP growth rate (-0.25).

Figure 3.16. Correlation graphs between A_{it} and dUR_{it}, EZ (panel a) and NoEZ (panel b) groups.

(a)



(b)

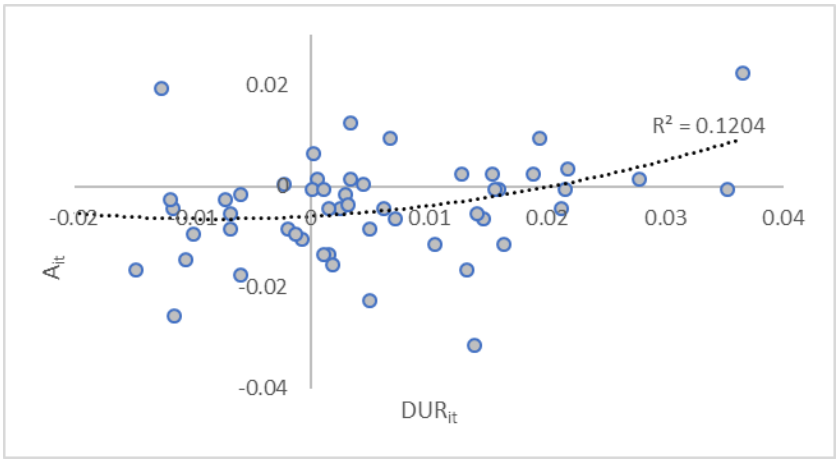


Figure 3.16 depicts the correlation between A_{it} and the differences in the unemployment rate (dUR_{it}) for the EZ and the NoEZ group: the R^2 is higher for the EZ group than for the NoEZ group but, overall, the relationship is weak.

In conclusion, the available data deliver a fuzzy picture. Some evidence can be found that austerity has to some extent been driven by compliance with EMU rules — in particular, the deficit rule — as well as by market discipline. In the majority of cases, austerity policies have been procyclical; some countries have afforded some cyclical sensitivity of austerity, others have not. Yet no systematic patterns emerge. For instance, not all countries overreacting to excess deficits, or being cycle insensitive, are also high debt countries or high spread countries, as one might expect.

Overall, differences in austerity seem rather erratic, or perhaps determined by specific local factors not considered here, possibly introduced into the bilateral negotiations of governments with the European Commission. Tailoring fiscal policy to local conditions may be sensible, but what is the rationale for advertising strict, non-discretionary, common rules in the EMU? If it is to provide a yardstick for coordination and equity, the result seems rather poor.

5. DYNAMIC PANEL DATA ANALYSIS

5.1. Methodology

In order to estimate the impact of the four sets of variables on austerity, the chosen estimator is the Dynamic Common Correlated Effects (DCCE) introduced by Pesaran (2006) and developed by Chudik and Pesaran (2015) that allows to analyse a panel model by considering a dynamic approach, heterogeneous slopes, forms of cross-correlation between the explanatory variables (i.e. cross-sectional dependence), and small-sample corrections. Given the dependent variable, the austerity measure A_{it}, the econometric model can be written as:

(3.4) $A_{it} = \alpha_i + \lambda_i A_{it-1} + \beta_i{}' X_{it} + u_{it}$

$u_{it} = \gamma'_i f_t + e_{it}$

where $i = 1, \dots, N$ is the number of panel units and $t = 1, \dots, T$ is the number of time periods, α_i is a N-dimensional vector of intercepts, X_{it} is a (NT×K) matrix of K general explanatory variables, β_i is a (N×K) matrix of heterogeneous panel coefficient, f_t is an unobserved common factor and γ_i is a heterogeneous factor loading. In this specific case, X_{it} includes the eight explanatory variables introduced in the previous section. The model in equation (3.4) is then estimated through:

(3.5) $A_{it} = \alpha_i + \lambda_i A_{it-1} + \beta_i{}' X_{it} + \sum_{k=0}^{p} \delta'_{i,k} \bar{w}_{t-k} + \varepsilon_{it}$

$\bar{w}_t = (\bar{A}_t, \bar{A}_{t-1}, \bar{X}_t)$

with the bar indicating the cross-sectional means and $p = \sqrt[3]{T}$, as suggested by Chudik and Pesaran (2015). In fact, the cross-sectional averages of the dependent and independent variables included in $\bar{w}_t$ allows to approximate a limited number of strong factors affecting all the panel units and an infinite number of weak factors affecting a subset of the panel units. The mean-group panel estimations are then computed as a simple mean of the heterogenous estimations:

(3.6) $\hat{\pi}_{MG} = \frac{1}{N} \sum_{i=1}^{N} \hat{\pi}_i$

where $\hat{\pi}_i = \left(\hat{\lambda}_i, \hat{\beta}_i\right)$.

The version of the DCCE estimator that I adopt here is, however, its pooled version with $\beta_i = \beta \; \forall i$, the so-called Pooled Dynamic Common Correlated Effects estimator (PCCE). This choice does not allow me to consider the slope-heterogeneity that the literature on FRFs suggests but, due to the not-so-large number of temporal observations, DCCE (which requires $T \to \infty$) cannot be properly applied. Moreover, as a robust analysis, I also estimate the econometric models by adopting the fixed effects estimator. Nevertheless, it must be stressed that the limited number of observations is the result of the choice to study and to focus the attention on the austerity period, undoubtedly began in 2010.

Furthermore, in order to reduce the number of explanatory variables, I summarise their joint behaviour by exploiting the correlations between them. The methodology is called Principal Component Factor Analysis (PCFA), and it allows for the extraction of meaningful linear combinations by decomposing the correlation matrix of a set of observed variables that may jointly explain a certain phenomenon and provides the so-called common factors and the corresponding factor loadings. The common factors are in fact latent variables which are described through their relationship with the variables of interest, while the factor loadings show the weight of each variable in explaining the factors. In details, given the observation on the j-th variable relative to the i-th unit, y_{ij}, the common factors z_{iq} relative to the same i-th unit contribute to explain it through the following relationship:

(3.7) $\quad y_{ij} = z_{i1}\lambda_{1j} + z_{i2}\lambda_{2j} + \cdots + z_{iq}\lambda_{qj} + u_{ij}$

where λ_{ij} is the factor loading and u_{ij} is a unique factor proper of the j-th variable. The appropriate number q of unobserved factors, necessarily smaller than the number of observed variables, depends on their observed correlations, and can be chosen either on the basis of the eigenvalues obtained from the decomposition of the correlation matrix, or on the basis of the percentage of explained variance.

In summary, the applied methodology consists of two steps: the application of PCFA to extract some meaningful indicators from the considered variables of

the dataset, thus reducing their number, and the estimation of a panel model with the PCCE estimator.[24]

5.2. Estimation results

The first step consists in the implementation of the PCFA, that aims to reduce the number of explanatory variables and to summarise the behaviour of each set of variables in one common factor. This procedure has been applied to all groups with the only exclusion of the "fiscal discipline" group, which include one continuous variable (the austerity EC forecast – $FF_{it|t-1}$) and two dummy variables (one for Eurozone membership and one for the EDPs) that cannot be appropriately included within a factor. While the effects of the latter variables will be studied separately, $FF_{it|t-1}$ has not been considered given the limited number of observations, the fact that $FF_{it|t-1}$ was not helpful to explain A_{it} in the previous statistical correlation analysis, and that this variable may not be exogenous if the fiscal correction is anticipated.

With the only exceptions of the dummy variables, all the considered variables have been differentiated or expressed in terms of growth rates to guarantee stationarity, and then standardised in order to compare their estimated coefficients. PCFA is justified by their correlation structure: as shown in Table A2, A3, and A4 in Appendix, the absolute values of the correlation coefficients are around or above 0.5. The only exception is the correlation between the growth rate of the public debt and $EDEF_{it}$, the deviation of the public deficit from the 3% threshold. Nevertheless, eigenvalues definitely led to retain one factor for each group, and thus three stationary factors have been obtained: the "market discipline" factor (*FMD*) whose increase describes a worsening in the spread/rating of the country; the "macroeconomic stabilisation" factor (*FMS*), that describes the cyclical position of the economy (an increase is associated to either a reduction in the unemployment rate, an increase in the GDP growth rate, or an improvement in the output gap); and the "fiscal consolidation" factor (*FFC*), representing either an increase or a decrease in the debt and deficit of the country.

[24] This two-steps methodology follows Passamani et al. (2015).

The second step of the analysis consists in the estimation of the dynamic panel model described in equation (3.5) by employing the PCCE estimator. This technique allows for three essential facets: small sample corrections, heterogenous intercepts, and corrections for the cross-sectional dependence. In particular, I have adopted the jackknife correction to avoid small-sample biases, I have allowed for heterogeneous slopes, and I have corrected the three factors *FMD*, *FMS* and *FFC* for the cross-sectional dependence arising according to the CD test statistics reported in Table 3.3.

Table 3.3. Pesaran (2015) panel cross-sectional dependence test, results.

Variable	Pesaran CD statistics	p-value
FMD_{it} *	3.21	0.000
FMS_{it}	13.86	0.000
FFC_{it}	14.53	0.000

*Germany excluded.

By applying the Pesaran (2015) test[25], that works well even in small panels and, differently from other tests, does not require variables with expected values equal to 0, I found that A_{it} and the three factors are affected by cross-sectional dependence at the usual 5% significance level.

Table 3.4 presents the estimations of three different specifications. Specification 1 includes the $Euro_{it}$ dummy that captures the effect of being in the Eurozone or of adopting the Euro. Specification 2 replaces the $Euro_{it}$ dummy and the constant with four dummy variables that represent the EZ5 group ($EZ5_{it}$), the EZ7 group ($EZ7_{it}$), the other EZ countries that are not part of EZ5 and EZ7 (OEZ_{it}), and the NoEZ countries ($NoEZ_{it}$). Finally, specification 3 excludes all the dummy variables.

Starting with the first specification of Table 3.4, the main contribution to A_{it} is provided by *Euro*, whose positive and highly significant coefficient captures the fact that austerity has been more severe in the Eurozone, above all within the EZ5 countries. Likewise, recalling the correlation analysis, it is no surprise

[25] Described as a test for weak cross-sectional dependence in Pesaran (2015).

that the estimated coefficient of *EDP* is positive and significant since it captures the effect of the EC adoption of an Excessive Deficit Procedure. These positive influences are partially offset by the negative coefficient of the first lag of FMS, the macroeconomic stabilisation factor, a result that reflects a general countercyclical behaviour, and is in line with the "fiscal fatigue" view: austerity has been reduced in response to better economic performances. Instead, the estimated coefficients of the lagged FMD and FFC are not significant. This result is interesting: neither the spreads/ratings nor the deviation of deficit from the 3% threshold and the public debt growth rate seem to have played a discriminant role for the austerity level. Therefore, austerity seems principally determined by regional and political factors.

Table 3.4. PCCE estimation results.

Specification:	**1**	**2**	**3**
Dep. Var.	**Austerity**	**Austerity**	**Austerity**
A(-1)	-0.5529***	-0.4080***	-0.5635***
	(0.1614)	(0.0919)	(0.1699)
FMD(-1)	-0.1131	-0.1726	-1261
	(0.2482)	(0.2593)	(0.2800)
FMS(-1)	-0.6712***	-0.2667	-0.5766***
	(0.1906)	(0.2067)	(0.2155)
FFC(-1)	0.0440	-0.0649	0.0570
	(0.1909)	(0.0839)	(0.2001)
EDP	0.5220**	-	-
	(0.2291)		
Euro	1.1434***	-	-
	(0.1629)		
EZ5	-	0.4955	-
		(0.3163)	
EZ7	-	-0.3167***	-
		(0.1119)	
OEZ	-	-0.1462	-
		(0.1818)	
NoEZ	-	-0.2434	-
		(0.1571)	
Mean Group	-1.1851***	-	-0.1190
Constant	(0.1313)		(0.0956)
# countries	28	28	28
CD test	0.4902	0.1505	0.0384
AR(2)	0.7275	0.6959	0.6959
R^2	0.87	0.54	0.85

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses. Variables are standardised.

Finally, it should be mentioned that the first lag of the dependent variable is negative and significant, thus capturing a smoothing effect over time, and that residuals are not affected neither by cross-sectional dependence (Pesaran (2015) cross-sectional dependence test) nor by second-order autocorrelation (Arellano-Bond serial correlation test statistics). These results confirm the goodness of the estimated model.

The previous conclusions do not vary if the estimation results of the second specification are considered. Nonetheless, this specification highlights the weight of the EZ7 countries: the estimated coefficient of the dummy variable $EZ7_{it}$ is negative, as expected, thus compensating the effects of the other dummy variables. Conversely, the coefficient of $EZ5_{it}$ is positive but non-significant, as well as the two estimated coefficients of OEZ_{it} and $NoEZ_{it}$.

These results are quite robust since they do not change if all dummy variables are removed (see column 3 of Table 3.4), but residuals are marginally affected by cross-sectional dependence.

As a robustness analysis, Table 3.5 reports the estimation results for the three specifications introduced above without common aggregate factors. Taking advantage of the correlation analysis of Section 3, I replace the three common factors with the most important variables of each group in explaining A_{it}. Therefore, I consider the first difference of spreads (dS_{it}), the GDP growth rate (gY_{it}), and the public debt growth rate (gD_{it}), beyond the dummy variables.

The first column of Table 3.5, specification 1b, corroborates the main conclusions reached in Table 3.4. First of all, the estimated coefficient of gY_{it-1} is negative and statistically significant, in line the estimated coefficient of FMS_{it-1}. This variable depicts the negative effect on A_{it} of an increase in the GDP and thus the countercyclical behavior of austerity. At the same time, the estimated coefficients of A_{it-1} and of EDP_{it} are in line with their counterparts in Table 3.4. Secondly and differently from Table 3.4, the coefficient of dS_{it-1} is positive and significant: it captures the market pressure on A_{it} of an increase in the government spreads, though its contribution is relatively lower in comparison to the other significant variables.

The results displayed in the second column confirms these findings. Specification 2b is meant to highlight the weight of the several groups of countries. Two dummy variables are here statistically significant: the positive estimated coefficient of $EZ5_{it}$ and the negative estimated coefficient of $EZ7_{it}$. While the first reproduces the higher level of A_{it} associated to the EZ5 countries, the second captures the lower level associated to the EZ7 countries, in line with Table 3.4 and with the figures of Section 2.

As before, these results are quite robust since they do not change if all dummy variables are removed (see specification 3b in Table 3.5).

Table 3.5. Estimation results without PCFA.

Specification:	**1b**	**2b**	**3b**
Dep. Var.	**Austerity**	**Austerity**	**Austerity**
A(-1)	-0.6257***	-0.2865*	-0.5944***
	(0.2100)	(0.1580)	(0.2029)
dS(-1)	0.2467**	0.1650*	0.2514**
	(0.1021)	(0.1002)	(0.1250)
gD(-1)	0.2820	0.1393	0.2269
	(0.3418)	(0.1690)	(0.3667)
gY(-1)	-0.5332***	-0.2610*	-0.5509***
	(0.1500)	(0.1528)	(0.1493)
EDP	0.5240***	-	-
	(0.1801)		
Euro	-0.2051	-	-
	(0.1386)		
EZ5	-	0.5010**	-
		(0.2356)	
EZ7	-	-0.3301***	-
		(0.1180)	
OEZ	-	-0.0717	-
		(0.1304)	
NoEZ	-	-0,1304	-
		(0.1457)	
Mean Group	-0.2126**	-	-0.0547
Constant	(0.0909)		(0.1038)
# countries	28	28	28
CD test	0.0000	0.0001	0.0384
AR(2)	0.3458	0.3484	0.3484
R^2	0.79	0.39	0.78

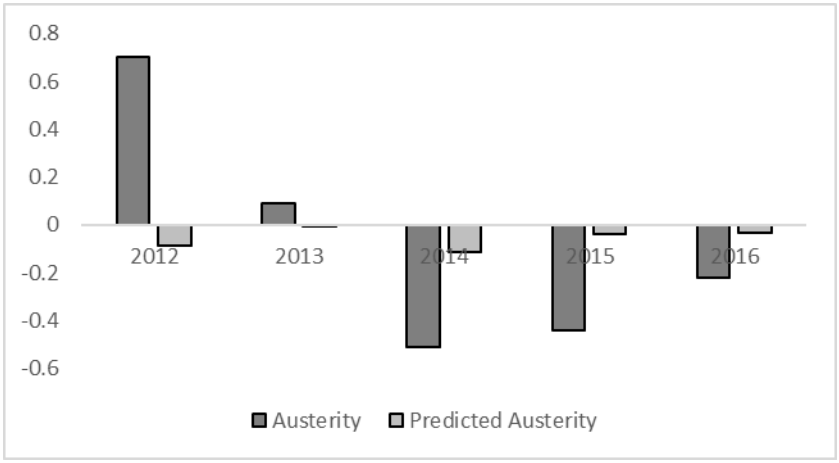
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses. Variables are standardised.

Two aspects deserve particular attention. First, since the dependent variables are exactly equal, as well as the number of included explanatory variables, the

R^2s of Table 3.4 and 3.5 are directly comparable: as it is possible to notice, the R^2s of Table 3.4 are all higher than the R^2s of Table 3.5, thus showing that the models with the common aggregate factors are able to capture a higher fraction of the variability of A_{it} and are more parsimonious to those in Table 3.5. Second, the residuals of the estimated models in Table 3.5 are all affected by cross-sectional dependence, despite the correction.

Finally, the first specification of Table 3.4 has been used to estimate the level of austerity explained by the factors and variables included into the analysis. Figure 3.17 compares the observed standardised average level of A_{it} for all countries with its estimated level: the explained part of A_{it} is rather low and far below 50%. In other words, austerity is underestimated — or, from another perspective, the average level of austerity is too high to be explained by market and fiscal pressures only — and there is a wide part of A_{it} that remains unexplained.

Figure 3.17. Average standardised austerity and its predicted value, all countries, 2012-16.



6. CONCLUSIONS

This chapter has presented an analysis of the determinants of austerity, determinants that have been sought within four groups of explanatory variables commonly employed in literature: fiscal discipline, market discipline, fiscal consolidation, and macroeconomic stabilisation.

The analysis has been divided into two parts. The first part has developed a correlation analysis that has described the relationship between austerity (measured as the first difference of the cyclically adjusted primary balance) and each explanatory variable, finding that the explanatory power of each variable is low when considered individually (in most cases around or below 20%).

In the second part I have performed an econometric analysis, firstly employing principal component factor analysis to retain the aggregate factors that might affect austerity, and secondly estimating a panel model by adopting the pooled common-correlated effect estimator. Results show that one factor can be extracted and identified from each set of explanatory variables, but only one of them (the lagged macroeconomic stabilisation factor) is then statistically significant. Therefore, governments have adjusted austerity according to the economic performance of the previous year. The more important contribution to austerity is provided by the Excessive Deficit Procedure and by *Euro*, the Euro dummy. Nonetheless, the considered variables and factors are not able to fully explain austerity, either individually or jointly.

APPENDIX

Data Appendix

The principle data source for my analysis is the Eurostat Database, from which I take the time series of the nominal GDP at current prices; the government consolidated gross debt i.e. the sum of liabilities, at the end of year, of all units classified within the general government sector; the government deficit as a share of GDP; the unemployment rate; the yields on the long-term government bonds denominated in national currency. From the latter I obtain the government bond spread computed as the difference between the yield on the government bond of each country and the corresponding German bond yield, both for Eurozone and non-Eurozone countries.

A second source is the Ameco Database, from which I take the output gap, the government deficit, and the cyclically adjusted structural primary balance to potential GDP (STPB/PGDP). Thus, I obtain the austerity measure in year *t* as the positive change in the STPB/PGDP over the previous year *t-1*, namely:

$$A_{it} = \Delta \frac{STPB}{PGDP} > 0$$

Another source is the European Commission website, from which I obtain the cyclically adjusted primary balance (CAPB) and its Spring and Autumn forecasts. I computed the average of the two forecasts to derive the yearly average of the CAPB forecast. From this website I also obtain the year of adoption and the year of abrogation of the Excessive Deficit Procedures (EDPs) for each country, used to construct the *EDP* dummy, equal to 1 for every year during which an EDP was open and 0 otherwise.

Finally, one last source was the website Trading Economics from which I take the S&P rating of the government bonds and any change occurred between 2010 and 2016. I first convert the S&P rating into numbers according to Table A3.1 below, and then I compute the yearly weighted averages.

Concluding, my final sample contains, for each variable, approximately 196 yearly observations from 2010 to 2016 from 28 countries (on average 7 years per country). Table A3.2 summarises the data sources.

Table A3.1. S&P ratings and associated numbers.

