Essays in empirical public finance

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Abstract

Both government net worth – the balance of government assets and liabilities – and government investment have fallen substantially, relative to national income, in many OECD countries in recent decades (Atkinson, 2015; IMF, 2014). This thesis investigates the macroeconomic implications of these developments, for fiscal sustainability on the one hand and for economic growth on the other.

Chapter 1 explores the relevance of the composition of government budget deficits for government bond markets. We use data for 31 OECD countries from 1990 to 2014 from the European Commission's AMECO database to show that, from the perspective of bond markets, not all budget deficits are created equal: markets charge significantly higher interest rates for deficits due to government current spending than for those due to government investment.

Chapter 2 investigates whether bond markets accord importance to the asset side of the government balance sheet and hence to government net worth, above and beyond government liabilities. We use data on both sides of the government balance sheet drawn from Piketty and Zucman (2014) – for a panel of 10 OECD countries in recent decades and for the United States over the long term – to show that, for bond markets, not all government debt is created equal: for explaining the cost of government borrowing empirically, government assets are significant, and it is government net worth rather than government liabilities that matters.

Chapter 3 is concerned with how government asset accumulation affects economic growth. We first assess the predictive relevance of government investment and government consumption for future growth, and then estimate a standard growth model in the spirit of Solow (1956) using econometric methods suitable for addressing possible endogeneity. We find that there is a significant difference in the growth effects of government investment and government consumption: government investment aids growth, while government consumption significantly impedes growth, both for a set of OECD countries and globally. These findings help to rationalise why bond markets take into account the extent to which a government budget deficit or debt increase is accompanied by government asset accumulation, as we found in Chapters 1 and 2. They also imply that the composition of government budget deficits and government balance sheets will impact future growth prospects and matter for the implementation of austerity policies and the design of fiscal rules in monetary unions.

Declaration and disclaimers

I certify that this thesis, submitted for the degree of Doctor of Philosophy in Economics at the University of Oxford, is my own work except where clearly stated otherwise. Any errors or omissions are my own.

Chapters 1 and 2 of this thesis build on the thesis submitted in partial fulfilment of the requirements for the degree of Master of Philosophy in Economics at the University of Oxford in 2016.

All statistical results were calculated using Stata 15.

I declare that this thesis consists of approximately 41,000 words (excluding Appendix D).

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Introduction

In many OECD countries, government net worth has fallen relative to national income in recent decades. For example, in the United States, government net worth has fallen from 80% of national income in the 1980s to 20% in 2010, and has entered negative territory since. Government net worth has fallen from 68% of national income in 1990 to 9% in 2013 in Germany, from 103% in 1990 to -5% in 2013 in Japan, and from 66% in 1990 to 6% in 2010 and further since in the United Kingdom (Atkinson, 1995; Piketty and Zucman, 2014). Moreover, government investment as a share of GDP has also declined recently – the IMF (2014) notes a trend reduction of 25 percent in OECD countries. These declines are linked: any part of a government budget deficit not used to finance government investment will have contributed to the decline in government net worth. It also seems likely that the focus of fiscal policy on austerity following the financial crisis played a part – in aiming to reduce debt and deficits, policy makers seldom appeared to explicitly consider implications for government asset accumulation and net worth.

Consider the case of Germany, where a balanced-budget requirement was introduced in 2009. Germany's budget deficit fell from 3.2% of GDP in 2009 to 0.1% of GDP in 2013 – that is, it decreased by 3.1 percentage points. Over the same period, government net worth as a share of national income fell by 3.6 percentage points, due to a corresponding fall of 3.6 percentage points in government non-financial assets, which comprise roads, bridges, buildings and so on. So one way of looking at the matter is that Germany paid for balancing its budget by shrinking government non-financial assets and net worth.

This thesis investigates the consequences of such approaches, specifically the macroeconomic effects of declining government asset accumulation and net worth: do bond markets care, and is economic growth affected? We conclude that the answer to both questions is yes, and hence that declining government net worth in many OECD countries is a development worth taking seriously. Thus, Chapters 1 and 2 show that, from the perspective of bond markets, not all government budget deficits and debt are created equal – instead, the extent to which they are accompanied by government asset accumulation is taken into account and viewed favourably. Chapter 3 considers a possible rationale for these results, finding that government investment contributes positively to economic growth while government consumption contributes negatively, with a statistically significant difference between the effects of the two.

Chapter 1

Government budget deficits and bond yields: is investment spending different?

The reasons why a government may be running a budget deficit – and hence, the underlying composition of such a deficit – are often disregarded, it seems, both by the policy debate about fiscal sustainability and by the academic literature about the links between fiscal policy and interest rates. We find that, from the perspective of bond markets, not all budget deficits are created equal: markets charge significantly higher interest rates for deficits due to government current spending than for deficits due to government investment, ceteris paribus. To show this, we use a panel regression approach on European Commission data for 31 OECD countries from 1990 to 2014. Based on our preferred specifications, a higher deficit solely due to higher government investment would in fact decrease long-term government bond yields. These findings suggest that austerity policies should focus more on government current spending than government investment, and that fiscal rules in individual countries and monetary unions should distinguish budget deficits that are the result of investment from those that are not.

1.1 Introduction

In the aftermath of the Great Recession and the ensuing sovereign debt crisis, troubled countries in Europe such as Greece, Ireland, Portugal and Spain slashed not only government current expenditure – say, on wages of government employees – but also government investment dramatically. Seemingly, policy makers made little distinction between these two types of government spending. Furthermore, even countries that were not directly embroiled in the sovereign debt crisis, such as Germany and the United Kingdom, have since tried to commit, politically or legally, to balanced budgets irrespective of both economic circumstance and government expenditure type. Since there is no plausible economic theory according to which an always-balanced-budget approach would constitute "good economic policy", it could be that these countries were hoping to avoid contagion from the sovereign debt crisis by sending a signal to financial markets that they were serious about maintaining a tight fiscal grip.

This chapter principally seeks to explore the appropriateness of such indiscriminate approaches to the management of government budgets and borrowing costs. Our findings, which reflect the perspective of bond markets, provide evidence against approaches of this kind. They suggest instead that markets distinguish deficits that are the result of higher government current spending from those that stem from higher government investment, and penalise the former significantly more than the latter.

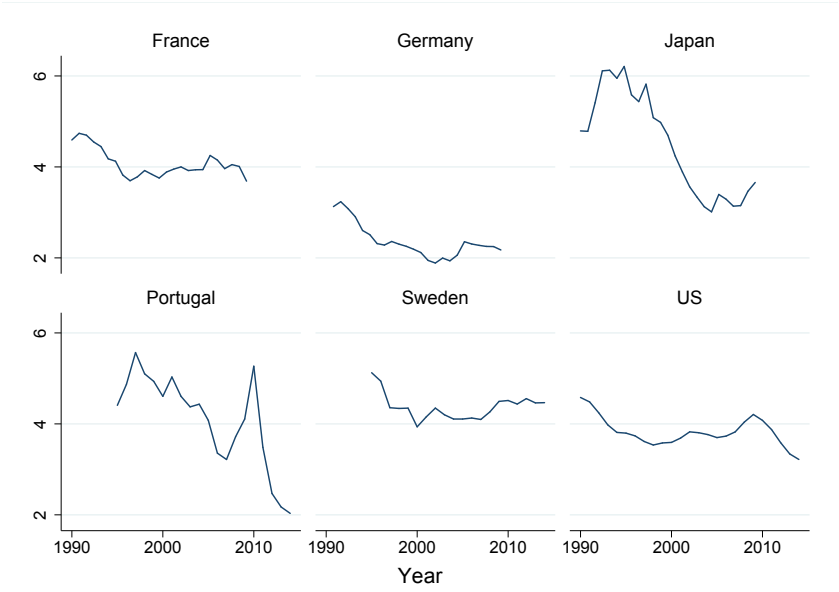
The existing empirical literature on the link between fiscal policy and interest rates has tended to disregard the reasons for which a government may be increasing its debt or running a budget deficit. A deficit may be the result of higher government current spending, higher government investment, or lower government revenue. The present chapter explicitly incorporates the current spending, investment and revenue components of the government budget deficit in an empirical analysis of the fiscal policy determinants of government bond yields: it thus takes seriously the intuitively plausible possibility that, from the perspective of bond markets, not all budget deficits are created equal.