S&P Rating			Associated number
Investment grade	AAA	Prime	10
	AA+	Very high grade	9.5
	AA	Very high grade	9
	AA-	Very high grade	8.5
	A+	Upper-medium grade	8
	A	Upper-medium grade	7.5
	A-	Upper-medium grade	7
	BBB+	Lower-medium grade	6.5
	BBB	Lower-medium grade	6
	BBB-	Lower-medium grade	5.5
Non-investment grade or speculative grade	BB+	Speculative	5
	BB	Speculative	4.5
	BB-	Speculative	4
	B+	Highly speculative	3.5
	B	Highly speculative	3
	B-	Highly speculative	2.5
	CCC+	Extremely speculative	2
	CCC	Extremely speculative	1.5
	CCC-	Extremely speculative	1
	CC	Substantial risk	0.5
	C	Default, little prospect of recovery	0
	D	Default	0

Table A3.2. Employed variables and data sources.

Variable	Source	Type of variable
CAPB	European Commission	Annual data
CAPB forecast	European Commission	Annual data, average of Spring and Autumn forecasts
Excessive deficit procedure (EDP)	European Commission	Dummy variable
GDP at current prices	Eurostat	Annual data
Government bond yield	Eurostat	Annual data, average of monthly data
Government debt	Eurostat	Annual data
Government deficit	AMECO	Annual data (% of GDP)
Output gap	AMECO	Annual data (% of potential GDP)
S&P Rating	Trading Economics	Annual data, weighted average of daily data
STPB/PGDP	AMECO	Annual data
Unemployment rate	Eurostat	Annual data

PCFA Appendix

The Principal Component Factor Analysis (PCFA) methodology allows for the extraction of meaningful linear combinations from a set of variables by decomposing their correlation matrix and provides the so-called common factors and the corresponding factor loadings. The common factors are latent variables which are described through their relationship with the variables of interest,

while the factor loadings show the weight of each variable in explaining the factors. I used this methodology in order to reduce the number of explanatory variables, starting from the correlations summarised from Table A3.3 and Table A3.5.

Table A3.3. Market discipline variables, correlations between the first difference in spreads (dSPREAD) and in ratings (dRA)

	dS_{it}	dRA_{it}
dS_{it}	1	-0.5354
dRA_{it}	-	1

Table A3.4. Macroeconomic stabilisation variables, correlations between output gap (OG), first variations in the unemployment rate (dUR) and the GDP growth rate (gY).

	OG_{it}	dUR_{it}	gY_{it}
OG_{it}	1	-0.4598	0.4503
dUR_{it}	-	1	-0.5790
gY_{it}	-	-	1

Table A3.5. Fiscal consolidation variables, correlations between the debt-to-GDP growth rate (gD) and the difference between the deficit-to-GDP and the 3% threshold (EDEF).

	gD_{it}	$EDEF_{it}$
gD_{it}	1	-0.3279
$EDEF_{it}$	-	1

Chapter 4
An Experimental Approach in Search of a Confidence Channel

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Abstract

This paper aims at investigating the relationship between public debt and the consumption side of economic growth from an experimental macroeconomics point of view, by analysing whether consumers' expectations about public debt are linked to tax compliance, consumption, and savings choices, that in turn affect GDP.

To this end, I have implemented a laboratory experiment in which the participants earn an income to be allocated between consumption, savings, and voluntary taxation for an unknown number of rounds. Debt's dynamics arises endogenously within a public good game with threshold: taxation is used to cover a given level of public expenditure, which is equally distributed to the participants at the beginning of each subsequent round. If the collected amount of taxes is lower than required, a deficit is generated, and it feeds public debt. Debt can then be unexpectedly reduced by the government through accessing subjects' savings. To check for the role of beliefs, participants' expectations about future debt reduction and perceived debt sustainability are elicited during the experiment.

Results show that this experimental framework is characterized by relatively high and often increasing aggregate savings and relatively low and decreasing aggregate consumption. An increase in the debt-reduction expectations and a decrease in the perceived debt sustainability are also found to explain savings and consumption behaviours.

These conclusions do not change if tax audits are introduced, but the average savings level lowers, thus increasing subjects' exposure to the unexpected shocks.

Keywords: experimental macroeconomics, public debt, economic growth, expectations, intertemporal choices, public-good games, fiscal audits.

1. INTRODUCTION

In contrast with the findings of the broad literature introduced in Chapters 1 and 2, the idea that public debt is always harmful to economic growth has partially been reconsidered in the last few years. Some works have shown that a general debt-threshold above which growth is stifled is unlikely to exist (see, among others, Pescatori et al., 2014; Woo and Kumar, 2015). Nevertheless, the existence of a linkage between debt and growth has not been rejected: the long-run relationship between such macroeconomic variables is inevitably and broadly affected by heterogeneous economic and behavioural factors. The focus of this chapter is on the latter and, in particular, on the behaviour of those consumers that faces the uncertainty of having to bear the cost of a public debt reduction, a situation that has barely been studied from an empirical perspective due to a lack of data. In fact, though some works have studied the impact of fiscal policies on the aggregate demand through model simulations and event studies (a review is provided in Briotti, 2005), to the best of my knowledge the role that debt-related expectations play in uncertain fiscal conditions has not yet been developed.

This was the case of those peripheral countries of the Eurozone that were involved in the debt crisis between 2011 and 2012[1], and by the austerity measures implemented in the aftermath that deeply affected the whole economic system. In fact, uncertainty about future fiscal policies and about the future sustainability of public debts might have amplified the contractionary impact that these measures had on growth rates. In the same period, the idea of a forced withdrawal from current accounts was retaken in some countries: notably, Italy faced this possibility in 2011 (as reported by many Italian newspapers), after the remarkable experience of 1992. Between July 9 and July 10, 1992, Amato's government actualized an unexpected 6% forced withdrawal on all bank accounts in order to respond to the imminent financial crisis and to the speculative attacks that led Italy out of the European Monetary System

[1] Spain, Italy, Portugal, Greece, and Ireland were involved in speculative attacks that had the potential to be self-fulfilling; see De Grauwe and Ji, 2013).

(EMS). In such situations, uncertainty about future fiscal policies and political actions might have influenced consumers' expectations, thus affecting the general economic performance.

To gain insight into the role of expectations about debt policies and their impact on economic growth under uncertainty conditions, I have studied how people react in a framework in which public debt may be unexpectedly reduced by implementing a laboratory experiment in which the debt dynamics arises endogenously: within a public good game, taxes are collected from all participants and are used to cover a given level of public expenditure, which is then equally distributed to the same participants at the beginning of each experimental round. If the collected amount of taxes is lower than what the public expenditure would require, a public deficit is generated. Moreover, reproducing a forced withdrawal, the outstanding amount of public debt can be reduced upon accessing subjects' savings.

Within this setting, expectations are directly elicited by asking subjects if they believe that public debt is going to be reduced, and if they think that the other subjects believe that public debt is sustainable. Therefore, I can identify whether and how agents' allocations and expectations are affected by the public debt path. The main goal is to study whether and when direct and indirect consumers' beliefs about public debt affect their choices about consumption, savings, and tax compliance[2] with a direct impact, at the aggregate level, on economic growth, interpreted as the GDP growth rate.

As mentioned above, a peculiarity of this approach is the endogenous dynamics of public debt: not only it avoids introducing predetermined dynamics, but also increases the ecological validity of the experiment. Participants are indeed more psychologically involved in the debt mechanism and they might feel responsible for the raise in debt, as they might feel when, for instance, the party for which they voted increases deficit spending. On the other hand, an exogenous dynamics might depict public debt and tax compliance as irrelevant.

The rest of the chapter is organized as follows. First, in Section 2 I review the literature involving public debt and economic growth with particular attention

[2] To keep the framework as simple as possible, I did not considered investments.

to expectations. Though it recalls the literature review of Chapter 1, this section is useful to provide a theoretical background for the following experimental hypotheses. In Section 3 I introduce the experimental literature, my research questions, my experimental design and the strategic analysis. The experimental data are discussed in Section 4, and general implications are inferred though panel models and robustness analysis. Section 5 concludes.

Findings clearly support the existence of a confidence channel, namely a linkage between debt and growth based on and determined by expectations: a worsening in the perceived debt sustainability is associated with an increase in aggregate savings and a decrease in aggregate consumption, regardless the level of the public debt.

1.1. Expectations within standard economic theories

Implications about consumers' behaviour are to be found within the existing economic approaches, each of which provides different implications as mentioned in Chapter 1. In the standard Neoclassical theory, the focus is on the crowding-out effect entailed by public deficits. On the consumption side and under the assumption of perfectly rational agents, with a finite lifespan and with access to perfect markets, the government borrowing allows to increase the predetermined consumption level of the current generation, as taxes are indefinitely postponed to next generations. Nevertheless, given fully employed resources, the raise in consumption must go hand in hand with a decline in savings, thus implying, on the investment side, an increase in the interest rate towards the new equilibrium, with the result that private capitals are crowded-out[3] (see Bernheim, 1989). Therefore, the typical impact of an increasing public debt on the long-run economic growth can be assumed to be negative, because of the crowding-out effect and because of the taxes required to finance the future interest payments, a point on which is hinged the so-called *burden view* (Modigliani, 1961).

This conclusion has also found support within the endogenous growth approach (for instance, Barro 1990, and Saint-Paul 1992), according to which

[3] All these aspects are included in the seminal model proposed by Diamond (1965).

the growth rate may be jeopardised by the direct and indirect influence of fiscal policies and outstanding debt. Noteworthy, as shown by recent studies, the negative consequences may be larger if government debt creates uncertainty, and if it generates expectations of future higher taxes (Cochrane, 2011), or if it affects the productivity of public expenditure (Teles and Cesar-Mussolini, 2014). Upon including different elements of analysis, some Neoclassical developments have allowed for broader results that show that public deficits may have a positive impact on growth. Nonetheless, since people are perfectly rational, they react to permanent income changes only, directly or indirectly determined by variations in the taxation level and in the public expenditure, though the final consequence may not be unfavourable.

The Keynesian theory, instead, assumes that a deficit financed fiscal expansion can have an expansionary impact on the aggregate demand. Indeed, if the resources are not fully employed, national income rises, generating the Keynesian multiplier effect that stimulates both the national income and the consumption level (Hemming et al., 2002), whereas, at the same time, taxes entail a short-run contractionary effect. However, as noted by some authors, expectations about the contractionary fiscal policies may outweigh the negative Keynesian multiplier effect leading to an expansion rather than a contraction (Barry and Devereux, 1995). Moreover, if indirect changes in the interest rate affect the magnitude of the multiplier, as described by Hemming et al. (2002), the Neoclassical crowding-out effect could still arise.

Last but not least, the Ricardian paradigm is based on the idea that agents incorporate the government intertemporal budget constraint, thus implying the irrelevance of the timing of taxes and, indirectly, the equivalence between taxes and government debt in financing the public expenditure. Besides, the change in the taxation level does affect the savings level, which follows the expected variation in the future disposable income. In this context, unlike the other approaches, a public deficit entails a full crowding-out effect. In Barro (1989) the author concluded that the Ricardian Equivalence is a "good first-order approximation to reality", supported also by the empirical evidence, but this conclusion has been criticized by some authors. For instance, in Bernheim

(1989), the Ricardian paradigm is deemed to require unrealistic assumptions to hold.

1.2. Further theories

An unconventional approach named "expansionary fiscal consolidation theory" has initially been discussed in the 90s by a group of Italian economists, who have proposed that a deficit reduction policy might have an expansionary effect on the economic system. In other words, a policy of deficit reduction could be associated with an expansion in the aggregate demand. This view was mainly introduced and discussed by Giavazzi and Pagano (1990), and Alesina and Perotti, (1995), and then retaken and revisited amid the European public debt crisis by Alesina and Ardagna (2010) and Alesina and Ardagna (2013) among others. However, the importance of this controversial school of thought has undeniably faded away, especially after the publication of some works that have casted doubts on its empirical relevance. For instance, the work of Perotti (2012) has showed that the explanations of four episodes of expansionary fiscal consolidations were to be found in exceptional and particularly favourable conditions in which they were implemented and not in the implemented policies. Yet, a similar expansionary effect may rather arise because of expectations: if people expect a future fiscal consolidation, they will save more until when the consolidation effectively occurs; as soon as such a consolidation has occurred, people increases their consumption (Sutherland, 1997).

1.3. Expectations and fiscal policies in experimental economics

Laboratory experiments are an extremely useful tool for the investigation of economic and fiscal policies since they allow the construction of a simplified and controlled framework in which to test for their validity, above all when empirical data are not available. In fact, though macroeconomic policies have been traditionally studied through non-experimental techniques, in the last few years experimental macroeconomics has gained wider academic interest[4].

[4] For a detailed review of experimental macroeconomics, see Duffy, 2014.

In the specific field of fiscal policies and expectations, the first experimental designs aimed at testing the Ricardian Equivalence within an overlapping generations framework. Cadsby and Frank (1991) have supported the empirical validity of the Ricardian Equivalence, but subsequent developments have found evidence of departures when more articulated experimental designs are employed (Slate et al., 1995; Ricciuti and Di Laurea, 2003).

A group of studies have focused on expectation formation and dates back to the 70s. For instance, Bernasconi et al. (2009) has studied the ability of people to forecast, either in front of real world data or laboratory data. Other experimental designs have studied expectation formation with respect to inflation (Arifovic and Sargent, 2003) or with respect to monetary policies (Kryvtsov and Petersen, 2013; Pfajfar and Zakelj, 2015; Assenza et al., 2014). However, these experiments do not explicitly deal with public debt, the debt-to-GDP ratio, and its effect on consumption and savings. As regards, only Geiger et al. (2016) have explicitly analysed fiscal consolidations, finding that an expectations channel linking fiscal policies and consumption exists, thus supporting the expansionary effect of Sutherland (1997):

> consolidations that occur in an unsustainable fiscal environment exert less contractionary effects on consumption, […] and this channel is more pronounced if the fiscal authority can convincingly commit to abstain from tax increases in the future. (Geiger et al., 2016, p.15)

This design undoubtedly shares some similarities with Geiger et al. (2016), but it differs in some important points that I will present in the next sections: the earning money task (in contrast with the house money approach of Geiger et al., 2016), the direct elicitation of the perceived debt sustainability and debt forecasts, and the endogenous dynamics of the public debt, for which all the participants are responsible. Therefore, my design is more sophisticated and keeps a greater number of variables under control.

Similarities are shared also with the vast experimental literature about tax evasion[5] and with the literature of the public good experiments with thresholds, in which subjects provide a freely determined amount to a public fund characterized by a given threshold. Within this setup, such a threshold represents the total amount of contributions (i.e. voluntary paid taxes) required to cover an exogenous level of public expenditure. Since a basic public good game does not commonly lead to full coordination between the subjects, it is already possible to say that the experimental debt dynamics will generally be upward trending, as observed in many developed countries during the last decades.

2. RESEARCH QUESTIONS AND BEHAVIOURAL HYPOTHESES

The experimental design aims at identifying the possible confidence channel that links public debt and economic growth, and whether it has an impact on the savings level. According to the economic theories introduced above, people's expectations may be interpreted in a Ricardian sense, may follow the Neoclassical theory, or may be in line with Sutherland (1997) and Geiger et al. (2016). It would also be possible to observe no influence at all.

Thus, the first research question aims at disclosing whether public debt expectations affect consumers' choices:

RQ1. Is there a confidence channel linking public debt and the consumption side of economic growth?

where the confidence channel is any expectational linkage, a broader concept than the expectations channel of Sutherland (1997), Ardagna (2004) and Geiger et al. (2016). Indeed, my approach is "to let the experimental data speak", without imposing any restrictions on such a channel.

[5] Tax payer behaviour is extensively studied from an experimental perspective. See Baldry (1987), Bosco and Mittone (1997), Mittone (2006).

An expectational channel might arise or might not arise according to the individual perception of the fiscal policies, namely, according to the uncertainty about the future probability of a debt reduction carried out by the government. Moreover, it can play a role in specific situations only, such as when public debt is perceived to be unsustainable. The second research question deals precisely with this aspect:

RQ2. Does the perceived debt sustainability affect the choices of the subjects?

Since, as said above, people may react according to the perceived debt sustainability and to personal beliefs, three behavioural hypotheses can be made about the dynamics of the aggregate private consumption and savings level observed in the experiment:

- Hypothesis 1. Given a constant public expenditure level, participants react to increasing public debt — namely, consecutive deficits — by increasing their own consumption level. This result would be explained by the Neoclassical theory if subjects believe that required taxes are indefinitely postponed and no debt reduction will occur. However, this behaviour can also be in line with the Keynesian theory, which attributes a multiplier effect on the deficit financed public expenditure in contrast with the contractionary effect implied by taxation, or by a debt-reduction intervention. If, instead, such a debt-reduction intervention led to an increase in consumption, subjects would react according to the expansionary fiscal consolidation hypothesis.
- Hypothesis 2. Participants react to increasing public debt by reducing, on average, their consumption and by increasing savings. Therefore, participants behave in a sort of Ricardian way: they expect that debt has to be repaid in the future, and they react by increasing the current savings levels. Moreover, uncertainty can amplify this result.
- Hypothesis 3. Given their income level, participants do not adjust their own consumption and savings levels to variations or expected variations in public debt. In this case, participants do not care about public debt if

it does not affect their income permanently through, for instance, an explicit increase in the fiscal pressure.

Evidently, different behaviours can emerge if different time horizons are considered; therefore, more than one hypothesis can be satisfied.

A last research question strictly linked to the experimental design involves tax compliance. In particular, it is interesting to understand whether and how the answers to the previous research questions are affected by voluntary taxation, a fundamental aspect of the experimental design. Given the endowment of the subjects, an increase in the fiscal contribution, namely a reduction in tax evasion, might intuitively lead to either a lower level of consumption, a lower level of savings, or a lower level of both, with different economic implications. Therefore, as described in Section 3, I will introduce tax controls and the third research question deals with it:

RQ3. Does an increase in fiscal contribution induced by a more severe fiscal strategy impact on consumption and/or savings?

It must be underlined that the introduction of fines and fiscal audits mimics an increase in fiscal pressure without altering the general experimental framework.

3. EXPERIMENTAL DESIGN

The experimental design is based on the public good games with thresholds, with earned-money and voluntary taxation, and without interactions between subjects. It does not aim to test a specific macroeconomic model, but to find out whether and how people's expectations about public debt affect their choices about consumption and savings in uncertain fiscal conditions, resembling, for instance, the situation in which many European countries were involved during the Sovereign Debt Crisis and the austerity period.

I develop two similar experimental designs whose difference is in the absence or presence of controls on tax evasion.

3.1. Design without tax controls

The experiment comprises of $t = 1,...,T$ periods, where T is a random number extracted from a discrete uniform distribution *U(10,20)*: the minimum number of possible periods is $T = 10$ and the maximum is $T = 20$. Therefore, subjects do not know when the experiment ends, and any end-effect is avoided[6]. Before period $t = 1$, subjects join in an earning task that determines the annuity per period. This earning-money strategy should reduce the house-money effect that can arise in public-good experiments and that can affect subjects' preferences (see Clark, 2002). Consequently, from period $t = 1$ to period $t = T$, subjects receive the constant amount a_t per period, and the final gross income of each subject i is:

$$A_i = \sum_{t=1}^{T} a_{it} \qquad (4.1)$$

Subjects must decide how to allocate a_{it} between the available private and public choices. On the private side, subjects can choose in each period between an immediate consumption (c_{it}) that, as described below, contributes to the final pay-off according to a factor γ $(0 < \gamma < 1)$, and positive savings (s_{it}) that can be used for future consumption only. Savings provides a constant interest rate r. If the stock of savings accumulated up to time t is S_{it}, the amount received in round $t+1$ is thus $S_{it+1} = S_{it}(1+r) = S_{it}R$.

On the public side, subjects know that the government has to collect a given amount of resources in order to cover the public expenditure, say E_t. This amount will be multiplied by $\mu > 1$ (a public-expenditure multiplier, known to all participants) and then equally divided among the participants at the beginning of the subsequent round. Therefore, in $t+1$ each subject will receive the amount $\left(\frac{\mu E_t}{N}\right)$, where N is the number of participants. Subjects are told the amount that they should contribute to reach the threshold E_t, but they are

6 This technical choices is arbitrary; there are no reasons to choose another strategy to avoid the end-game effect.

free to decide how much to contribute effectively, an amount T_{it} that remains unknown to all the other participants. Subjects might also decide to contribute more than what is suggested, a circumstance that would capture the subjective aversion to debt creation and the fear of a debt reduction. The collected amount in each round is thus:

$$(4.2) \qquad F_t = \sum_{i=1}^{N} T_{it}$$

If $F_t \geq E_t$, the amount μF_t is distributed. Instead, if $F_t < E_t$, a deficit $d_t = (E_t - F_t)$ is generated and the amount $\mu E_t = \mu(F_t + d_t)$ is distributed. To cope with the insufficient amount of collected resources, the government has to resort to an exogenous amount of public debt, on which interests accrue according to a constant rate i. The dynamics of public debt is described by:

$$(4.3) \qquad D_{t+1} = \begin{cases} (1+i)(D_t + d_t) & \text{if } d_t > 0 \\ (1+i)D_t & \text{if } d_t \leq 0 \end{cases}$$

where $d_t < 0$ corresponds to the situation in which, on the whole, participants contribute more than what is required to cover the public expenditure.