The concern of this chapter with government investment or asset accumulation and, hence, one of the underlying drivers of government budget deficits is motivated by two key observations in particular. First, in many OECD countries, government net worth ratios – that is, total government assets less total government liabilities, relative to GDP or national income (Buiter, 1985) – have declined substantially in recent decades (Atkinson, 2015; Piketty and Zucman, 2014). This means that a considerable share of new debt in these countries was not used to finance investment, or that the process of asset accumulation through investment stalled. For example, in the United Kingdom, in recent years, net worth has fallen to 6% of national income in 2010 and further since, having stood at above 66% in 1990. Chapter 2 discusses this development in more detail and assesses its implications from a balance sheet perspective.

Second, although trend levels of government investment vary substantially across OECD countries – they are typically around or just below 4% of GDP in France and the United States, but only about half that in Germany – they have declined noticeably in recent years in many places, both in countries facing immediate domestic sovereign debt crises, such as Portugal, but also in those that did not, such as Japan or the United States. Proxying government investment with gross fixed capital formation of general government, Figure 1.1 illustrates this fact.

The present chapter explores the relevance of the investment, current spending and revenue components of government budget deficits for government bond yields, and hence for government borrowing costs and fiscal sustainability. To do so, we use data on these components of the deficit drawn from the European Commission's AMECO database for a panel of 31 OECD countries over the period from 1990 to 2014. To the best of our knowledge, the existing empirical literature on the links between fiscal policy and bond yields has not yet taken into account the underlying drivers of budget deficits through this kind of decomposition. In line with the literature, we confirm that higher government budget deficits (relative to GDP) increase government bond yields, with statistically significant yet quantitatively small effects. We then decompose the budget deficit to show that markets charge significantly higher interest rates for government budget deficits due to government current spending than for deficits due to government investment. Based on our preferred specifications, an

Figure 1.1: Government investment, selected countries, 1990-2014



Gross fixed capital formation of general government in percent of GDP
Source: AMECO

increase in the deficit solely due to an increase in government investment would *decrease* bond yields, while an increase in the deficit solely due to an increase in government current spending would *increase* bond yields, ceteris paribus. This suggests that markets perceive government investment, on average, as favourable for growth or as having a positive return (see also Durlauf et al. (2005) and Chapter 3 of this thesis).

These findings reflect the perspective of government bond markets on sovereign risk, fiscal sustainability and government budget management. Hence, they could have important policy implications, especially given the feedback loops between bond market behaviour and fiscal policy decisions that became apparent again during Europe's recent sovereign debt crisis. They imply that austerity policies ought to focus more on government current (or non-investment) spending than government investment (or capital) spending. They also suggest that fiscal rules in individual countries and monetary unions – such as the European Union's Maastricht criteria, which limit budget deficits to 3% of GDP irrespective of economic circumstance and underlying government expenditure composition – should distinguish government budget deficits that are the result of government investment from those that are not.

The remainder of this chapter proceeds as follows. The related empirical literature and theory on the links between government budget deficits and interest rates are discussed in Section 1.2. Section 1.3 introduces the data, model specification and identification approach. Our main results, robustness tests and extensions are presented in Section 1.4. Section 1.5 concludes.

1.2 Government budget deficits and interest rates

1.2.1 In the empirical literature

Fiscal policy directly and indirectly impacts a vast number of macroeconomic outcomes. One way of empirically evaluating fiscal policy is to identify its effects on a macroeconomic outcome of interest. The approach of Reinhart and Rogoff (2010) is to bracket countries by the magnitude of their debt-to-GDP ratio, and compare different brackets' mean and median growth and inflation rates. An alternative approach is to use government bond yields, which reflect investors' perspectives on the country's growth and inflation prospects as well as its sovereign default risk, as the dependent variable and employ controls for the business cycle and the monetary policy stance to achieve identification of the effects of fiscal policy on these yields. This is the approach taken here.[1]

It is commonly stated that results from research on the fiscal policy determinants of long-term government bond yields and hence borrowing costs have not been conclusive.[2] However, recent panel-based empirical literature on the question – such as Ardagna et al. (2007) and Gruber and Kamin (2012) – typically concludes that more expansionary fiscal policy, as reflected in a higher government debt ratio or a higher (primary) deficit relative to GDP, increases government bond yields. Econometric

[1] Our approach is supported by the findings of Dai and Philippon (2006), who conclude that empirically, "in order to price long-term bonds correctly, it is important to take into account the fiscal position of the government, above and beyond inflation and real activity".