At the beginning of period t and before subjects' choices, the government can decide to reduce the outstanding amount of debt and interests, $D_t = [(1+i)(D_{t-1} + d_{t-1})]$, to a lower amount αD_t (with $0 < \alpha < 1$) by forcedly accessing the subjects' outstanding amount of capitalised savings, and this can occur from 0 to $T-1$ times[7]. If subject's savings is higher than the unknown demanded amount $\left(\frac{\alpha D_t}{N}\right)$, subject's savings is reduced by this amount; otherwise, savings is reduced to 0 and the subject is forced to pay a penalty on his final pay-off (this can be interpreted as a forced fiscal withdrawal on the final individual earnings which avoids affecting the dynamics of the experimental variables). The government cannot declare default on its public debt.

[7] The first period is excluded, no debt reduction can occur.

Summarizing, in the case in which $d_t > 0$, the government budget constraint in each period $t > 1$ represents the balance between revenues (tax income) and expenditures (public expenditure), reached through a deficit:

(4.4) $F_t + d_t = E_t$, *with* $d_t \geq 0$

while, during the experiment, the subject *i*'s budget constraint is given by:

(4.5) $a_{it} + max\left\{\frac{\mu F_{t-1}}{N}, \frac{\mu E_{t-1}}{N}\right\} + max\left\{\left[p\left(S_{i,t-1}R - \frac{\alpha D_t}{N}\right) + (1-p)S_{i,t-1}R\right], 0\right\} = c_{it} + S_{it} + T_{it}$

with $\{c_{it}, S_{it}, T_{it}\} \geq 0$, and p being the exogenous probability of bearing a reduction in public debt (more details are given in the next section).

The monetary pay-off of each subject at the end of the experiment is determined by the realized consumption levels c_{it} if $c_{it} \geq h$ (while levels below h are disregarded), and by the accumulated number of penalties $m \geq 0$ that determines an overall compounded reduction equals to $(1-k)^m$. Savings and public expenditure do not contribute to the final pay-off. In such a way, h is to be considered as the consumption subsistence level.

Finally, in order to study expectations, in each period participants are asked two questions. If the answer is right, the "winning" participant receives $\bar{g}$ tokens at the end of the experiment, otherwise he receives 0 tokens. These tokens do not contribute to the endowment of the participants: they cannot be spent, and they are provided at the end of the experiment only. Given a general conversion factor from tokens to euro of f, the final monetary pay-off of subject *i* accumulated from period $t = 1$ to period $t = T$ is thus:

(4.6) $P_i(c_{it}, g_{it}) = f\,(1-k)^m \sum_{t=1}^{T}(x_{it} + g_{it})$

where $g_{it} = (0, \bar{g})$ is the forecast-related earning amounts, and

(4.7) $$x_{it} = \begin{cases} \gamma c_{it} & \text{if } c_{it} \geq h \\ 0 & \text{if } c_{it} < h \end{cases}$$

is the discounted total amount of the realized consumption.

3.2. Forecasts and final questionnaire

In each round subjects' expectations are elicited. Two questions[8] are asked after the allocation of the endowment and for which subjects receive a prompt response on their accuracy:

- *Forecast 1*: Do you believe that public debt will be reduced by the government in the next round?
- *Forecast 2*: How many participants do you believe that think that the actual level of public debt is sustainable?

For the first question, subjects enter "1" if they believe that public debt will be reduced and "0" otherwise. For the second question, subjects enter a number from 0 to the number of participants according to their perceived degree of debt sustainability, whose intuitive definition was provided in the intructions (see the Appendix at the end of the chapter). For each correct[9] prediction, subjects receive a prize at the end of the experiment.

Therefore, subjects are simultaneously asked to provide their expectations about a future debt reduction (a short-term forecast) carried out by the government and the related perception of the current debt sustainability (a long-term forecast), which reflect the ability of the current and future government revenues to cover the current level of public debt. These questions aim to directly elicit subjects' expectations, and to relate them to the current and past levels of consumption and public debt.

The analysis is then reinforced and linked to real world by a series of questions reported in table 4.1 to be asked through a questionnaire at the end of the experiment which allows to get insight into the subjects' general knowledge of the topic.

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8 This methodology is commonly adopted in experimental economics to elicit expectations. For a review of experiments on expectations, see Assenza et al. (2014) and Duffy (2014). For applications, see Kryvtsov and Petersen (2013), and Duffy and Fisher (2005). Participants are trained through a training round.

9 The tokens earned from forecasta are determined according to a beauty-contest game: the winner is the subject that provides the closest answer to the group average (it is possible to have more than one winner simultaneously). Subjects are not aware of such a mechanism but, since they are not competing against each other, this is not relevant for the experimental results.

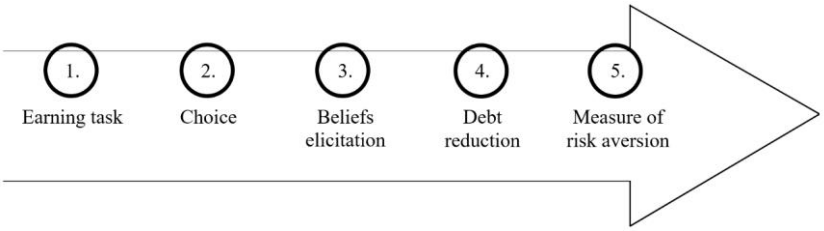
Table 4.1. Questionnaire, final questions.

Question	Possible answers
1. In which slot does the actual (2017) Italian debt-to-GDP ratio fall?	60-100%, 100-120%, 120-140%, >140%
2. In your opinion, will the debt-to-GDP ratio go up or down during the next 5 years?	Up, Down
3. Do you believe that the current level of the Italian public debt is sustainable?	Yes, No
4. Do you believe that the level of public debt directly or indirectly affects private consumptions?	Yes, No, I do not know

3.3. Laboratory implementation, calibration, subject pool

The structure of the laboratory experiment can be divided into four parts, as depicted in Figure 4.1.

Figure 4.1. Experimental steps.



In the first part, subjects join an earning task in which they have to correctly count the number of "1"s included in random tables for six times without time limits. This part is only meant to avoid the house-money effect and is carried out at the beginning of the experiment. Then, each subject receives the same amount of tokens per round.

In the second part, subjects must decide how to allocate their endowment between consumptions, savings, and voluntary taxation.

In the third part, the public debt level is updated, and subjects must provide their two forecasts by observing the available data (the public debt level, the debt-to-GDP ratio, the total amount of collected taxes, and the related public deficit). At the beginning of the subsequent round, subjects discover whether public debt is reduced or not and whether their forecasts are correct. Then, part two and three are repeated for each round until the end of the experiment.

The fourth and last part at the end of the experiment includes the Holt and Laury (2002) task to measure risk aversion.

The values of the many parameters are calibrated for 18 and 20 participants to each laboratory session, and they are reported in Table 4.2. The number of rounds (T) is fixed to 15, unknown to the participants in order to avoid an end-effect; as described above, they only know that the experiment will finish between period 10 and 20 (the fixed number of rounds made the comparison of data easier). Tokens are the unit of measure of the whole laboratory experiment: in each round the endowment is composed by an income a_{it} = 10 tokens and a public transfer of 9 tokens, given by the public expenditure amount multiplied by $\mu = 1.2$ (arbitrarily chosen) and divided by the number of subjects. The minimum consumption level required to avoid penalties is h = 6 tokens, while the interest rate on savings is $r = 10\%$. The conversion factor from tokens to euro (f) is *1 euro=25 tokens* and the tokens spent for consumption enter the final payment with a 0.8 weight (γ).

For what regards the public sector, the initial debt level (D_0) is 150 tokens for 20 participants and 135 for 18 participants respectively, and it equals the public expenditure amount of each round, so that the required amount of taxes is always 7.5 tokens. The debt interest rate is fixed and equal to i = 15%. Public debt can be reduced from the second round on by a random amount α included between 60% and 90% but, to directly compare different treatments, the rounds of the debt reductions are accurately chosen, although the participants are not aware of it. Finally, 2 tokens are paid at the end of the experiment for each correct forecast[10] (g_{it}). In addition, €3 are paid as a *presence contribution* to everyone.

The experiment is programmed with z-Tree (Fischbacher, 2007), and the main computer screens are reported in Appendix (see Figures from A4.1 to A4.4). The participants are Italian-speakers graduate and undergraduate students from University of Trento, who cannot participate to more than one laboratory session. All of them are provided with detailed instructions and experienced

[10] The maximum number of extra tokens that can be gained by a subject in such a way is 60.

with a trial session for each task. Laboratory instructions are reported in Appendix.

Table 4.2. Experimental parameters, calibrated values for 20 (18) participants

Parameter	Value	Parameter	Value
N	20 (18)	R	10%
a_t	10	γ	0.8
T	15	h	6
e_t	7.5	μ	1.2
D_0	150 (135)	i	15%
α	From 60% to 90%	R	1.1
f	1/25	*Presence*	3 euro

3.4. Strategic analysis

Can an optimal strategy be identified? To study the rational choices from the participant's perspective, this section focuses on two generic subsequent rounds (*t, t+1*) after round 9, when the experiment can finish, and I exclude the forecasts' prize. To comprise these two aspects of my framework that are of interest for the participants, i.e. the future experimental endowment and the consumed tokens that determine the final monetary payment, let me define $C_{it-1} = \sum_{j=1}^{t-1} c_{ij}$ as the amount of consumed tokens accumulated up to round $t-1$, D_t as the outstanding amount of debt at round t, and W_{it} as the sum of the stock of consumed tokens that contributes to the final payment and the subject's income at round t. W_{it} is thus given by:

$$W_{it} = C_{it-1} + \left(a_{it} + \frac{\mu E}{N}\right) + S_{it-1}R \equiv C_{it-1} + Y + S_{it-1}R \tag{4.8}$$

where $Y \equiv a_{it} + \frac{\mu E}{N}$ is the sum of the individual income and of the individual public transfer, which is constant if the total contribution is assumed to be at most equal to the public expenditure ($E_t = E \; \forall t$). A representative subject, say subject i, should decide how to allocate $Y + S_{it-1}R$ optimally to maximise his final monetary pay-off, which is entirely determined by the stock of consumption.

At round t, a further round $t+1$ can be reached with probability q, while with probability $1-q$ the experiment ends. If this is the case, each subject should consume all the endowment (savings and taxes do not contribute to the final payment), and C_{it} is just:

(4.9) $$C_{it} = C_{it-1} + (Y + S_{it-1}R) \equiv C_{it-1} + c_{it}$$

If, on the contrary, the experiment continues, participants face an uncertain situation in which public debt can be reduced with probability p at the beginning of round $t+1$, thus affecting their savings. At the same time, the new flow of income and the flow of interests on savings are received. In formulas, if public debt is not reduced, W_{it+1} can be written as:

(4.10) $$W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R$$

S_{it} being period t's savings, namely

(4.11) $$S_{it} = Y - c_{it} - T_{it}$$

If, instead, public debt is reduced, equation (4.10) becomes:

(4.12) $$W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R - \frac{\alpha D_t}{N}$$

where it should be recognised that, given D_{t-1}, D_t is an endogenous variable determined by the individual contributions at round t. Indicate with T_t' the total amount of subjects j's collected taxes, i.e. $T_t' \equiv \sum_{j=1\ j\neq i}^{N} T_{jt}$, and with $T_t'^{*}$ the collected amount if everyone pays exactly the required amount of taxes. Two extreme cases can be identified according to the overall contribution level:

a) Subject i is the only participant who pays taxes at round t. Hence, $T_t' = 0$ and equation (4.12) becomes:

(4.13) $$W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R - \frac{\alpha(D_{t-1} + E - T_{it})(1+i)}{N}$$

b) Everyone pays the required amount of taxes:

(4.14) $$W_{it+1} = C_{it-1} + c_{it} + Y + S_{it}R - \frac{\alpha(D_{t-1} + E - T_{it} - T_t'^{*})(1+i)}{N}$$

The actual contribution level T_t' is likely to be included within these two extremes. The strategic tree depicting these outcomes is shown in Figure A4.5 in the Appendix at the end of this chapter.

Considering that savings is given by equation (4.11), the expected value of W_{it+1} to be maximised is, without penalties:

(4.15) $$E_t[W_{it+1}] = (1-q)(C_{it-1} + Y + S_{it-1}R) + q(1-p)(C_{it-1} + c_{it} + Y + (Y - c_{it} - T_{it})R) +$$
$$+qp\beta\left(C_{it-1} + c_{it} + Y + max\left\{(Y - c_{it} - T_{it})R - \frac{\alpha(D_{t-1} + E - T_{it})(1+i)}{N}, 0\right\}\right) +$$
$$+qp(1-\beta)\left(C_{it-1} + c_{it} + Y + max\left\{(Y - c_{it} - T_{it})R - \frac{\alpha(D_{t-1} + E - T_{it} - T_t'^{*})(1+i)}{N}, 0\right\}\right)$$

where β is the subjective probability associated to case (a) and $1-\beta$ is the subjective probability associated to case (b).

On the one hand, the strategic component of the experiment can be seen by computing $\frac{dE_t[W_{it+1}]}{dT_{it}}$. In the most general case in which T_t' is included between the two extremes, the partial derivative is:

(4.16) $$\frac{dE_t[W_{it+1}]}{dT_{it}} = -q(1-p)R + (qp)max\left\{-R + \frac{\alpha(1+i)}{N}\left(1 + \frac{dT_t'}{dT_{it}}\right), 0\right\}$$

where $\frac{\partial T_t'}{\partial T_{it}} \in [0,1]$ captures the strategic relationship between the choice of i and the choices of the other participants[11] or, in other terms, the correlation between the choice of i and the choices of all the others. Equation (4.16) can be either positive or negative but, given the calibration presented in the previous section with $N = 20$, the $max\{\}$ term in (4.16) is 0; thus, equation (4.16) reduces to:

(4.17) $$\frac{\partial E_t[W_{it+1}]}{\partial T_{it}} = -q(1-p)R < 0$$

which is clearly negative. Therefore, it is always convenient to pay less taxes, until 0: taxes are not paid in the Nash equilibrium.

[11] If 0, subject i is the only one who pays taxes; if 1, everyone pays taxes.

On the other hand, the analysis of c_{it} and S_{it} does not allow to precisely identify how much to save and how much to consume, beyond the imposed consumption subsistence level. Nonetheless, equation (4.15) can be evaluated: since $(D_{t-1}+E-T_{it})>(D_{t-1}+E-T_{it}-\sum_{j=1,j\neq i}^{N}T_{jt})$, three scenarios can be detected with respect to the savings level S_{it}:

- Scenario 1: the amount of S_{it}, say S_1, can cover the worst reduction in public debt:

$$max\left\{S_{it}R-\frac{\alpha(D_{t-1}+E-T_{it}-T_t'^{*})(1+i)}{N},0\right\}>0,\ max\left\{S_{it}R-\frac{\alpha(D_{t-1}+E_t-T_{it})(1+i)}{N},0\right\}>0$$

- Scenario 2: the amount of S_{it}, say S_2, can cover the reduction in public debt only if everyone pays taxes:

$$max\left\{S_{it}R-\frac{\alpha(D_{t-1}+E-T_{it}-T_t'^{*})(1+i)}{N},0\right\}>0,\ max\left\{S_{it}R-\frac{\alpha(D_{t-1}+E_t-T_{it})(1+i)}{N},0\right\}=0$$

- Scenario 3: the amount of S_{it}, say S_3, cannot cover any reduction in public debt:

$$max\left\{S_{it}R-\frac{\alpha(D_{t-1}+E-T_{it}-T_t'^{*})(1+i)}{N},0\right\}=0,\ max\left\{S_{it}R-\frac{\alpha(D_{t-1}+E_t-T_{it})(1+i)}{N},0\right\}=0$$

Starting from Scenario 1, equation (4.15) becomes:

(4.18) $$E_t[W_{it+1}]=C_{it-1}+(1-q)S_{it-1}R+Y(1+qR)+c_{it}q(1-R)-T_{it}q\left(R-\frac{p\alpha(1+i)}{N}\right)+$$

$$-qp\alpha\left(\frac{(D_{t-1}+E-(1-\beta)T_t'^{*})(1+i)}{N}\right)$$

which corresponds to the equation of a straight line in the plane $(E_t[W_{it+1}],c_{it})$, with intercept $h_1=[C_{it-1}+(1-q)S_{it-1}R+Y(1+qR)-T_{it}q\left(R-\frac{p\alpha(1+i)}{N}\right)-qp\alpha\left(\frac{(D_{t-1}+E-(1-\beta)T_t'^{*})(1+i)}{N}\right)]$ and slope $l_1=q(1-R)$.

Penalties can now be introduced into the analysis: if savings is not sufficient to cover the debt reduction, Scenario 2 and Scenario 3 entail a penalty on the amount $C_{it-1}+c_{it}$, that is reduced by a factor k to $(1-k)(C_{it-1}+c_{it})$. Thus, $E_t[W_{it+1}]$ for Scenario 2 is given by:

(4.19) $$E_t[W_{it+1}] = C_{it-1}(1-qp\beta k) + (1-q)S_{it-1}R + Y(1+qR) + c_{it}q(1-R-p(k-\beta R)) +$$
$$-T_{it}q\Big(R(1-p\beta) - \frac{p\alpha(1+i)}{N}(1-\beta)\Big) - qp\alpha(1-\beta)\Big(\frac{(D_{t-1}+E-T_t^{i*})(1+i)}{N}\Big)$$

and, again, it corresponds to the equation of a straight line with intercept $h_2 = C_{it-1}(1-qp\beta k) + (1-q)S_{it-1}R + Y(1+qR) - T_{it}q\Big(R(1-p\beta) - \frac{p\alpha(1+i)}{N}(1-\beta)\Big) - qp\alpha(1-\beta)\Big(\frac{(D_{t-1}+E-T_t^{i*})(1+i)}{N}\Big)$ and slope $l_2 = q(1-R-p(k-\beta R))$. Finally, $E_t[W_{it+1}]$ for Scenario 3 can be written as:

(4.20) $$E_t[W_{it+1}] = C_{it-1}(1-qpk) + (1-q)S_{it-1}R + Y(1+qR) +$$
$$+c_{it}q\big(1-R-p(k-R)\big) - T_{it}q(R-pR)$$

and the intercept is $h_3 = [C_{it-1}(1-qpk) + (1-q)S_{it-1}R + Y(1+qR) - T_{it}q(R-pR)]$ while the slope is $l_3 = q(1-R-p(k-R))$.

As can be seen, the three intercepts depend not only on C_{it-1}, T_{it} and the amount of the others' contributions, but also on the unknown α; by comparing them, one can see that three situations are feasible: either $h_1 > h_2$ or $h_1 < h_2$ [12], either $h_1 > h_3$ or $h_1 < h_3$ [13], and either $h_2 > h_3$ or $h_3 < h_2$ [14]. On the contrary, the three slopes depend on parameters only. By comparing them, it is straightforward to see that $l_3 > l_2$ and $l_3 > l_1$, but $l_1 > l_2$ if and only if $k > \beta R$, which depends on the subjective weight β. An example is given in Figure 4.2, where $h2 > h3 > h1$ and $l_3 > l_1 > l_2$.

Although there is no unique solution, an intuitive strategy would be to save as much as possible (accounting for *h*) until the second to last round, and then to consume the whole endowment in the last round, thus avoiding penalties and obtaining the maximum amount of interests to spend. However, the experiment comprises important sources of uncertainty: simultaneous choices with an

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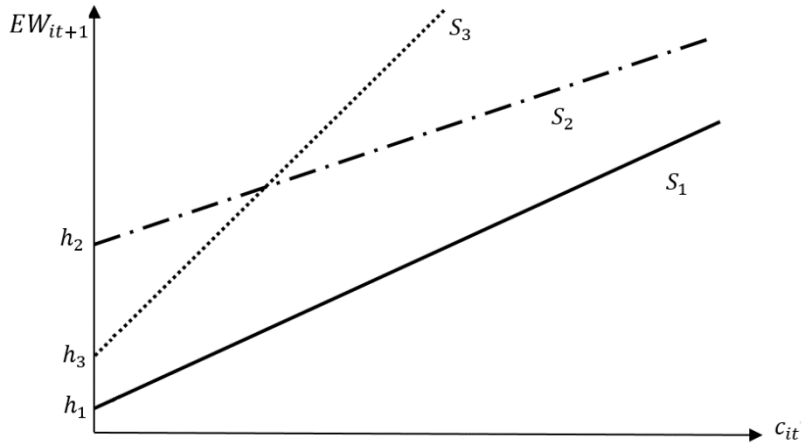
[12] If $C_{it-1} < \frac{T_{it}}{k}\Big(R - \frac{\alpha(1+i)}{N}\Big) + \frac{\alpha(1+i)}{Nk}(D_{t-1}+E)$.

[13] If $C_{it-1} < \frac{T_{it}}{k}\Big(R - \frac{\alpha(1+i)}{N}\Big) + \frac{\alpha(1+i)}{Nk}(D_{t-1}+E-(1-\beta)\sum_{j=1, j\neq i}^{N} T_{jt})$.

[14] If $C_{it-1} < \frac{T_{it}}{k}\Big(R - \frac{\alpha(1+i)}{N}\Big) + \frac{\alpha(1+i)}{Nk}(D_{t-1}+E-\sum_{j=1, j\neq i}^{N} T_{jt})$.

unknown ending. Moreover, the unknown reductions in debt make the comparison with the cost of a penalty impossible. In fact, this amount depends on the choices of the other subjects, implying that the exact optimal allocations from round 10 to the end of the experiment cannot be found without allowing for full coordination between the participants. Obviously, no optimal strategy exists for the forecast part.

Figure 4.2. Expected value of W_{it+1} for three values of savings, S1, S2, and S3 (example).



3.5. Design with tax controls

One of the primary aspects of the experimental design that can influence the debt dynamics and thus subjects' behaviour is the level of tax compliance: since subjects' contribution is free, the total contributed amount depends not only on the fear of a debt reduction, but also on the individual's predisposition to honesty and the related moral cost (see Rosenbaum et al., 2014).

To control for tax evasion, I reformulate the first treatment with the addition of an exogenous probability of tax auditing: subjects are aware of the fact that if their individual contribution is below the required amount of taxes, they have to pay a fine. In details, the known auditing probability is 25% in each round and, following the structure of the penalties, the fine corresponds to a 5% reduction in the final pay-off. In this case, the formula for the final monetary pay-off becomes:

(4.21) $P_i(c_{it}, \mathrm{g}_{it}) = f\ (1-k_1)^{m_1}(1-k_2)^{m_2}\ \sum_{t=1}^{T}(x_{it}+\mathrm{g}_{it})$

which is equal to equation (4.6) except for k_2, the fine percentage amount, and m_2, the total number of fines.

The difference with the design without tax auditing is in the willingness to limit and explicitly punish the free-riding behaviour, incentivising subjects to pay taxes. However, this setting includes two more elements into the analysis: the risk aversion towards a tax audit and the comparison between the costs and the benefits of debt evasion. Jointly with the burden of the debt reduction and the propensity to honesty, they determine the amount of paid taxes.

From the participants' point of view, the difference between the treatment without tax controls and the treatment with tax controls is in the probability to get the total pay-off. Whereas without auditing such a probability is 1 regardless of the contributed amount, with tax auditing it becomes 0.75 if the individual contribution is below the amount required to sustain the public expenditure. In formal terms, the expected final pay-off with tax evasion up to round t is:

(4.22) $$VA_t = 0.75C_{it} + 0.25(1-0.05)^{m_2} C_{it}$$

It is possible to notice that the expected cost of a fine is relatively low: for the first fiscal evasion ($m_2 = 1$) and given a reference amount of 100 tokens, such a cost is just 1.25 tokens; for the second fiscal evasion ($m_2 = 2$) is 2.44 tokens, and so on. Nevertheless, this structure allows to consider a high auditing probability, keeping the results fully comparable with the no-tax controls case. In fact, realistic auditing rates are between 1.70% and 1.80% according to the latest Italian data[15], a rate that is too low for a laboratory experiment.

3.6. Treatments

I implement two treatments: an early-shock treatment (T1) and a delayed-shock treatment (T2), both without tax controls and with three exogenous shocks. The

[15] For instance, in 2013 there had been 713,000 fiscal controls, down from 741,000 in 2012, and over approximately 41 million of taxpayers. See:
http://www.corriere.it/economia/15_giugno_13/fisco-10-milioni-italiani-versano-55-euro-anno-446a4af8-118e-11e5-8b3a-62b7e966c494.shtml;
http://www.economiaepolitica.it/lavoro-e-diritti/diritti/giustizia-e-ordine-pubblico/fenomenologia-dellevasione-fiscale-in-italia.

exogeneity of the three shocks is fundamental since it avoids introducing any predetermined ad-hoc relationship between the level of public debt and its reduction: it would be misleading to reduce public debt only above a given threshold. As a consequence, the debt reductions should be interpreted as an exogenous political action.

In the first treatment, T1, the first public debt reduction occurs at the beginning of round 3, while in the second treatment, T2, it occurs at the beginning of round 6. The other two shocks are planned at round 9 and 13 respectively. The scope of this differentiation is to formally check whether subjects' allocations are affected by the time of the first debt reduction. Furthermore, treatment T1 is carried out also with the inclusion of a random mechanism of audit and fines for tax evasion, in order to control for the free-riding behaviour in the experiment as explained in Section 3.5.

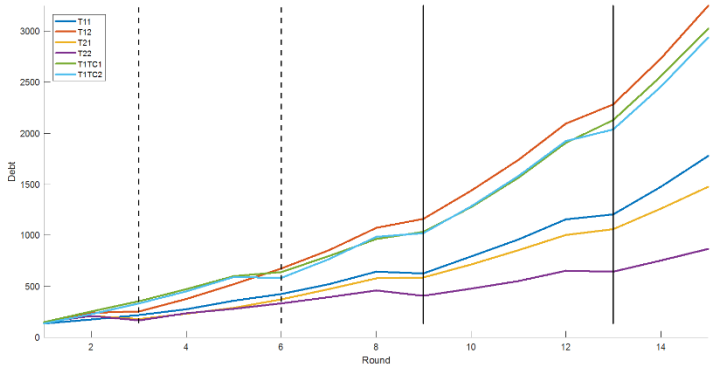
4. DATA ANALYSIS

For T1 and T2, the two treatments without tax controls, I actually carried out two experimental sessions collecting data from 38 subjects and 40 subjects respectively. For T1 with tax controls, I carried out three experimental sessions collecting data from 56 subjects. However, the data collected through one of these sessions have been excluded from the empirical analysis because the number of participants was low (16) and because the instructions were clearly misunderstood at the beginning of the experiment by a group of participants that did not read the instructions. Therefore, I considered data from two sessions and 40 subjects only.

Considering at first T1 and T2, I constructed one panel dataset for each treatment with the inclusion of the following variables: individual consumption, tax compliance, and savings levels, the two forecast variables for debt reduction (*Forecast 1*) and debt sustainability (*Forecast 2*), in addition to public debt, the debt-to-GDP ratio, and public deficits, which are equal for all subjects. Data about consumption, tax compliance, savings, public debt, and the two forecast variables have also been aggregated to construct an aggregate panel dataset

based on "macroeconomic" variables, in which the panel units are the experimental sessions without tax controls. In details, consumption, tax compliance, and savings for all participants have been summed up and expressed in terms of endowment to make them comparable throughout different sessions and rounds, while *Forecast 1* and *Forecast 2* have been averaged to obtain the average market sentiment. The GDP dynamics is entirely given by the dynamics of the aggregate consumption since the experimental GDP is the sum of individual consumptions and of the constant public expenditure[16]. Therefore, the three main variables are the outstanding debt — that followed, as anticipated, an uprising dynamics (see Figure 4.3) — and the consumption and savings levels, whose dynamics is discussed in the next sections. Data have been analysed with Matlab R2016b, while econometric panel models have been estimated with Stata 13.

Figure 4.3. Public debt, experimental dynamics.



Legend. T11: first session of the first treatment; T12: second session of the first treatment; T21: first session of the second treatment; T22: second session of the second treatment; T1TC1: first session of the first treatment with tax audits; T1TC2: second session of the second treatment with tax audits.

4.1. Qualitative analysis, no tax controls

4.1.1. Treatment 1, results

I carried out two experimental sessions for each treatment; details are reported in Table 4.3 and Table 4.4. The first session of T1 was composed by 18 subjects,

[16] I am aware of the fact that my artificial GDP measure cannot comprise all the aspects of the real-world GDP, but consumption is usually highly correlated with the GDP and my goal is to get insight into the consumption's side of growth.

8 males and 10 females, whose mean age was 22.39 years. The average final payment was euro 9.06, with a minimum of euro 6 and a maximum of euro 12. The second session was composed by 18 subjects, 9 males and 9 females, whose mean age was 21.72 years, and the average final payment was euro 9.67, with a minimum of euro 6 and a maximum of euro 13. Figure 4.4 shows the dynamics and the detailed boxplots of average consumptions, collected taxes, and savings for the first session. As one can see, the consumption trend and the savings trend are both upward sloping, while the tax compliance trend is clearly downward sloping. Moreover, there are some differences in the response of these variables to the debt-reduction shocks. The response of consumption is unambiguous: after each shock, the average consumption increased. The same occurred for the tax compliance level, with the exception of the first early shock, while the dynamics of the average savings level increased after the first and the third shocks, but it decreased after the second (though the general positive trend were never reversed).

The figures depicting the results of the second session of T1 are shown in Figure 4.5. The general after-shock behaviours of consumption, savings, and tax compliance are comparable to the dynamics of the first session, but the overall dynamics of consumption and savings are rather different. In fact, between the first and the second shock, the participants increased their savings, giving rise to an outstanding upward trend. After the second shock, however, this trend was abruptly reversed, reaching an exceptionally high consumption level and an exceptionally low savings level, then promptly adjusted during the subsequent round. This behaviour is in line with the intuitive optimal strategy for consumption and savings discussed above, even though it must be noticed that the savings level reached a local maximum just before the end of the experiment, while, at the same time, consumption did not increase during the last rounds. Moreover, during the first part of the experiment, savings was certainly excessive.

Table 4.3. Laboratory sessions, synthesis.

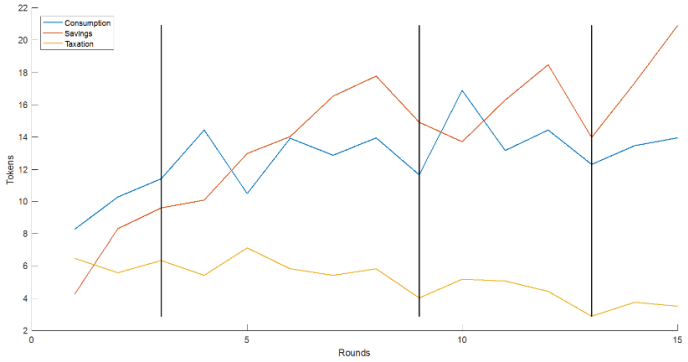
Treatment	Session	Participant	M	F	Average Age	Average Payment
T1, no tax controls	1	18	8	10	22.39	9.06
	2	20	6	14	21.50	8.15
T2, no tax controls	1	18	9	9	21.72	9.67
	2	18	9	9	21.94	8.50
T1, tax controls	1	20	9	11	22.35	8.15
	2	20	3	17	21.50	8.45
	Discarded	16	5	11	21.44	8.75
Total			49	81	/	/

Treatment	Session	From economic sciences	Right Italian DtG	Italian DtG will increase	Italian DtG, sustainability	DtG, consumption
T1, no tax controls	1	8	8	11	4	13
	2	11	7	16	1	18
T2, no tax controls	1	13	10	13	6	16
	2	9	8	8	5	9
T1, tax controls	1	6	10	11	2	14
	2	14	7	13	5	13
	Discarded	12	4	11	1	12
Total		73	54	83	24	95

Table 4.4. Means and standard deviations of savings (S), tax compliance (T) and consumption (C) for each session.

		Mean			Std. Dev.		
Treatment	Session	S	T	C	S	T	C
T1, no tax controls	1	13.94	5.12	12.77	22.67	3.28	5.81
	2	14.69	3.91	13.79	22.13	4.06	7.38
T2, no tax controls	1	16.15	3.02	14.86	23.02	3.93	13.86
	2	21.34	2.87	13.96	35.39	3.68	11.33
T1, tax controls	1	10.68	6.09	12.63	16.59	3.21	10.81
	2	11.15	6.88	11.41	12.3	2.35	4.29

Figure 4.4. Average consumption, savings, and tax compliance dynamics with boxplots without outliers. Treatment 1 without tax controls, Session 1.



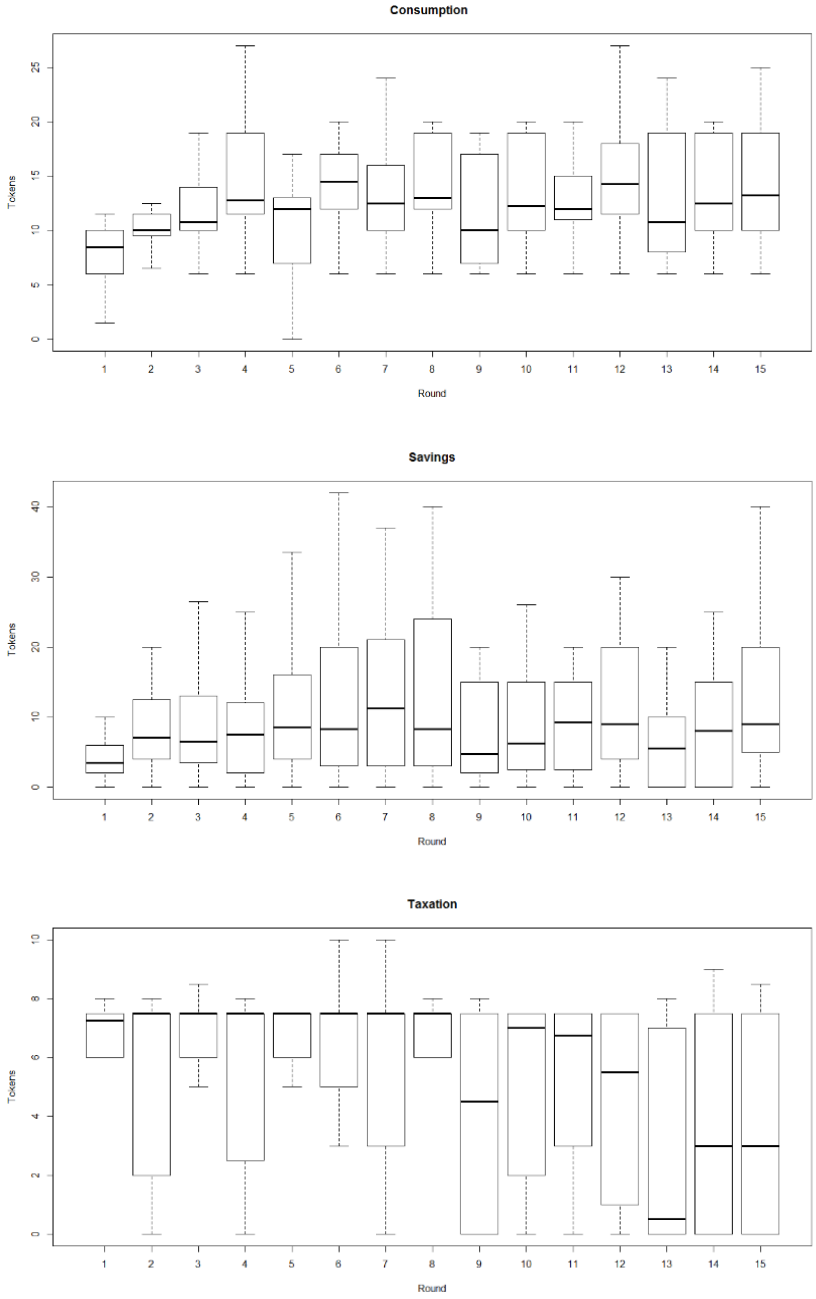
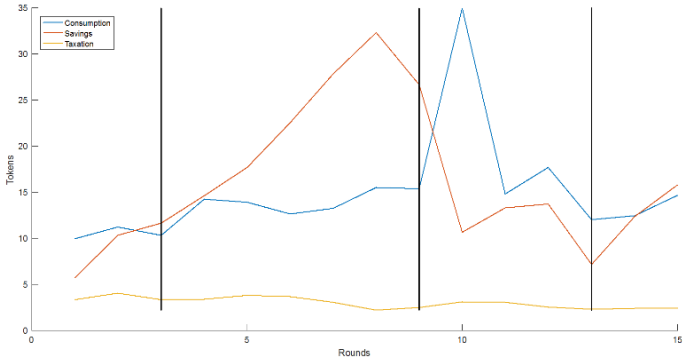
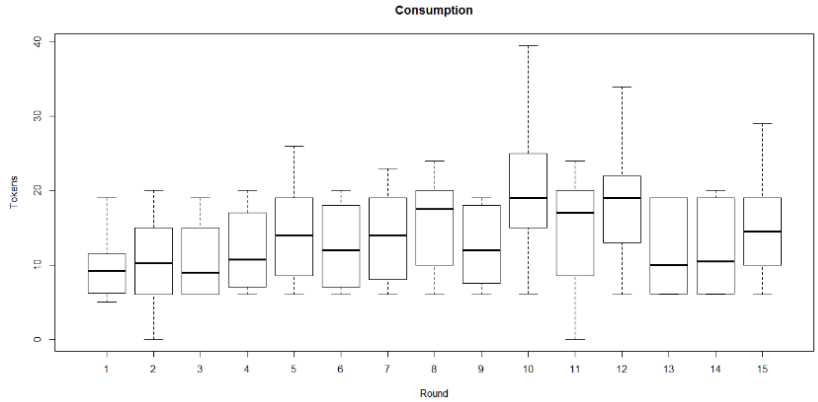
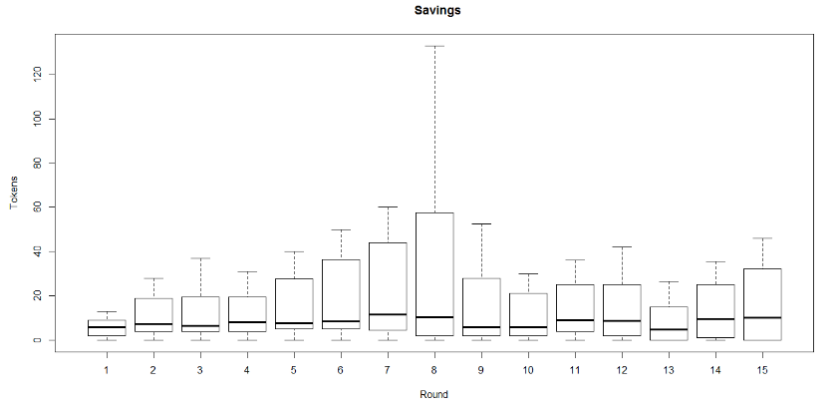
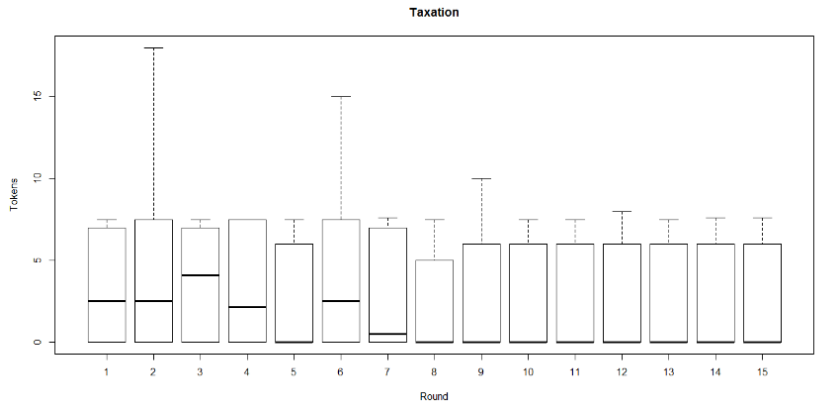


Figure 4.5. Average consumption, savings, and tax compliance dynamics with boxplots without outliers. Treatment 1 without tax controls, Session 2.









Analysing the aggregate macroeconomic variables expressed in terms of total endowment and depicted in Figure 4.6 and Figure 4.7 for the first and the second session respectively, results are even more engaging. For the first session of T1, the consumptions-to-endowment ratio (CtE) is clearly downward sloping, while the savings-to-endowment (StE) ratio is upward sloping and steeper than the former. Furthermore, the CtE ratio strongly increased after each shock, but it decreased immediately after. On the contrary, the StE ratio remained almost constant or slightly increased in the two rounds that followed

the shocks (though to a lower extent than consumption), with the only exception of the last shock, that evidently had the largest impact on savings.