[2] For example, Ardagna et al. (2007) but also Bernheim (1989), who states: "The evidence is extremely mixed, and it is easy to cite a large number of studies that support any conceivable position."

approaches and conclusions vary, as regards the precise measure of fiscal policy that is found to matter, the importance of non-linear effects and the extent of spatial and temporal heterogeneity of effects.[3]

Overall, to the best of our knowledge, the existing literature has not yet considered the relevance of the composition of government budget deficits for government bond yields. It has not, as far as we are aware, taken into account the current and investment spending components of the deficit in estimation. Doing so would amount to testing the validity of the restriction that, in a regression with the government bond yield as the dependent variable, all components of the deficit enter with coefficients that are equal in absolute magnitude. This restriction is frequently imposed in the existing literature and its validity will be examined here.[4] Dai and Philippon (2006) distinguish deficits caused by changes in spending and changes in taxes, and Laubach (2009) similarly separates total revenue and total spending, but neither considers the investment and current components of spending separately. Ardagna et al. (2007) use a different decomposition of the deficit, stating that changes in the government wage bill, transfers, public investment and business and labour taxes matter for yields, but do not report these results. Yet taking into account the current spending and investment components of government budget deficits provides an insightful lens on the underlying drivers of deficits, and investor perceptions of these drivers. This chapter thus adds to the existing literature by doing so. To this end, we bring to bear on the question information that – as far as we are aware – has not been used previously in this context: we use data on the components of government budget deficits from the European Commission DG ECFIN's Annual Macroeconomic database (AMECO). These data are discussed in more detail in Section 1.3.1.

[3]Econometrically, unrestricted reduced-form regression approaches such as the one used here, but also reduced forms imposing restrictions derived from theory, simple or structural VARs and narrative approaches have been used in the literature to investigate the fiscal policy determinants of government bond yields. Fiscal policy may be measured in stock (debt) or flow (deficit) terms, and in ex post or projected form. Effects may be allowed to differ for high-debt and low-debt countries or for regular and crisis periods.

[4]Most of the literature uses the primary deficit rather than the total deficit, since excluding government interest payments directly deals with one potential source of endogeneity of the deficit measure as an explanatory variable in a model of bond yields.

1.2.2 In theory

From a theoretical perspective, the expectations hypothesis of the term structure of interest rates implies that fiscal policy can principally influence the long-term interest rate and thus government borrowing cost through two main channels (Gürkaynak and Wright, 2012). First, fiscal policy might affect current and expected future short-term nominal interest rates, which in turn reflect both real short-term interest rates and expected future inflation. Second, fiscal policy might affect the risk or term premium, which reflects the compensation risk-averse investors require to hold a longer-term bond instead of a series of shorter-term bonds and is thought to vary over time (Swanson, 2007).

As regards the first channel, operating via short-term interest rates, the focus of the discussion here lies on whether in theory, the impact of fiscal policy on these interest rates is affected by the underlying composition of government expenditure. This is because most of macroeconomic theory appears to agree that fiscal expansions lead to higher interest rates (Fatás and Mihov, 2001; Gale and Orszag, 2003).[5] One way to distinguish different government spending types in a macroeconomic model is to make an assumption as to whether they generate assets that enter firms' production function and, thus, whether they contribute to the stock of public assets. Government investment is commonly and plausibly assumed to do so, and is hence called "productive" government expenditure.[6] Interestingly, in New Keynesian models (such as Linnemann

[5] In standard macroeconomic frameworks such as New Keynesian models, the effects of fiscal policy are commonly presumed to operate via the current short-term interest rate, such as the central bank's policy rate. By the expectations hypothesis, long-term interest rates will also be affected. To illustrate the wide range of possibilities in thinking about this matter theoretically, one might consider the static or dynamic and partial- or general-equilibrium and direct or indirect effects on nominal or real long- or short-term interest rates, related to each other by the Fisher equation and flexible or sticky prices. These interest rates may be responding to persistent or temporary changes in government current or investment spending which do or do not enter the utility function or contribute to the capital stock and which are financed by a deficit and thus debt, or by an increase in lump-sum or distortionary taxation. All of this is taking place in the context of a more or less open economy with Ricardian or non-Ricardian consumers and with a central bank targeting inflation or the output gap, or the nominal or real interest rate, via a Taylor rule or otherwise.

[6] This can be implemented via a non-zero elasticity ϑ_G of output Y_t with respect to public capital G_t in a Cobb-Douglas production function, as in Baxter and King (1993) in the context of a real business cycle (RBC) model: $Y_t = F(K_t, L_t, G_t) = AK_t^{\vartheta_K} L_t^{\vartheta_L} G_t^{\vartheta_G}$

and Schabert, 2005), an increase in "productive" government spending in this sense would tend to raise interest rates by *less* than an increase in non-productive government spending. The opposite is true in the RBC model based on Baxter and King (1993).[7] Table A.1 in Appendix A provides an overview of these effects on short-term interest rates. To the extent that shocks to fiscal measures are persistent and price adjustment is gradual, such effects will also feed through to long-term interest rates (Ardagna et al., 2007). However, note that in the type of model commonly estimated in the empirical literature on fiscal policy and interest rates and used as the baseline here, too – in which the long-term bond yield is the dependent variable, and a short-term interest rate is included as a control for monetary policy and cyclical conditions – it is typically not these short-term interest rate effects that are identified, but instead those that operate via the term premium. These are discussed next.

As regards the second channel, operating via the (time-varying) term premium, a number of further direct links between fiscal policy and long-term interest rates are theoretically plausible. Most importantly, these relate to perceptions of default risk and inflation (or exchange rate) risk over the time horizon until maturity of the bond. More expansionary fiscal policy – as reflected in, for example, a higher government budget deficit relative to GDP – is generally thought to increase default risk (Alesina et al., 1992; Ardagna et al., 2007; Laubach, 2010). Yet to the extent that the government investment component of a deficit is thought to contribute to overall economic growth and higher future tax revenues,

[7] In New Keynesian and RBC models, assuming that government investment is "productive" in the spirit of $\vartheta_G > 0$ entails that it affects the marginal product schedules for both private capital and labour. In the RBC model of Baxter and King (1993), in response to a shock to productive government spending, the interest rate rises by more than in the case of current or non-productive government spending. In the New Keynesian model of Linnemann and Schabert (2005), the resulting increase in G_t reduces firms' marginal costs, but higher aggregate demand also puts upward pressure on firms' real marginal cost, as would be the case for non-productive government spending. If the former effect dominates the latter, consumption increases and inflation – which depends on marginal cost – declines, and so the nominal interest rate will actually decline in response to the increase in government investment. As an aside, note that the magnitude of effects in New Keynesian models depend on whether the monetary authority is assumed to follow a Taylor rule that responds only to the inflation gap or to the output gap as well, as D'Auria (2015) notes – in the latter case, effects are more muted. However, she does not consider whether productive government spending affects the level of potential output against which the output gap is measured, and the story might change if one were to do so.

it should render any given fiscal policy stance more sustainable. Hence, we would expect a budget deficit due to government investment to increase default risk by less than a budget deficit due to government current spending. The inflation risk channel works via inflation expectations, and thus expectations of future short-term nominal interest rates. Here, the positive association between higher deficits and the risk premium arises from investors' fear that central banks will attempt to monetise the government's deficits or debt, thereby eroding the value of the bond to the bondholder (Gruber and Kamin, 2012; Gürkaynak and Wright, 2012).[8] However, if government investment is thought to add to the economy's capacity, it should reduce pressure on inflation, both current and expected. Then, to the extent that a government's investment in year t is perceived to be informative about the government's future policy mix in terms of investment and current spending, one would expect government investment in year t to increase inflation risk by less than government current spending in t.