Figure 4.6. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 without tax controls, Session 1.

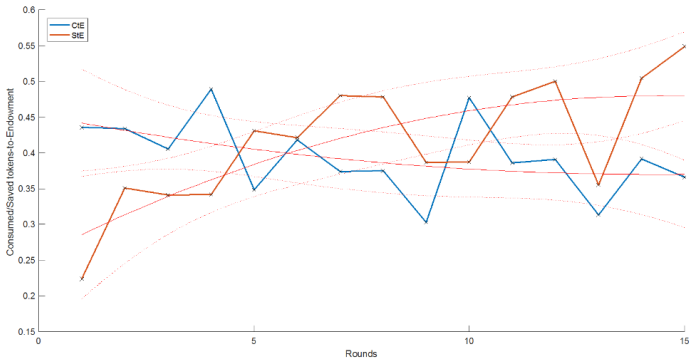
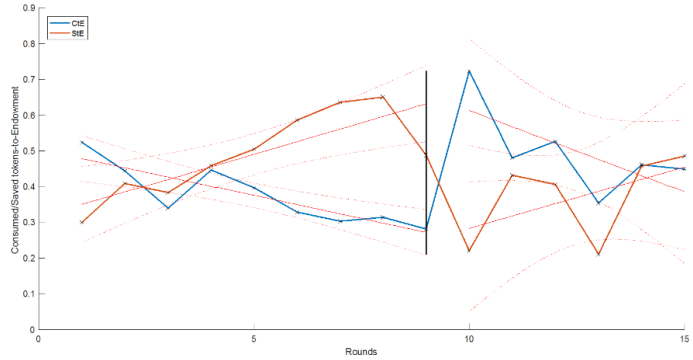


Figure 4.7. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 without tax controls, Session 2.



On the one hand, the behaviour of the two trends is surprising: though savings did not contribute to the final payment, and though subjects were aware of the fact that the experiment could have finished after round 10, they steadily decreased consumptions and increased savings with respect to their total endowment, so that the highest StE ratio was reached in the last round.

On the other hand, the short-term response of consumption after each shock can clearly be ascribed to a myopic behaviour, indeed immediately corrected in the subsequent round. In general terms, this behaviour is in line with the *bomb crater effect* discussed by Guala and Mittone (2005) and Mittone (2006), and it probably reflects the belief that debt could not have been reduced for two consecutive rounds. Similar conclusions can be achieved for the second session, though the two trends are affected by the break occurred after the second shock.

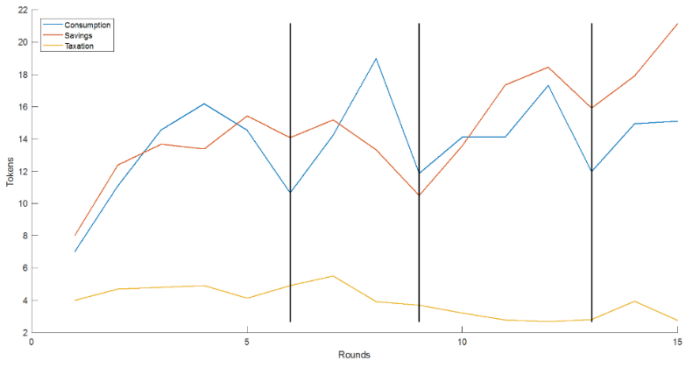
4.1.2. Treatment 2, results

The second treatment was implemented in two experimental sessions. The first session was composed by 20 subjects, 6 males and 14 females, whose mean age was 21.50 years, and the average final payments was euro 8.15, with a minimum of euro 7 and a maximum of euro 13. The second session was composed by 18 subjects, 9 males and 9 females, whose mean age was 21.94 years, and the average final payments was euro 8.50, with a minimum of euro 6 and a maximum of euro 10.

The patterns discussed for the first treatment emerged also in the two sessions of the second treatment (see Figure 4.8 for the first session, and Figure 4.9 for the second session). The consumptions average level responded positively to the three debt shocks but for one round only, whereas savings responded positively too, with only one exception (the second shock of the second session — see Figure 4.9). Little can be said for the average contribution level, which seems to increase temporarily after the debt-reduction shocks.

The dynamics of the aggregate StE and CtE ratios (Figures 4.10 and 4.11) are also comparable to the first treatment, although the two trends are evidently smoother for the first session and steeper for the second session. Note two important caveats, however. Firstly, in the first session the level of the StE ratio exceeded the level of the CtE ratio after the second shock, which means that subjects started to save more when the experiment could have finished. Secondly, in the second session the level of the StE ratio is always higher than the level of the CtE ratio.

Figure 4.8. Average consumption, savings, and tax compliance dynamics with boxplots without outliers. Treatment 2 without tax controls, Session 1.



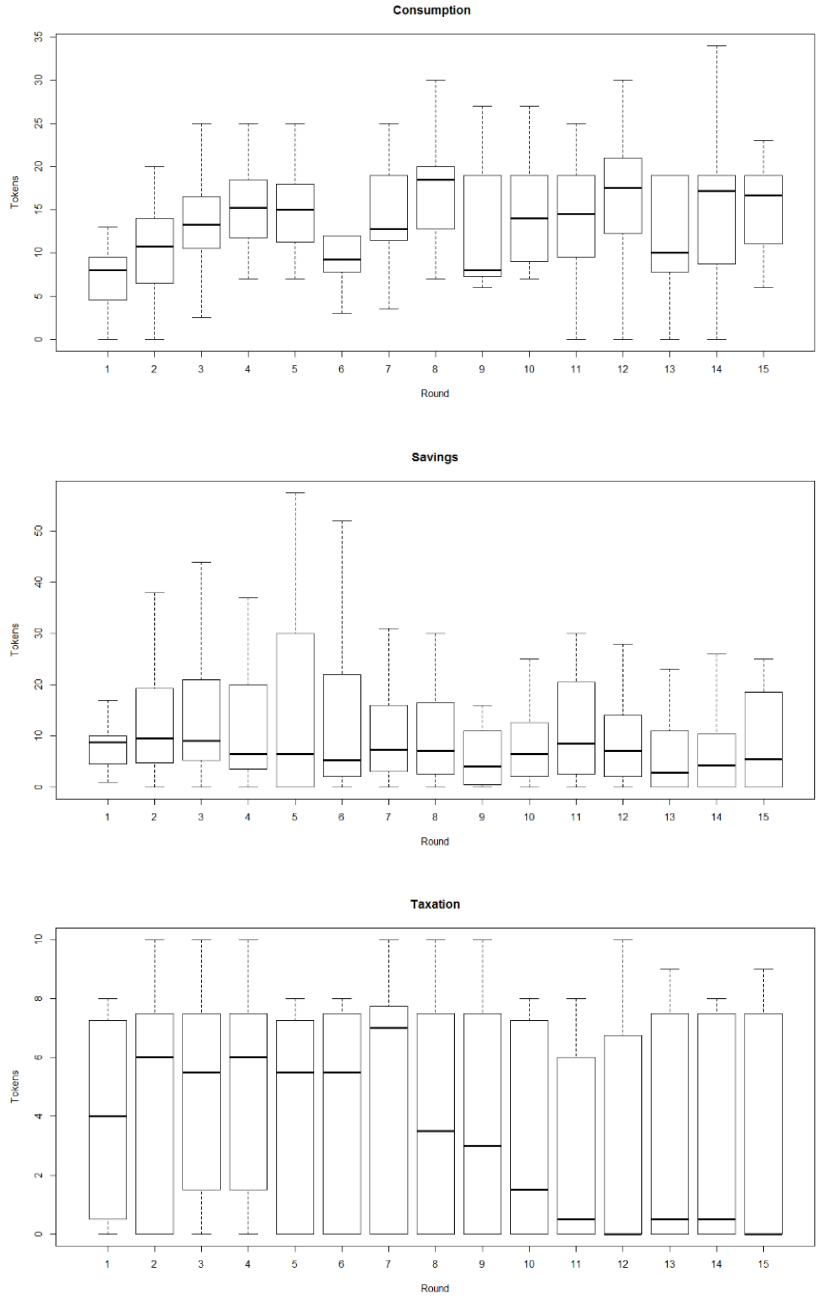
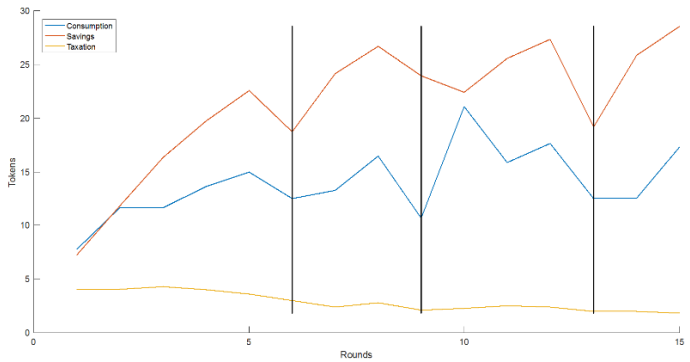


Figure 4.9. Average consumption, savings, and tax compliance dynamics with boxplots without outliers. Treatment 2 without tax controls, Session 2.



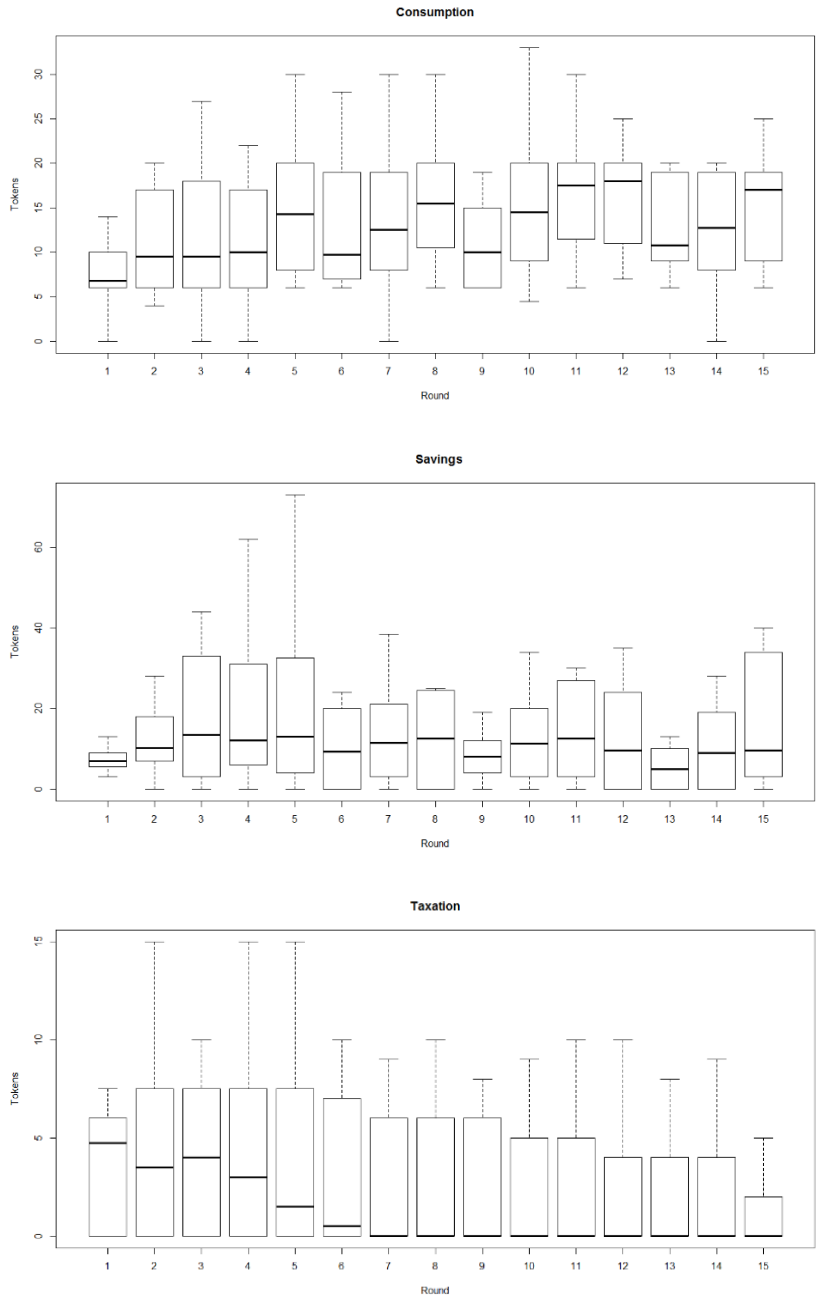


Figure 4.10. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 2 without tax controls, Session 1.

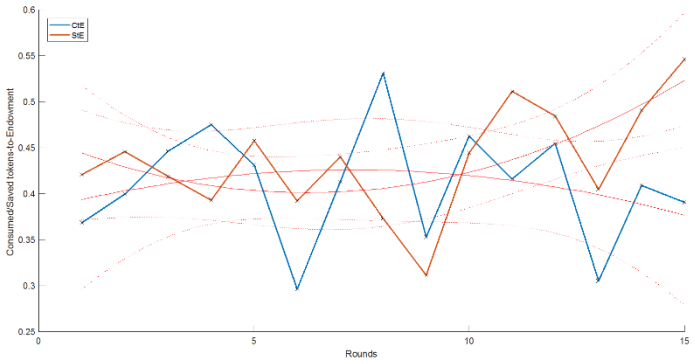
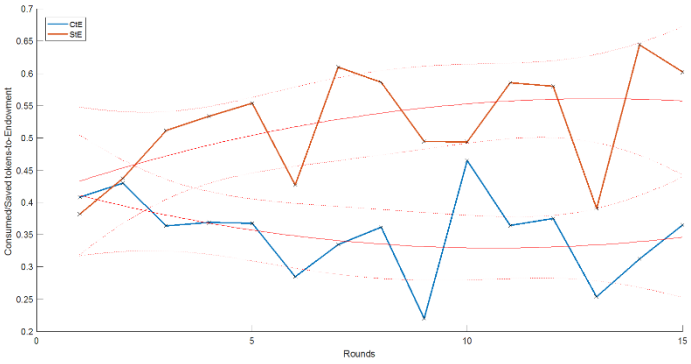


Figure 4.11. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 2 without tax controls, Session 2.



Finally, T2 has been formally compared with T1 through an ANOVA F-test, to check whether the differences among the means of the treatments were significantly different. Given a commonly adopted 5% significance level, the p-values shown in Table 4.5 do not allow to reject the null of equal means for consumption, savings, and the gross endowment. On the contrary, the null is rejected for tax compliance, which, however, depends only on the participants' honesty and free-riding propensity.

Table 4.5. ANOVA, comparison of T1 and T2 without tax controls.

	F statistics	P-value	#Obs.	Root MSE
Savings	3.11	0.0782	1110	26.3788
Consumption	0.01	0.9276	1110	10.0587
Tax compliance	7.93	0.0049	1110	3.8450
Endowment	1.94	0.1635	1110	26.2384

4.1.3. Forecasts, results

The fundamental part of this experimental design is represented by subjects' expectations, whose average dynamics are depicted from Figure 4.12 to Figure 4.16. Considering the debt-reduction related expectation (*Forecast 1*), the average number of subjects expecting a debt reduction increased after the first and the second shocks, but it decreases after the third shock, probably reflecting the belief that a further shock was unlikely. On the contrary, subjects reacted differently between the first and the second treatment for what concern sustainability-related expectations (Forecast 2). Interestingly, when the average perceived sustainability was relatively low, it increased after the shock,

but when it was relatively high, it decreased. On the whole, however, the dynamics of *Forecast2* followed the same decreasing trend throughout each session, clearly in opposite direction to the debt dynamics.

Figure 4.12. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2).
Treatment 1 without tax controls, Session 1.

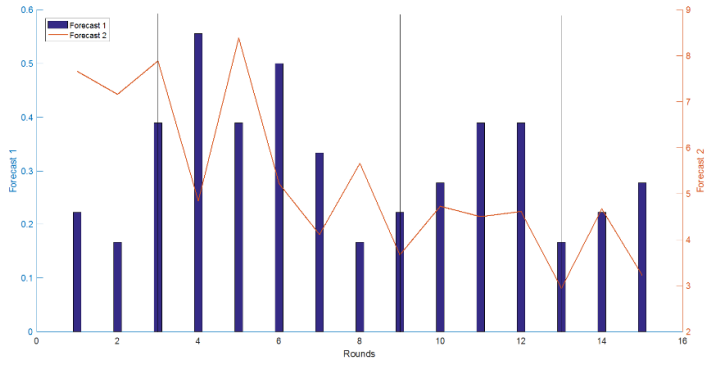


Figure 4.13. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2).
Treatment 2 without tax controls, Session 1.

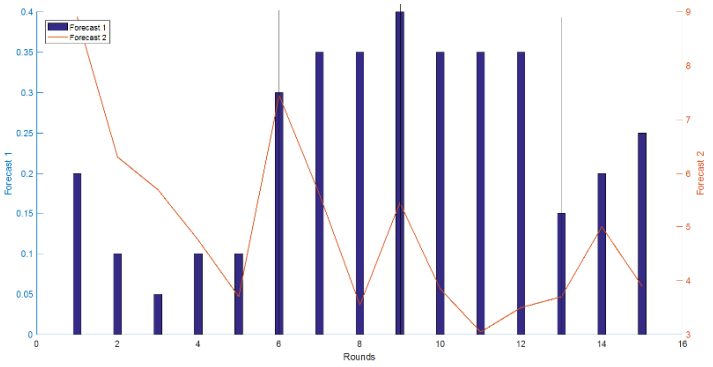


Figure 4.14. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2).
Treatment 1 without tax controls, Session 2.

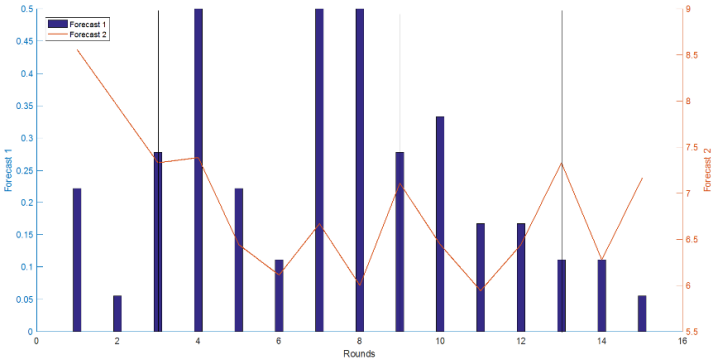
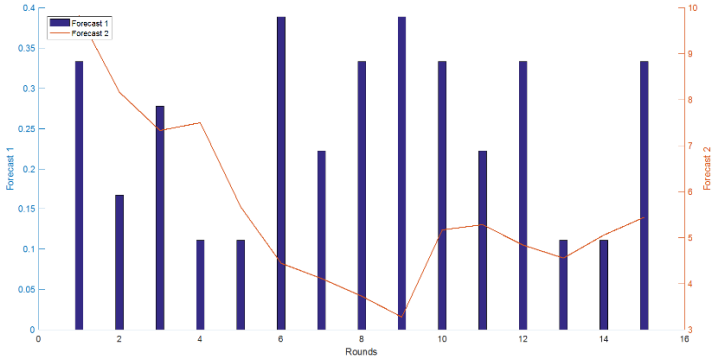


Figure 4.15. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2).
Treatment 2 without tax controls, Session 2.



4.2. Research question 1

According to the first research question — "Is there a confidence channel linking public debt and the consumption side of economic growth?" — a variation in subjects' expectations should be associated with a significant variation in the consumption level (note that nothing is said about its sign). To find evidence against or in favour of this argument, I estimated several regression models on the basis of the aggregate variables, linking the growth rate of the CtE ratio (i.e. the experimental GDP growth rate) to the growth rates of the debt-to-GDP ratio and of the forecast variables, then adding several other controls. The basic panel model is thus:

(4.23) $$dCtE_{it} = \alpha_i + \beta_1 dCtE_{it-1} + \beta_2 dDtG_{it} + \beta_3 dF1_{it} + \beta_4 DR_{it} + \epsilon_{it}$$

where i refers to the experimental session, t refers to the round or period, $dCtE_{it}$ is the growth rate of the aggregate consumption-to-endowment, α_i is the unobserved individual component, $dDtG_{it}$ is the growth rate of the debt-to-GDP, $dF1_{it}$ is the first difference of *Forecast 1* (debt-reduction forecasts for the following round), DR_{it} is a dummy variable indicating the rounds of the debt-reduction shocks, and ϵ_{it} is an error term with the usual statistical properties. The other variables that have been considered are $dStE_{it}$ and $dTtE_{it}$, the savings and the tax compliance growth rates respectively. For all these variables is possible to reject the null of "Panels contain unit-root" according to two panel unit-root tests, the Harris-Tzavalis test with the small-sample correction, and the Breitung test (see Table 4.6).