Hence, in a regression of the government bond yield on fiscal policy measures and controls, including a short-term interest rate, the central question that this chapter seeks to explore is whether the coefficient on government current spending is significantly larger than that on government investment. In essence, we thus examine here whether the composition of a government's budget deficit matters for government borrowing cost and fiscal sustainability.

1.3 Methodology

1.3.1 The data

In order to investigate the effects of the composition of the government budget deficit on government bond yields, a new sample for econometric analysis is assembled. It includes annual data on government budget deficit components for 31 OECD countries drawn from AMECO and

[8] Ardagna et al. (2007) also mention a related channel working via expected currency depreciation. Note that joining a currency union and relinquishing monetary control means that monetising one's debt is no longer possible. This could potentially reduce perceived inflation risk while simultaneously increasing perceived default risk for holders of Euro area country bonds (Bernoth et al., 2004).

covering, on average, 18 years per country. It also includes annual interest rate and macroeconomic data from AMECO, the OECD and the IMF. The focus of all our fiscal policy measures and the surrounding discussion is on "general government", as defined in international accounting standards to include central, local and state government and social security funds (2008 SNA; ESA 2010). The sample covers Austria, Belgium, Bulgaria, Canada, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom and the United States over a maximum time span from 1990 to 2014 and is unbalanced.[9,10]

The dependent variable is, almost always, the annual average of the 10-year constant-maturity secondary-market nominal government bond yield, as is standard in this literature (see, for example, Ardagna et al., 2007; Gruber and Kamin, 2012), with data drawn from the OECD. The dependent variable will be referred to as the "long-term government bond yield" or as $GBY10$ below.[11]

Data on the components of the primary government budget deficit ($GDEF$) – that is, the deficit excluding interest payments – are drawn from AMECO. It allows decomposing the deficit into an accounting identity as

$$GDEF = GCEX + GOCE + GINV - GREV. \tag{1.1}$$

Current spending ($GCEX$) includes, most saliently, social benefits and the

[9]It would have been topical and interesting – yet potentially also distorting, given Greece's drawn-out sovereign debt crisis and bailouts – to add Greece to the sample, yet available data covers too short a time period.

[10]Some data is available from before 1990, but focussing on more recent decades has a number of advantages. Firstly, financial liberalisation in the 1980s, particularly the abolition of capital controls, could have affected the relation between government bond yields and domestic fiscal variables. Secondly, the relationship in more recent times is likely to provide more relevant evidence for current debates about the effects of fiscal policies. Finally, focussing on data after 1990 means we avoid structural breaks in the data for Germany as a result of reunification. Results are robust to including available observations from before 1990 (cf. Table 1.4, column (7)).

[11]Specifically, these yields are typically based on daily closing market bids on actively traded securities, not adjusted for tax or brokerage commissions and averaged over the year of interest. Comparability of this measure of government bond yields across countries is considered to be high by the OECD (2014).

compensation of government employees.[12] Importantly, it does not include interest payments on the government's outstanding debt. Other capital expenditure ($GOCE$) includes capital expenditure that does not amount to new productive investment, comprising capital transfers payable, changes in inventories, net acquisitions of valuables such as gold and net acquisitions of non-financial non-produced assets, such as subsoil assets or patents. It thus often includes extraordinary or one-off items. Because $GOCE$ enters insignificantly in all specifications considered here – and with a coefficient for which the restriction that it is equal to that on $GCEX$ is not rejected – we subsume it into current expenditure ($GCEX$) in estimation and call the resulting variable $GCEX2$.[13] This also facilitates applying instrumental variable approaches, since the extraordinary nature of items typically included in $GOCE$ makes its lagged values relatively uninformative instruments for the components of the deficit. Investment spending ($GINV$) refers to government gross fixed capital formation and covers net acquisitions of fixed assets, such as investments in roads, railways, bridges and so on.[14,15] Finally, government revenue ($GREV$) includes, most importantly, direct and indirect taxes as well as social contributions. It refers to all revenue accrued to the government in a given year. All fiscal variables are always measured in percent of GDP.