Table 4.6. Panel unit-root tests, p-values.

	Variable					
	dCtE	**dDtG**	**dF1**	**dF2**	**dStE**	**dTtE**
Harris-Tzavalis*	0	0	0	0	0	0
Breitung	0	0	0.004	0	0.006	0.003

*with small-sample correction.

Given the limited number of panel units (N = 4) and time periods (T = 15), common GMM estimators such as Arellano-Bond and Arellano-Bover would be inappropriate (their asymptotic properties require N→∞). Therefore, I estimated the pooled-OLS version of model (4.23) and adopted the heteroskedastic-robust standard errors[17]. Results are shown in Table 4.7.

Table 4.7. RQ1, panel estimation for dCtE.

Specification	**1**	**2**	**3**	**CM1**
Dep. Var.	**dCtE**	**dCtE**	**dCtE**	**dCtE**
dCtE(-1)	0.0595	0.2028	0.1238	0.1953
	(0.1686)	(0.1438)	(0.1188)	(0.1440)
dDtG	-1.0967**	-1.4767***	-1.4859***	-1.4858***
	(0.4447)	(0.3383)	(0.3073)	(0.3339)
dF1	-0.0367*	-0.0095	0.0845	-
	(0.0183)	(0.0163)	(0.0569)	-
dStE(-1)	-	-0.5605***	-0.5275***	-0.4902***
	-	(0.1522)	(0.1392)	(0.1331)
dTtE(-1)	-	0.1523	0.1119	-
	-	(0.1425)	(0.1168)	-
DR	-0.2814***	-0.2436***	-0.2496***	-0.2541***
	(0.0464)	(0.0442)	(0.0436)	(0.0431)
dDtG*dF1	-	-	-0.5809**	-0.2321**
	-	-	(0.2887)	(0.1113)
Const.	0.3237***	0.4266***	0.4109***	0.4194***
	(0.0980)	(0.0795)	(0.0727)	(0.0757)
#Obs.	52	52	52	52
Adj. R^2	0.6007	0.7848	0.8115	0.7969

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. Robust standard errors are in parentheses.

The basic specification is shown in column 1, from which three facts emerge. First, the consumption growth rate and the debt-to-GDP growth rate are linked through a negative significant relationship, entailing that an increase in the debt-to-GDP ratio is associated with a decrease in the consumption-to-

[17] It must be underlying, however, that the Arellano-Bond and the Arellano-Bover estimators approximately led to the same estimated coefficients of the pooled-OLS estimator.

endowment ratio. Second, the estimated parameter of DR_{it} is negative and significant: it captures the negative impact of the debt-reduction shock on the level of the CtE ratio. Third, the coefficient of $dF1_{it}$ is negative and significant, thus capturing the inverse relationship between the public debt and the CtE ratio described above. In other words, if subjects' expectations about a debt consolidation worsen, they react by reducing their consumption level with respect to their endowment.

The second column of Table 4.7 adds two explanatory variables: the savings-to-endowment (StE) and the taxation-to-endowment (TtE) growth rates. The former variable is significant and negative, implying that an increase in the StE ratio is associated with a decrease in the CtE ratio in the subsequent round, a fact that stems directly from the dynamics of the two variables described in the qualitative analysis. The latter, instead, is not statistically significant, thus underlying that the dynamics of the TtE ratio is mainly influenced by individual behavioural aspects. Noteworthy, the significance and the sign of the other variables included in the basic model do not change, with the only exception of $dF1_{it}$, whose estimated coefficient is not significant. The lagged dependent variable, instead, is not significant.

Recalling the analysis performed in Chapter 2, the third column of Table 4.7 adds an interaction term between the growth rate of the debt-to-GDP ratio and *dF1* in order to describe their joint impact on *dCtE*. Estimation results confirm the non-significance of *dF1*, but its negative impact on the dependent variable is fully captured by the interaction term. At the same time, the sign and the statistical significance of the other variables are not affected. This model can reveal the existence of a scale effect between *dDtG* and *dF1*, according to which a large variation in both the debt-to-GDP ratio and the expectations of a debt reduction entails a larger negative impact on *CtE*.

On the basis of this analysis, the econometric specification used to describe the relationship between the variables of interest is *CM1* (Table 4.6, column 4), a specification that do not incorporate the lagged *dTtE* (never significant) and *dF1*. With respect to the model in column 3, the only difference is in the

magnitude of the coefficient of the interaction term, which is affected by the exclusion of *dF1*.

According to this model, the existence of a confidence channel between consumption and public debt seems reasonable, a channel that associates a worsening in the expectations of a debt reduction — or, in general, to the expectations of worse fiscal measures — to a reduction in the consumption level.

4.3. Research question 2

The previous analysis is extended to incorporate the concept of perceived debt sustainability, directly elicited during the experiment with the debt-sustainability expectation in order to answer to the second research question — "Does the perceived debt sustainability affect the choices of the subjects?". The variable of interest is thus *Forecast 2*, whose rate of change is indicated with $dF2_{it}$. The analysis takes two directions: I expand equation (4.23) to incorporate the new forecast variable, and I employ the same strategy adopted in Section 4.2 to describe the behaviour of the aggregate StE ratio and *CtE* ratio.

The first part of the analysis aims at identifying the impact of the perceived sustainability on the consumption level, alone, and jointly with the debt-reduction forecast (*F1*). Therefore, equation (4.23) is developed to incorporate $dF2_{it}$

$$dCtE_{it} = \alpha_i + \beta_1 dCtE_{it-1} + \beta_2 dDtG_{it} + \beta_3 dF2_{it} + \beta_4 dDt_{it} * dF2_{it} + \beta_5 DR_{it} + \epsilon_{it} \quad (4.24)$$

and then $dF1_{it}$ and $dF2_{it}$ together:

$$dCtE_{it} = \alpha_i + \beta_1 dCtE_{it-1} + \beta_2 dDtG_{it} + \beta_3 dF2_{it} + \beta_4 (dDt_{it} * dF2_{it}) + \beta_5 DR_{it} + \epsilon_{it} \quad (4.25)$$

where $(dDt_{it} * dF2_{it})$ indicates the interaction term between the two variables. Estimation results are shown in Table 4.8.

The first column, which refers to equation (4.24), confirms the negative impact of debt on consumption, but $dF2_{it}$ is not statistically significant. This result changes once the model is expanded to incorporate other explanatory variables. Column 2 shows that $dF2_{it}$ becomes positive and significant if an interaction term is added: a positive variation in the perceived sustainability has a positive

impact on the consumption level, which is partly compensated by the negative sign of the interaction term.

Table 4.8. RQ2, panel estimation for dCtE.

Specification	**1**	**2**	**3**	**4**	**CM2**
Dep. Var.	**dCtE**	**dCtE**	**dCtE**	**dCtE**	**dCtE**
dCtE(-1)	0.0795	0.2046	0.2020	0.1307	0.2099
	(0.1749)	(0.1452)	(0.1466)	(0.1193)	(0.1526)
dDtG	-1.0841**	-1.4757***	-1.4801***	-1.4974***	-1.4818***
	(0.4416)	(0.3494)	(0.3545)	(0.3241)	(0.3615)
dF1	-	-	-0.0098	0.0780	-
	-	-	(0.0149)	(0.0579)	-
dF2	0.0916	0.3019**	0.3025**	0.2828**	0.2442**
	(0.1035)	(0.1158)	(0.1159)	(0.1200)	(0.1204)
dStE(-1)	-	-0.5755***	-0.5704***	-0.5432***	-0.4795***
	-	(0.1524)	(0.1544)	(0.1391)	(0.1354)
dTtE(-1)	-	0.2308	0.2315	0.1978	-
	-	(0.1498)	(0.1511)	(0.1250)	-
DR	-0.3084***	-0.2263***	-0.2212***	-0.2308***	-0.2461***
	(0.0465)	(0.0386)	(0.0401)	(0.0385)	(0.0401)
dDtG*dF1	-	-	-	-0.5464*	-0.2216**
	-	-	-	(0.2982)	(0.1074)
dDtG*dF2	-	-0.8762*	-0.8705*	-0.6928	-0.7473
	-	(0.4995)	(0.5052)	(0.5808)	(0.5388)
Const.	0.3163***	0.4248***	0.4269***	0.4151***	0.4155***
	(0.0959)	(0.0847)	(0.0860)	(0.0765)	-0.0833
#Obs	52	52	52	52	52
Adj. R^2	0.5967	0.8128	0.8093	0.8331	0.8113

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. Robust standard errors are in parentheses.

Column 3 reports the estimation of equation (4.25), and shows that the previous results, in terms of sign and significance, are confirmed. In fact, not only the coefficients of $dF2_{it}$ and of the interaction term are comparable to those of the second column, but also $dF1_{it}$ is not statistically significant as in Table 4.8. With respect to $dF2_{it}$ and its interaction term, this result is confirmed by the model in column 4, in which the significant interaction term of $dF1_{it}$ is added. On the basis of these results and out of consideration of the adjusted R^2, the chosen model is *CM2* (column 5), which does not include *dF1* and, as before, *dTtE*.

The second part of the analysis aims at identifying the impact of the perceived sustainability on savings. Following the same steps, for brevity only the chosen model (*CM3*) is reported in Table 4.9.

Table 4.9. RQ2, panel estimation for dStE.

Specification	**CM3**
Dep. Var.	**dStE**
dStE(-1)	-0.1779
	(0.1571)
dDtG	0.8800***
	(0.2133)
dF1	0.0693*
	(0.0352)
dF2	0.1213
	0.1048
dCtE(-1)	-0.2864**
	(0.1308)
dTtE(-1)	-
	-
DR	-0.4200***
	(0.0702)
dDtG(-1)*dF1	-0.2012
	(0.1951)
dDtG(-1)*dF2	-0.5301*
	(0.3128)
Const.	-0.0056
	(0.0545)
#Obs.	52
Adj. R^2	0.5104

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

By looking at the estimation results, a statistically positive relationship links $dDtG_{it}$ and $dStE_{it}$, entailing that an increase in the debt-to-GDP ratio is associated with an increase in the savings-to-endowment ratio. As expected, the same occurs for *dF1*: if the expectations about a debt reduction worsen, the savings level increase. On the other hand, $dF2_{it}$ is not statistically significant, but the related interaction term with $dDtG_{it}$ shows a possible non-linear (negative) relationship of the perceived sustainability, which depends on $dDtG_{it}$ itself.

The negative sign of DR_{it} reflects the already recognised *bomb crater effect*, according to which a debt shock is usually followed by a decrease in the savings level and an increase in the consumption level. This short-life effect could be seen as supporting the expansionary fiscal consolidation hypothesis, according to which a debt consolidation is followed by an expansion in the aggregate demand, but in fact it is only an experimental phenomenon (see Guala and Mittone, 2005; Mittone, 2006).

Finally, it can be observed that the negative relationship in models *CM1* and *CM2* between consumption and savings arises anew between savings and consumption, thus confirming the reverse relationship between the two variables. Moreover, the relationship between $dTtE_{it}$ and savings within this framework is not theoretically defined. For this reason, and since the variable was not significant, $dTtE_{it}$ has been excluded from model *CM3*.

In conclusion, I have shown that an increase in the perception of a debt reduction is associated with a decrease in the consumption-to-endowment level and an increase in the savings-to-endowment level, while an increase in the perceived sustainability is associated with an increase in the consumption-to-endowment level, but it appears to have no impact on the savings-to-endowment level.

These findings are in line and expand the comprehension of the qualitative analysis: a situation of increasing public debt in which people might be forced to pay an uncertain amount and to bear the cost of the debt reduction is associated with relatively high and increasing aggregate savings and decreasing aggregate consumptions. Moreover, an increase in the debt-reduction expectations and a decrease in the perceived debt sustainability are linked to a reduction in the CtE ratio and an increase in the StE ratio, as predicted by Hypothesis 2.

4.4. Analysis of residuals

The residuals of three "chosen models" *CM1*, *CM2*, and *CM3* have been analysed through a couple of tests (see Table 4.10) to evaluate the goodness of fit.

First, the Arellano-Bond panel test has been applied to test for the presence of first order and second order residuals autocorrelation, which can bias the standard errors and affect the other statistical tests, but the null of no serial correlation has not been rejected[18].

[18] Though the Arellano-Bond test statistic requires $N \to \infty$, the results can give an indication of the presence of autocorrelation.

On the contrary, the p-values of the pooled Shapiro-Wilk test have allowed to reject the null of normality. This test, however, has been repeated for the same series without the outliers referred to the post-shock reactions and, in this case, normality has not been rejected at 5% for CM2 and CM3 and at 1% for CM1. Therefore, it is possible to say that, even with DR_{it}, the estimated models are unable to capture the impact of the shocks, both in terms of consumption and savings.

Then, the estimation of the specifications in Table 4.7, 4.8, and 4.9 have been repeated excluding the first two observations for each variable in order to check whether the results were influenced by the number of observations and whether they were highly determined by the behaviour of the participants at the beginning of the experiment, when they are commonly deemed to be still on a learning path. The estimation results confirmed the previous findings; in fact, the estimated coefficient did not change much, both in terms of significance, sign, and value.

Finally, I have estimated the chosen models without including the constant term. The magnitude of the estimated coefficients changed, naturally, but the sign and the significance levels were not much affected. Since the constant is almost always significant, it interacts with DR_{it}, and it does not affect the analysis, I have decided to keep it.

Table 4.10. Tests on chosen models' residuals (CM1, CM2, CM3): autocorrelation and normality.

		Autocorrelation		
Test	**CM1**	**CM2**	**CM3**	**Result**
Arellano-Bond (1)	0.0806	0.0529	0.8310	No autocorrelation
Arellano-Bond (2)	0.7829	0.8128	0.0827	No autocorrelation
		Normality		
Test	**CM1**	**CM2**	**CM3**	**Result**
Shapiro-Wilk	0.0000	0.0000	0.0000	Non-normality
Shapiro-Wilk	0.0271	0.1389	0.8625	Normality

4.5. Qualitative analysis, tax controls

Despite being freely possible to avoid paying taxes, during the four experimental sessions without tax controls it was observed a positive average

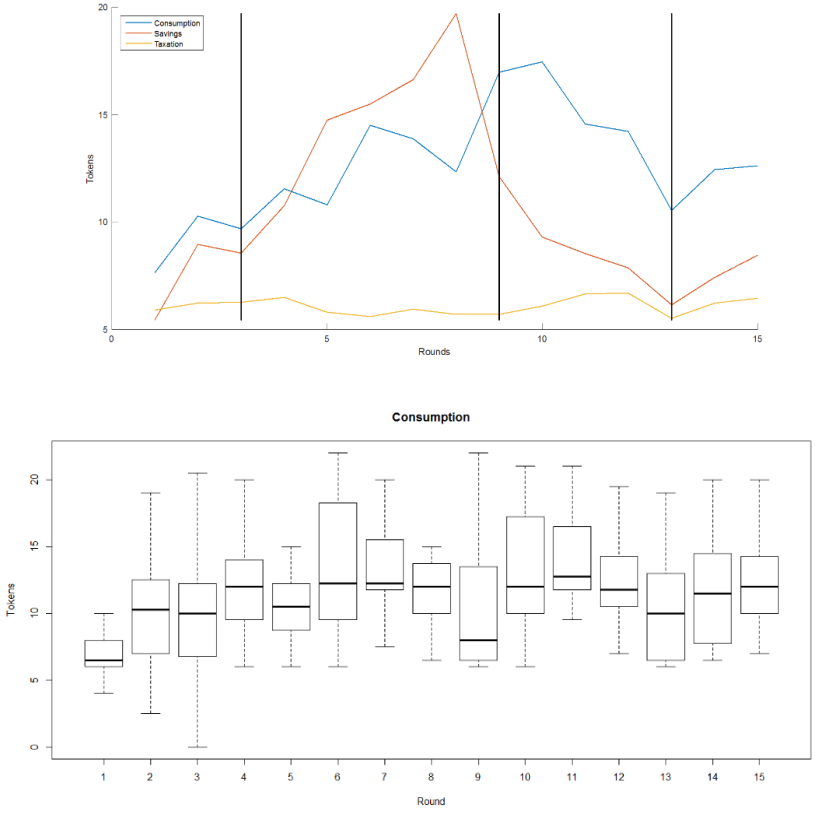
contribution level that may reflect both honesty propensity and concern about the cost of a debt reduction. However, average contributions fell steadily during each of the four sessions as a consequence of the rise in the free-riding behaviour that had the direct consequence of feeding the public debt uprising dynamics. To examine whether this behaviour had an impact on the subjects' choices, I implemented the first treatment with the fiscal audits mechanism explained in Section 3.5. The details about the two sessions are reported above, in the last two rows of Table 4.3.

The results of the first session with tax controls are shown in Figure 4.16 and Figure 4.17. They are in line with the previous discussion and, in particular, with the results of the second session of T1 (Figure 4.5): the general after-shock response of consumption and tax compliance is positive, while the response of savings is positive except for the second debt shock, when participants increased their consumption level permanently while they kept the level of savings low. Therefore, the second debt-reduction shock coincided with a break: between the first and the second shock, subjects constantly increased their savings, giving rise to an upward trend that was reversed after the second shock (Figure 4.17). This aggregate behaviour is the closest to the intuitive optimal strategy for consumption and savings, even though the CtE ratio decreased after the time break and the StE ratio was on a slightly upward trend. Also the average forecast variables followed the path already recognised in the previous sessions: looking at Figure 4.18, the perceived sustainability (*Forecast2*) decreased constantly with the only exception of a temporary increase after the second debt-reduction shock, while the average perceived probability of a debt reduction (*Forecast1*) is less informative in this case but, as usual, it increased after the first and the second shock and it decreased after the third one, probably reflecting the approaching of the end of the experiment. The second session with tax controls confirms these results. Starting from Figure 4.21, the dynamics of the average *Forecast1* does not show relevant differences with respect to the previous analysis, while the dynamics of *Forecast2* is more shock-dependent. At the same time, Figure 4.20 depicts a situation that is in contrast with the one depicted in Figure 4.17: the StE ratio steadily increased, but it

became greater than the CtE ratio in the second part of the experiment, while at the beginning it was much lower. However, though the dynamics of savings did not seem to be affected by fiscal audits, what emerges from both Figure 4.17 and Figure 4.20 is the fact that the StE ratio seems translated downwards with respect to the no-tax-controls sessions. In fact, by looking at the first two columns of Table 4.4, the average level of savings in the two sessions with tax controls is not only lower than in the sessions without tax controls, but also lower than the average consumption, which remained comparable with the previous average values.

Recapitulating, both sessions contributed to show three outstanding results: a) tax evasion was not totally eradicated, but it was curbed and the decreasing trend observed for paid taxes disappeared; b) on the whole, the results are comparable with the four sessions without tax controls; c) the level of the CtE ratio does not seem to be strongly affected by tax controls, but the level of the StE ratio appears to be lower, as if the burden of the higher contribution level were mainly borne by savings.

Figure 4.16. Average consumption, savings, and tax compliance dynamics with boxplots without outliers. Treatment 1 with tax controls, Session 1.



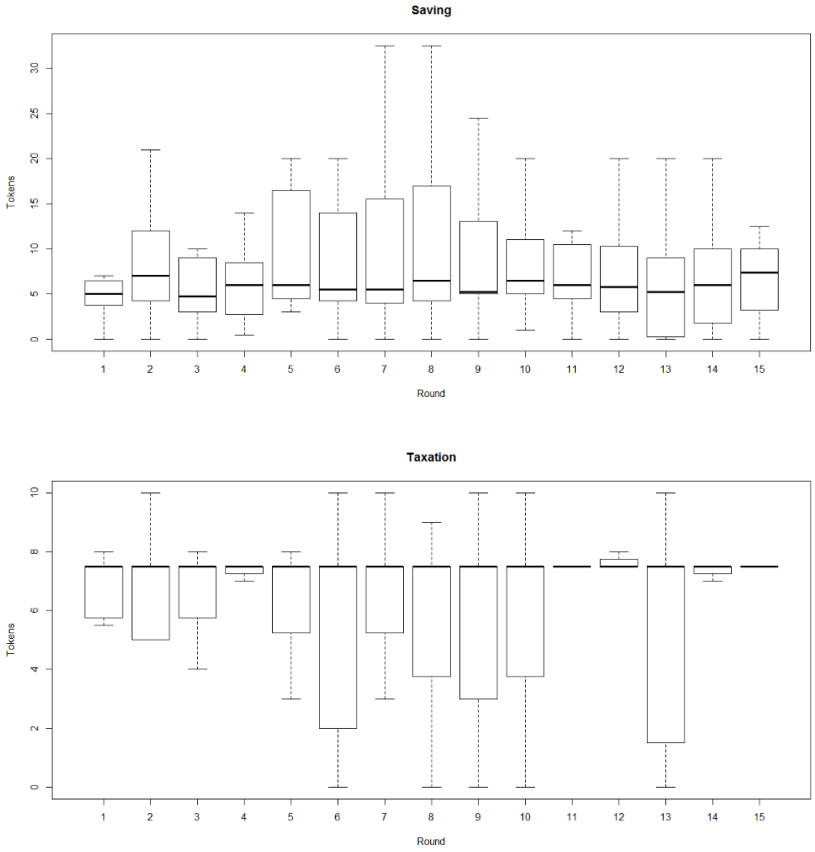


Figure 4.17. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 with tax controls, Session 1.

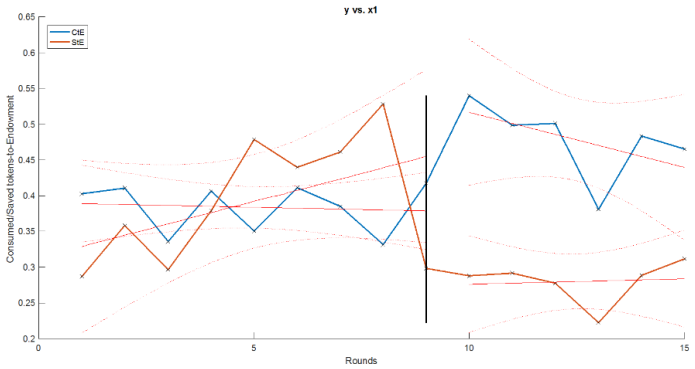


Figure 4.18. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2).
Treatment 1 with tax controls, Session 1.

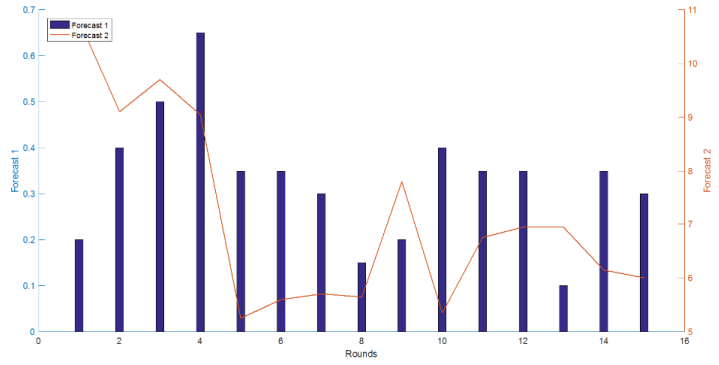


Figure 4.19. Average consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 with tax controls, Session 2.

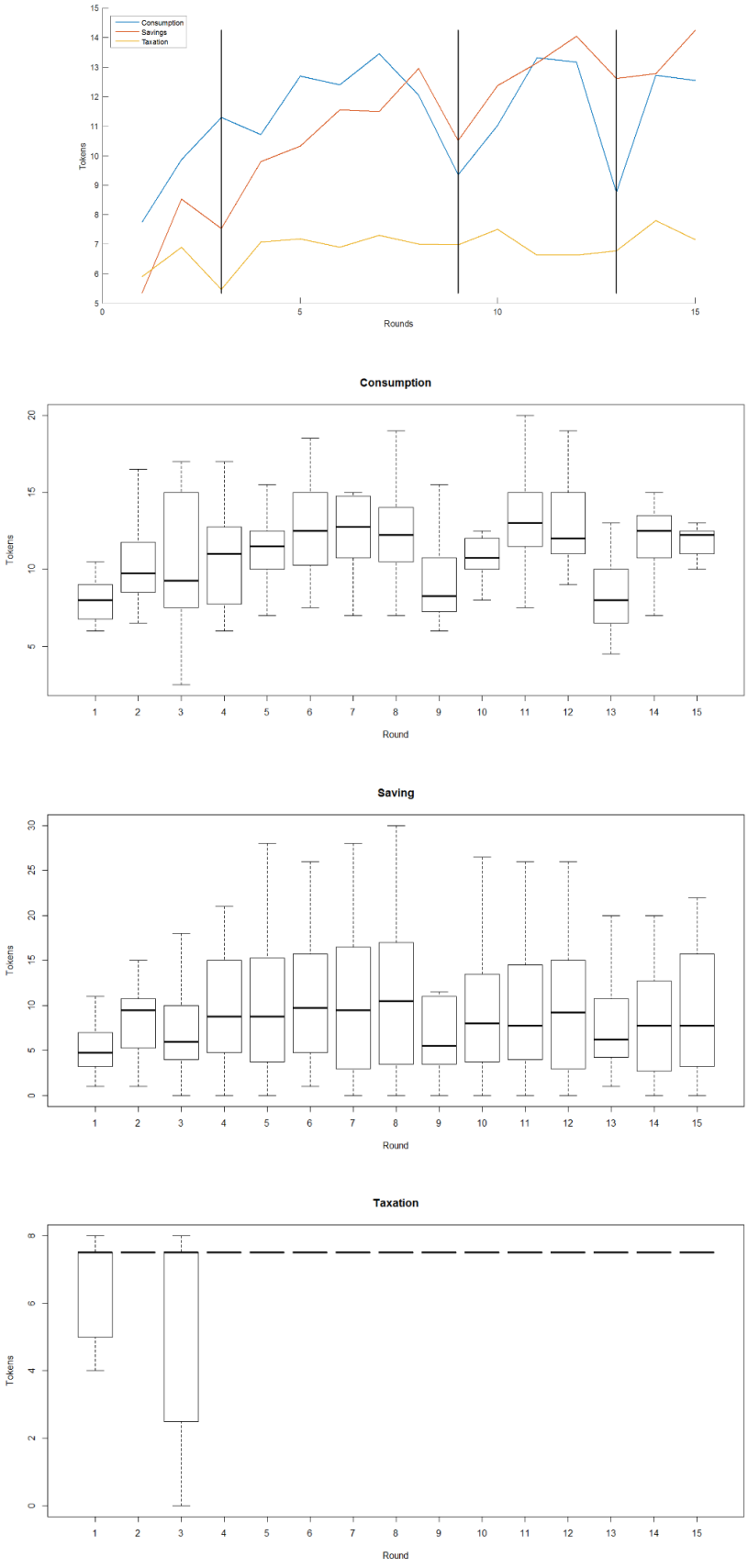


Figure 4.20. Aggregate consumptions-to-endowment (CtE) and savings-to-endowment (StE) ratios. Treatment 1 with tax controls, Session 2.

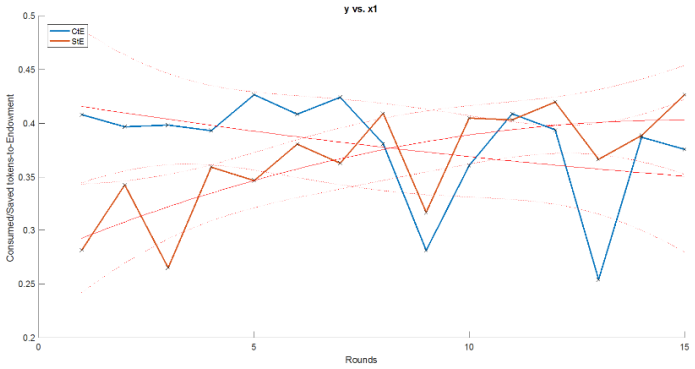
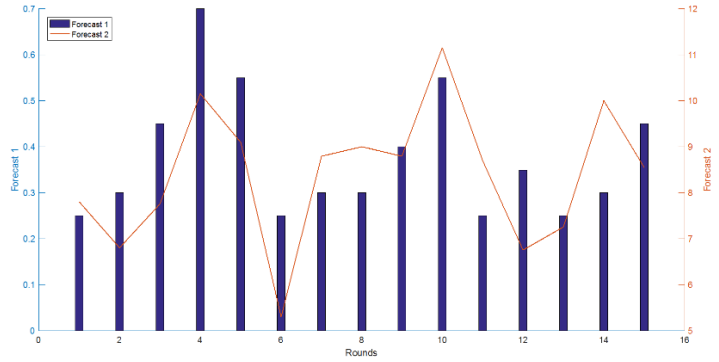


Figure 4.21. Aggregate expectations, fraction of "Debt will be reduced in the next round" (Forecast1), and average sustainability perception (Forecast2). Treatment 1 with tax controls, Session 2.



4.6. Research question 3

To study the influence of the average higher amount of taxes paid by the participants as a consequence of the controls on tax evasion, I constructed a dataset formed by the four sessions without tax controls and the two sessions with tax controls. To compare the experimental sessions, I excluded the forecast variables and I included, beyond the growth rate of the $dTtE_{it}$ ratio, an interaction term meant to capture the impact of the tax-control: $dTtE*D$, where D is a dummy variable equals to 1 for the two sessions with tax controls and equals to 0 for the experimental sessions without tax controls. Results are shown in Table 4.11.

As it can be observed, the interaction term on which I focus is not statistically significant for the *dCtE* regression (model *CM2b*), but it is slightly significant and negative for the *dStE* regression (model *CM3b*). Beyond statistical significance, the negative sign reflects the conclusions of the qualitative analysis.

Table 4.11. RQ3, panel estimation for dCtE and dStE.

Specification	**CM2b**	**CM3b**
Dependent Var.	**dCtE**	**dStE**
dCtE(-1)	-0.1064	-0.2251**
	(0.1168)	(0.1139)
dStE(-1)	-0.4894***	-0.1870
	(0.1343)***	(0.1429)
dDtG	-1.2719	0.6951***
	(0.2827)	(0.1835)
DR	-0.2797***	-0.3386***
	(0.0324)	(0.0436)
dTtE(-1)	0.0916	0.0926
	(0.1248)	(0.1104)
dTtE(-1)*D	0.0706	-0.3143*
	(0.2062)	(0.1735)
Const.	0.3470***	0.0261
	(0.0620)	(0.0442)
#Obs.	78	78
Adj. R^2	0.7481	0.5173

Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. All robust standard errors are in parentheses.

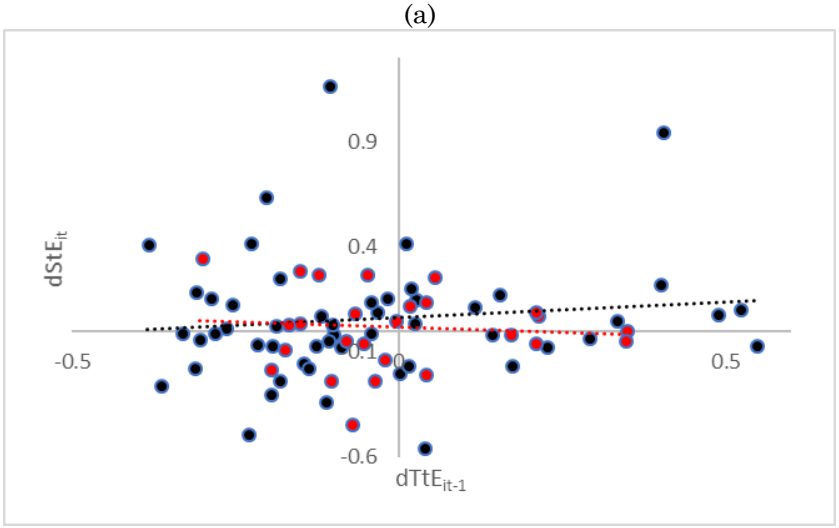
On the whole, subjects compensated for the higher contributions due to the fiscal audits by reducing savings. This result sheds light on a possible dangerous condition, represented by a situation in which people, given their endowment, sacrifice savings in order to pay relatively higher taxes and to maintain a certain level of consumption. In such a case, however, subjects' endowment grows slower and they are more exposed to unexpected shocks, beyond hampering future consumption. This fact is also confirmed by the values shown in Table 4.4 — it is evident that the average savings in the two sessions with tax controls are lower than in the other sessions — and from Figure 4.22: whereas the two linear interpolation functions for $dCtE_{it}$ overlap (panel B), the interpolation functions referring to dStE go in opposite directions (panel A): the line that refers to the experimental sessions with tax controls has slightly negative slope, while the line that refers to the to the experimental sessions without tax controls has positive and statistical significant slope.

This finding is also in line with the common impact of taxation on the savings rate, according to which an increase in income taxes negatively affects the savings rate (see for instance Zee and Tanzi, 1998). Accordingly, the adopted experimental design seems to be empirically robust as it can capture this phenomenon even in a quite complex framework.

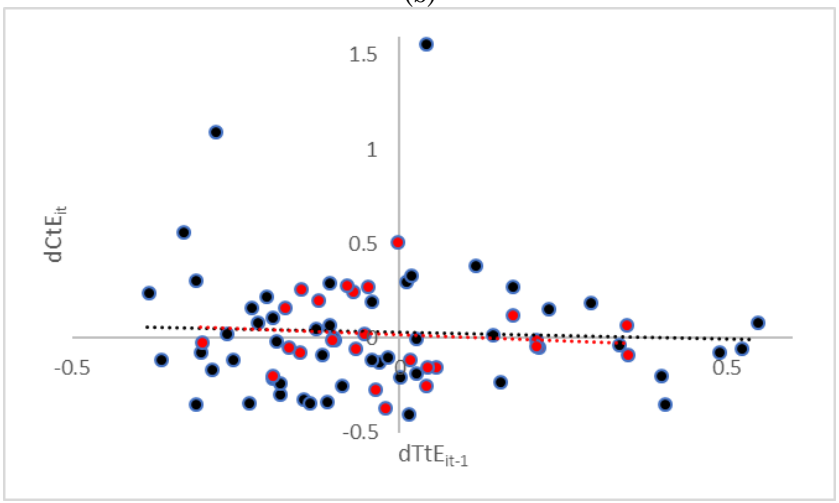
In conclusion, the level of the StE ratio of the two sessions in which subjects faced a tax control mechanism are relatively lower than the level of the StE ratio registered without such a mechanism, thus making subjects relatively poorer in the long-run and more exposed to the shocks.

Figure 4.22. Linear relationships between dStE and dTtE (panel a) and dCtE and dTtE (panel b). Sessions without tax controls (black) and sessions with tax controls (red).

(a)



(b)



4.7. Questionnaire and risk aversion, results

Subjects' knowledge about the topic was assessed at the end of the experiment through a number of questions (Table 4.1). All in all, the knowledge of the Italian financial situation looks poor, as the right 2017 Italian debt-to-GDP ratio slot (120-140%) was selected by only 41.54% of the participants. This

should be seen as an advantage that confirms that the participants could not be considered as "experts". Moreover, to check whether this fact had an impact on the aggregate results discussed in the previous sections, I included in specifications *CM1* and *CM2* two explanatory variables[19]: the percentage of students from economic sciences ("Economics") and the percentage of right answers to the Italian actual debt-to-GDP question ("Right Italian DtG"). Results in Table 4.12 confirm that neither of these variables is significant. Nevertheless, the awareness of a relatively problematic Italian situation emerges from other two questions: 63.85% of the participants believes that the Italian debt-to-GDP ratio will increase in the near future, while only 18.46% believes that it is sustainable. Noteworthy, 73.08% of the participants reckons that the public debt level somehow affects the private consumption level, but this result might depend on the experiment itself and would deserve further research.

For what concern the degree of risk aversion, the Holt and Laury task has always led to an average degree of risk aversion included between 0.61 and 0.75, thus confirming that subjects were, on average, mid risk averse, a result that is in line with the savings and consumption behaviour observed in the experiment. The results for each session and the distribution of the degree of risk aversion are shown in Figure 4.23.

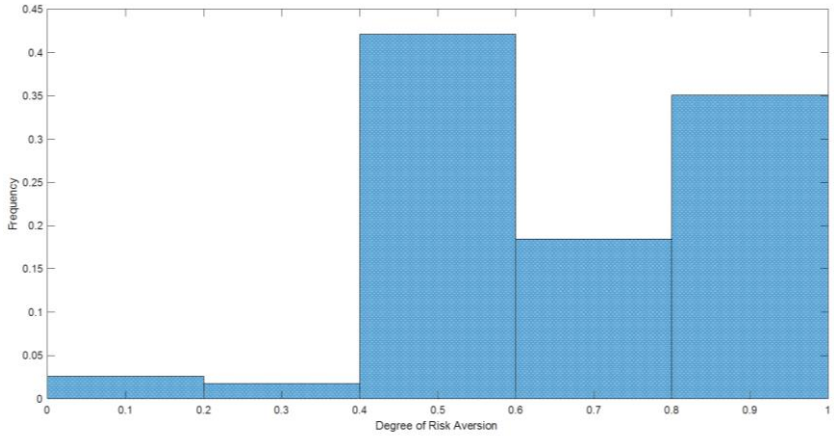
Table 4.12. Panel estimation for dCtE and dStE, further controls.

Model	**CM2c**	**CM3c**	**CM2d**	**CM3d**
Dep. Variable	**dCtE**	**dStE**	**dCtE**	**dStE**
Explanatory variables	[...]	[...]	[...]	[...]
Economics	0.0404	-0.0657	-	-
	(0.1529)	(0.1872)	-	-
Right Italian DtG	-	-	-0.6084	-0.1397
	-	-	(0.3890)	(0.5679)
#Obs.	52	52	52	52
Adj. R^2	0.8071	0.4993	0.8260	0.5001

[19] Because of collinearity, the two variables were included separately.

Figure 4.23. Halt and Laury task, average degree of risk aversion, standard deviations, and overall distribution.

Session	T1, 1	T1, 2	T2, 1	T2, 2	TC, 1	TC, 2
Mean	0.6167	0.6722	0.6500	0.7000	0.6889	0.7444
Std. Dev.	0.2771	0.1965	0.1948	0.2401	0.1906	0.1854



5. CONCLUSIONS

This chapter studied the relationship between public debt and the consumption side of economic growth from an experimental macroeconomics point of view, by analysing whether consumers' expectations about public debt and the uncertainty about the fiscal behaviour of the government affect their decisions in terms of consumption and savings choices.

I implemented a laboratory experiment in which the participants earned an income to be allocated between consumption, savings, and voluntary taxation for an unknown number of rounds. The core of the experiment was represented by a public-good game with threshold: taxation was used to cover a given level of public expenditure, equally distributed to the participants at the beginning of each round. If the collected amount of taxes was lower than what was required, the government had to ask for an amount of exogenous debt in order to sustain its public expenditure. Then, at the beginning of each round the outstanding amount of public debt could have been reduced by accessing subjects' savings. Within this framework, I elicited subjects' expectations about their perceived debt sustainability and future debt reduction.

Conscious of the limits of this experimental design, I do not want to overstate its external validity, that is limited though the design is, in my opinion, empirically robust. In fact, the dynamics of public debt is determined by tax evasion which simply implies, as in reality, that the equality between government revenues and government spending does not hold. Nonetheless, results shed light on the existence of a confidence channel between public debt, fiscal policies, and consumptions, broader than the expectations channel of Sutherland (1997). As a matter of fact, findings have showed that subjects' consumption and savings decisions seem to be affected by their debt expectations and by the uncertainty about the political intervention and its cost. As the public debt and the debt-to-GDP ratio increase, subjects reduce their consumption and increase savings with respect to their endowment, fearing the burden that they would bear if the government intervened to reduce the soaring public debt. This behaviour is not only explained by their expectations on a debt reduction, but also by their perceived debt sustainability: econometric estimations show that both forecast variables are significant and coherent with this conclusion. On a short-term perspective, instead, what we commonly observed is an increase in consumption and a decrease in savings after a debt-reduction shock, in line with the experimental *bomb crater effect*.

Summarising, a soaring public debt within an uncertain political framework triggered a combination of increasing savings and decreasing (or at least constant) consumption levels, influenced also by expectations that were found to be related to subjects' decisions and that affected the experimental economic growth. The introduction of a tax evasion control did not alter the conclusions and showed that the participants sacrificed savings rather than consumption in order to bear a higher level of taxes, ending up being more exposed to the exogenous shocks.

All these elements shed light on the existence of a confidence channel that, in uncertain periods like during the Sovereign Debt Crisis, might have negatively affected economic growth.

APPENDIX

Screenshots

Figure A4.1. Counting task. The screen provided the number of tables counted correctly.

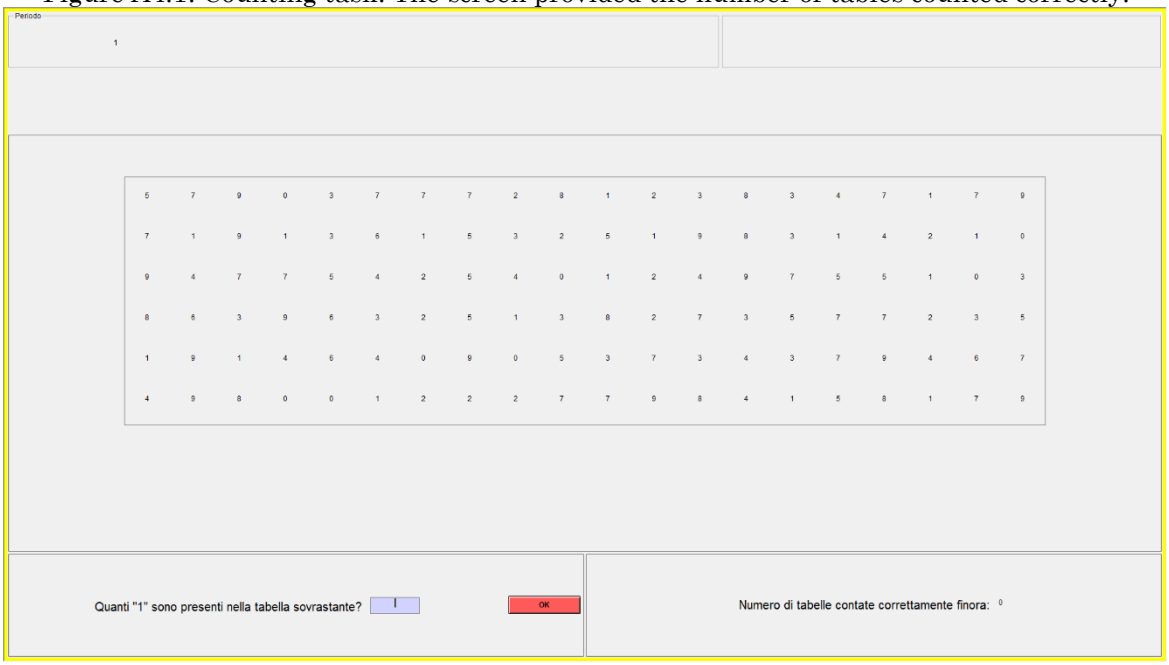


Figure A4.2. Allocation screen. The screen provided the suggested amount of taxes, the history of the past allocations, and the level of the public debt at the beginning of the round.

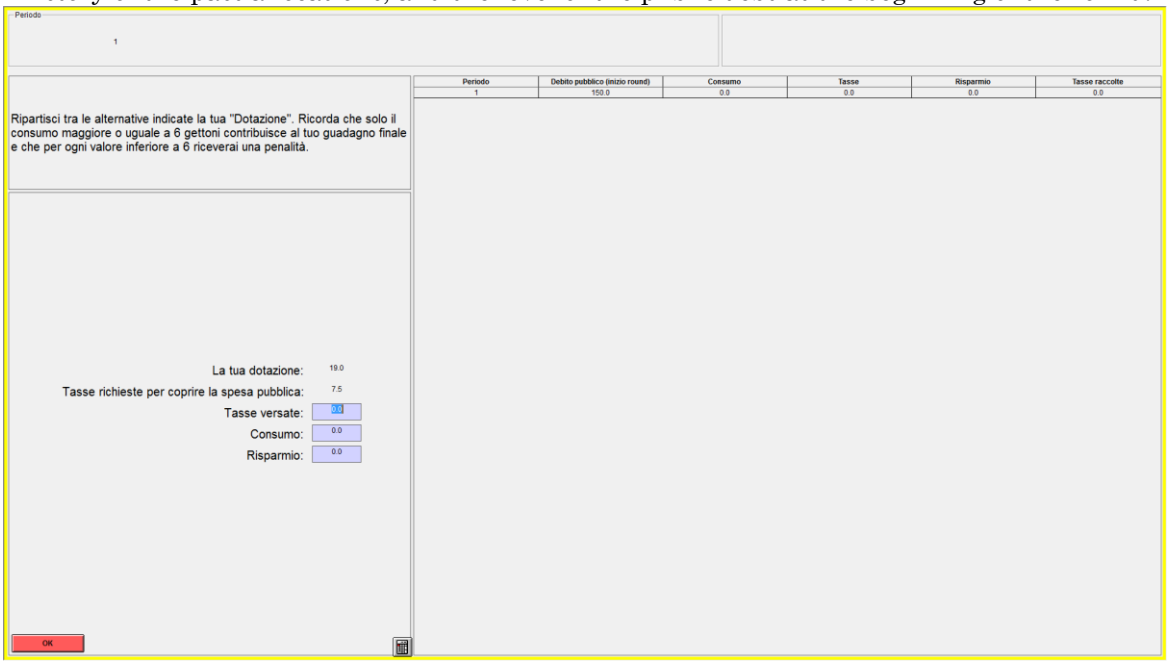


Figure A4.3. Allocation results and forecasts. Subjects could check their personal allocation and how public expenditure was subdivided between taxes and debt. Moreover, they were provided with the public-debt trajectory.

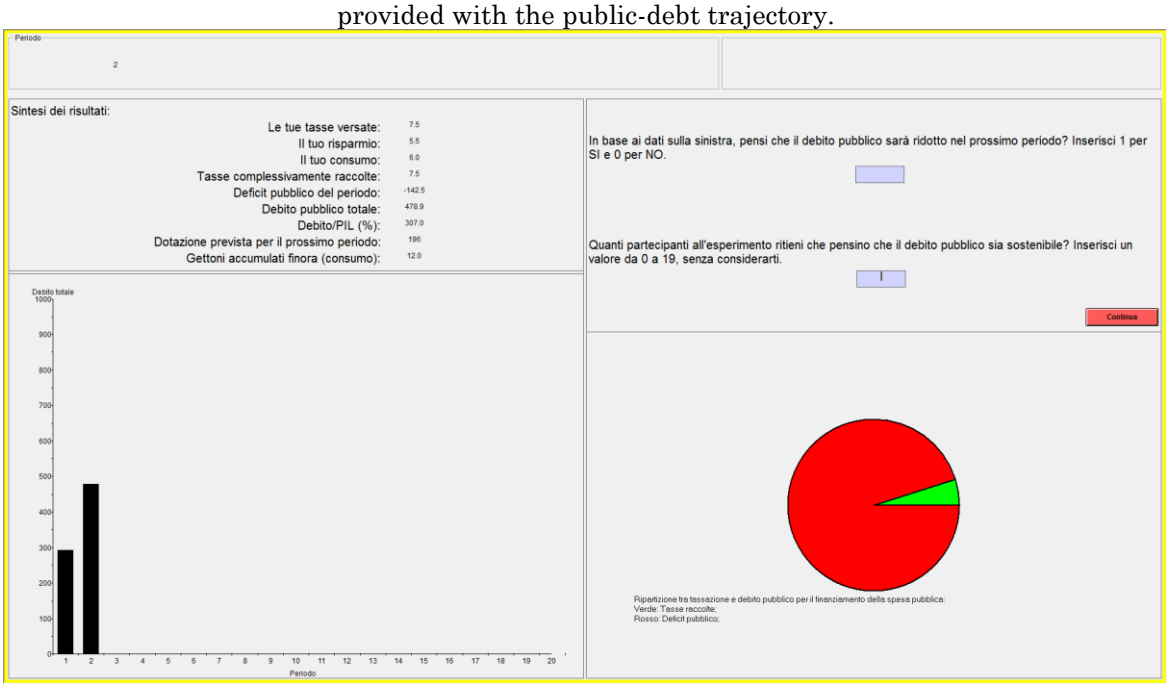
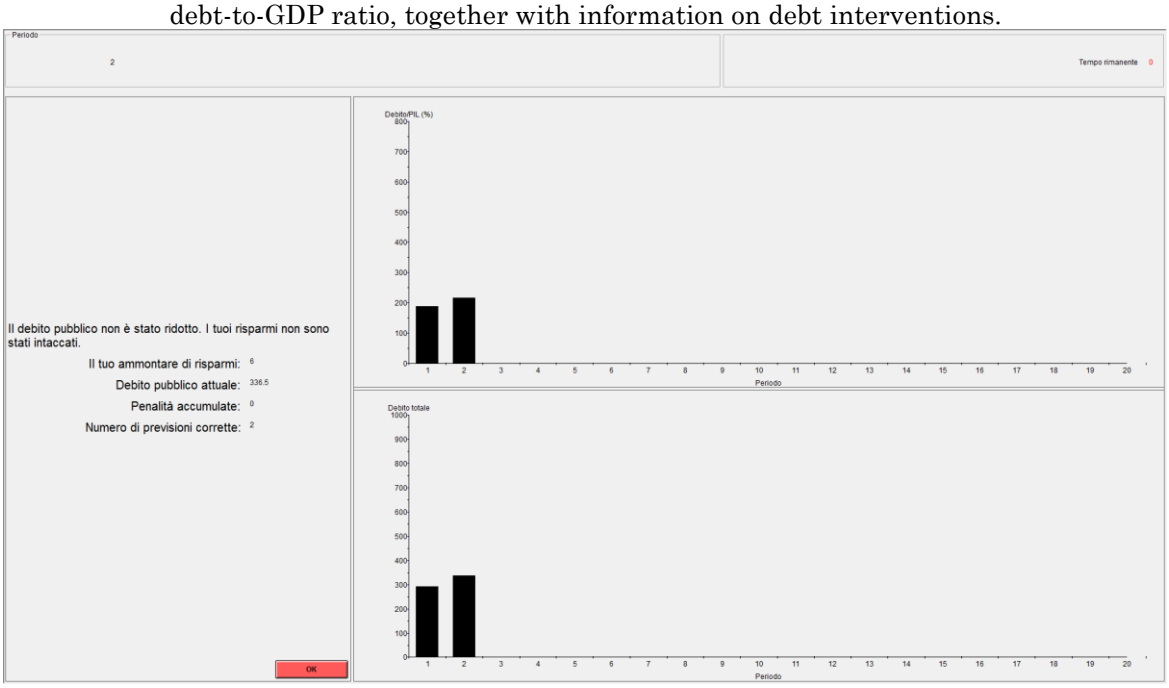


Figure A4.4. Debt reduction. The screen shows the dynamics of the public debt and of the debt-to-GDP ratio, together with information on debt interventions.



Laboratory instructions

General instructions

Good morning and thank you for having accepted to join this experiment. Please, do not talk with the other participants, remove your personal things from the desk and turn off your mobile phone. Pay attention to the experimental instructions and, should you have any question, raise your hand and ask the experimenters.

You are about to join a study about decisions and expectations in an economic framework. Your answers will be anonymous, and the experimenters will not be able to associate them to your name.

During the experiment you could gain an amount of money that will depend on your decisions and on the decisions of the other participants. Your gains will be expressed in tokens and then converted in Euro.

You will also gain euro 3 for the participation.

At the end of the experiment you are required to fill a questionnaire.

Your decision

The experiment consists of many rounds, between 10 and 20. This implies that it could finish at any time between round 10 and round 20, and it could not go further than round 20.

At the beginning of the experiment you will join a task that determines the constant number of tokens that you will receive in each round. This amount is your income.

Your total endowment is formed by your income and a governmental transfer which is computed as described below. You task is to allocate your total endowment between three choices: consumptions, taxation, and savings.

- Round 1.

1) <u>Publix expenditure and taxation:</u>

The total amount of public expenditure (E) is constant and equal to 150 tokens per round. Taxation is required to cover it. The individual amount that you

should pay is shown on the computer screen, but you are free to decide how much to disburse.

WITHOUT FISCAL AUDITS:

The government will not check the paid amount and you cannot be sanctioned.

WITH FISCAL AUDITS:

The government will randomly check the paid amount and, if the taxes you paid are lower than the required amount, you will be sanctioned by a reduction of 5% of your final payment.

If the collected amount is lower than E=150, let's say F<150, the government must finance the remaining amount of public spending (E-F) by asking for a loan with an interest rate of 15% for each round. Therefore, if the collected amount in round 1 is, for instance, F=50 tokens, the borrowed amount in round 1 is D = (150-50) = 100 tokens. Interests are accrued in the next round and are equal to 100*0.15=15 tokens.

The amount E+D=150 tokens will then be multiplied by 1.2 (120%) and will be equally distributed to all the participants. Therefore, each participant will receive (150*1.2)/20=9 tokens. If the collected amount is higher than 150 tokens, that is F>150, F will be multiplied by 1.2 and distributed among all the participants at the beginning of the next round.

Period 1 public expenditure is financed with debt only; thus, D_1=E=150 tokens.

In summary:

$$public\ expenditure = taxes + debt$$

Example: Let's consider a total contribution of 80 tokens. The amount of debt is (150-80)=70 tokens. At the beginning of the next round, each participant will receive (150·1.2)/20=9 tokens, independently from the individual amount of paid taxes.

2) Consumption and savings:

You can also spend your total endowment to buy a dummy basket of goods or you can save it to increase your endowment in the next rounds.
Your consumption expenditure will determine your final payment as explained below (see "Final payment"). On your savings, instead, you will gain interests according to a fixed interest rate (10% per round). In this manner, if you save 10 tokens, you will get 10*1.1=11 tokens in the next round.
All your financial results are shown and described on the screen.

- From round 2 to the end of the experiment.

From round 2 to the end of the experiment you are again required to allocate you total endowment between consumption, taxation, and savings. The experiment will finish between round 10 and round 20.

Government debt reduction

The amount that the government must borrow to sustain public expenditure feeds public debt. The government can decide to reduce the total amount of debt at any time after round 1 according to a given probability p. This could never occur or occur at every round.
To reduce its debt, the government uniformly withdraws the required amount from the total amount of savings. Two consequences are possible:

- If your total amount of saved tokens is higher than the required amount, your savings will be reduced by this amount.

- If your total amount of saved tokens is lower than the required amount, your savings will go to 0 and your final payment will be reduced by 15% (15 tokens for 100 tokens). In this case, government debt will be reduced by a lower than expected amount.

Example: If the individual number of tokens required to reduce government debt is 20 tokens and your total saving is 30 tokens, it will be reduced to (30-20)=10 tokens. If the individual number of tokens required to reduce government debt is 20 tokens and your total saving is 15 tokens, it will be reduced to 0 tokens and your final payment will be reduced by 15%. Thus, if, for instance, you have accumulated 100 tokens, you will lose just 15 tokens, in this case less than the 20 tokens required for the debt reduction.

Forecasts

At the end of each round you are requested to answer to a couple of questions:

Do you believe that public debt will be reduced by the government in the next round?

If you believe that government debt will be reduced, you must insert **1**; if you believe that public debt will NOT be reduced, you must insert **0**.

How many participants do you believe that think that the actual level of government debt is sustainable?

where sustainability means the future ability of the government to repay its debt or, in other words, the ability of current and future earnings to cover the current level of public debt. You will gain 2 tokens at the end of the experiment for each correct answer. You will gain 0 tokens for each wrong answer. Should you have any question, please rise your hand and ask the experimenters.

Example: If you believe that none of the participants (you excluded) believes that public debt is going to be reduced, you must insert 0. If you believe that 5 participants (you excluded) believes that public debt is going to be reduced, you must insert 5.

Final payment

Your final payment is determined by the sum of your consumptions expenditures whenever that amount is higher than 6 tokens per round (subsistence level of consumption). If the consumption expenditure of one period is lower than 6 tokens, it will not be considered for the final payment and it will reduced by 15% as explained above. This amount is then adjusted according to:

- The number of penalties.
- The number of right forecasts.

Savings and public expenditure do not contribute to the final payment, which is, however, increased by 2 tokens for each correct answer to the two questions shown above. Then, the total amount of tokens is converted in Euro according to the conversion rate (25 tokens=1 Euro). The formula for the final payment can thus be summarised as:

$$P = f(1-k_1)^m(1-k_2)^n \sum_{t=1}^{T}(0.8w_t + g_t)$$

Where P is the final payment expressed in Euro, f = 1/25 = 0.04 is the conversion rate, k_1=15% is the penalty for a level of consumption lower than 6 tokens or because the total amount of savings is lower than the amount required for the debt reduction, k_2=5% is the penalty for tax evasion, and m and n are the numbers of the two penalties respectively, T is the number of rounds, w_t is the consumption expenditure of round t, and g_t is a binary variable that indicates the amount received for each correct forecast (0 or 2 tokens).

Example: If the experiment ends after 10 rounds and your consumption expenditure has been constant and equal to 10 tokens, the number of tokens that contributes to the final payment is 0.8*10*10=80 tokens. If, however, you have accumulated two 15% penalties, the final payment is reduced to 80*(1-0.15)^2 = 68 tokens.

Final task

As soon as everyone has finished the experiment and before the final questionnaire, you will join one last task. For this task, you have a screen

showing ten rows. Each row is a paired choice between Option A and Option B. You will need to think about your preference between these two options for each row of the table, but only one of the rows will be used to determine your earnings.

After you have entered your decision, the computer will randomly determine which of the ten rows will count toward your earnings. The computer will then randomly determine your earnings according to the choice that you made, either Option A or Option B, for the row that it selected. This amount will be added to your earnings from the first part of the experiment and paid to you in cash at the end of the experiment.

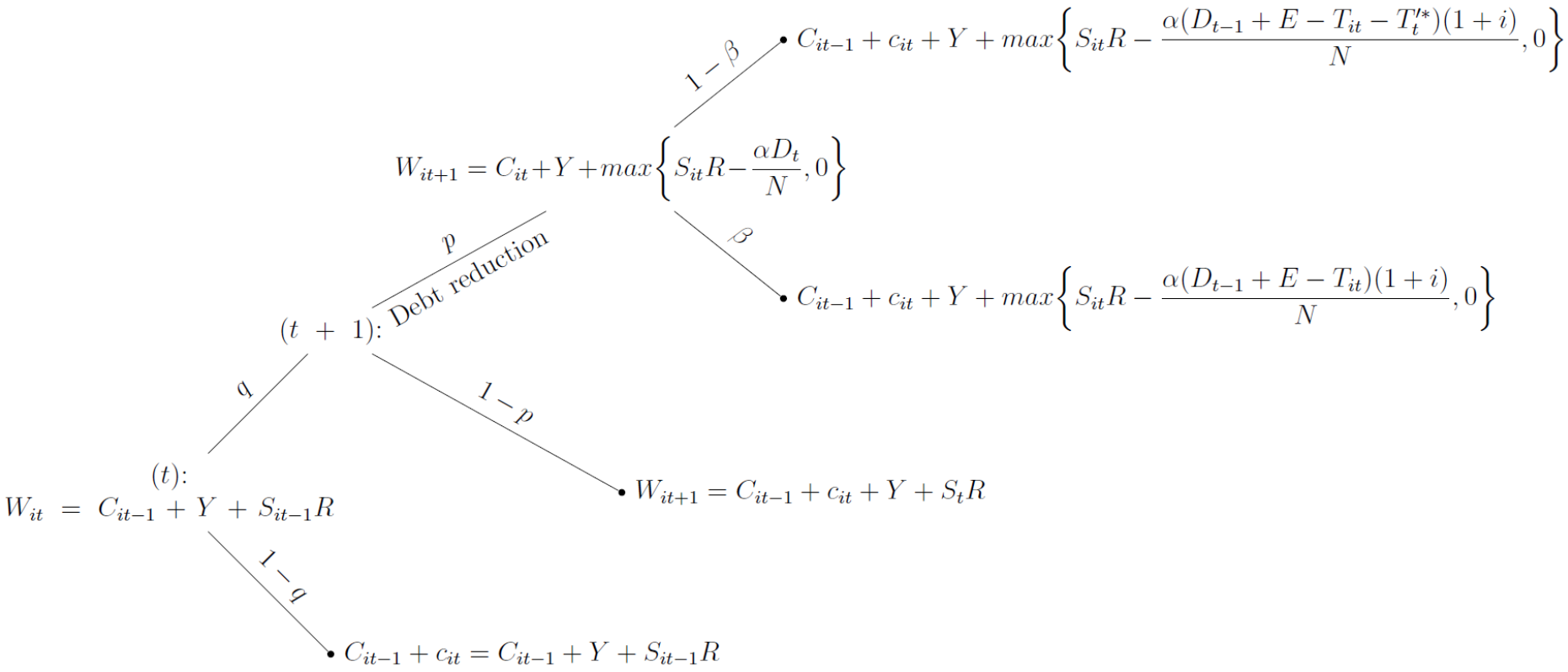
You will need to think about your preference between Option A and Option B in all ten rows. Only one of the rows will end up affecting your earnings, but you will not know in advance which one that will be. Each row has an equal chance of being used.

Example: Option A presents a 10% probability of winning 20 tokens and a 90% probability of winning 16 tokens. At the same time, Option B presents a 10% probability of winning 38.5 tokens and a 90% probability of winning 1 token.

Should you have any question, please rise your hand and wait for the experimenters.

Strategic analysis

Figure A4.5. Strategic analysis, subject i's outcomes, two rounds, (t,t + 1).



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