Data on a set of macroeconomic controls – including short-term interest rates (in particular, the three-month interbank money market rate and the monetary policy rate), inflation and real economic growth – are also mostly drawn from AMECO as well as the OECD and the IMF. Table A.2

[12]Since government assets do not include human capital (2008 SNA: 3.48, ESA 2010: 7.19), government spending on education and health services is treated as current spending rather than investment (Piketty and Zucman, 2014).

[13]The OLS estimates of specifications which include $GOCE$ separately indicate that the two types of capital expenditure included ($GINV$ and $GOCE$) enter very differently. This may be because $GINV$ captures new productive investment, as reflected by government fixed capital formation, whereas $GOCE$ does not.

[14]For data availability reasons, $GINV$ is included as a gross measure, that is, it is not net of depreciation or consumption of fixed capital (see ESA 2010, P.51g).

[15]Based on the data available through AMECO, government investment spending cannot be decomposed into its constituent parts – one might plausibly expect the economic effects of investment spending on military equipment to differ from those of infrastructure or social housing – but a fruitful future line of research could be to attempt such a decomposition using national sources. Government current spending can be decomposed into social transfers, employee compensation and other current spending using AMECO data. The analysis of the effects of these different types of current spending is left for future research.

in Appendix A provides summary statistics, units of measurement and sources for all included variables.

Finally, as Table A.3 in Appendix A demonstrates, the evidence for all series included in the analysis – in particular, long- and short-term interest rates as well as fiscal and other control variables – is in favour of stationarity. The only exception to this are liabilities as a share of GDP, which are found to be non-stationary and hence are not included in baseline specifications, in order to ensure the validity of the regression set-up with a stationary dependent variable. In line with the literature, the panel unit root test developed by Im, Pesaran, and Shin (2003; "IPS test") is used here.[16] The test is applied to demeaned series to reflect the fact that all main specifications presented below include year fixed effects.[17] Interestingly, the existing literature has related bond yields and fiscal policy measures in $I(0)$ as well as $I(1)$ terms (see Ardagna et al. (2007) for both). Although the literature frequently allows for common effects by including year fixed effects in specifications, it does not appear to apply unit root tests to the demeaned series. This, coupled with the fact that individual countries' time series included in our sample are comparatively short – with T ranging around 20 for most countries and below 20 for a few – may play a role in explaining the conclusions regarding series' stationarity properties reached here.

1.3.2 Model specification

We employ the following reduced-form regression model to investigate the relevance of the composition of the government budget deficit for government bond yields:

$$y_{i,t} = \alpha_i + \beta F_{i,t} + \gamma C_{i,t} + \delta_t + \varepsilon_{i,t} \tag{1.2}$$

[16]The IPS test estimates an augmented Dickey-Fuller equation for each variable and country and averages the resulting t-statistics across countries. It thereby combines the results from N unit root tests performed on the data for N countries (Maddala and Wu, 1999). We reach the same conclusions regarding the stationarity properties of the data using other standard panel unit root tests.

[17]This is equivalent to estimation in terms of deviations from the cross-sectional mean.

Here, $y_{i,t}$ refers to the cost of government borrowing in country i in year t. α_i is a country-specific fixed effect, controlling for time-invariant unobserved characteristics of country i that affect its borrowing cost, such as the quality of its fiscal institutions and governance (De Grauwe and Ji, 2013). $F_{i,t}$ includes the set of fiscal policy variables of interest, $C_{i,t}$ is a vector of controls for current economic conditions, and β and γ are vectors of coefficients. δ_t is a year-specific fixed effect, accounting principally for the common long-term downward trend in yields since the 1990s and the possibility that this trend is not adequately captured by the included country-specific explanatory variables.[18] Finally, $\varepsilon_{i,t}$ is the error term. This model is in line with, for example, the approaches of Ardagna et al. (2007) and Gruber and Kamin (2012).

The cost of government borrowing ($y_{i,t}$) is proxied with the 10-year government bond yield ($GBY10_{i,t}$) in estimation, the precise measurement of which is discussed in more detail in Section 1.3.1 above. The set of fiscal variables ($F_{i,t}$) typically comprises either the primary deficit ($GDEF_{i,t}$) or its decomposition into current spending ($GCEX2_{i,t}$), investment ($GINV_{i,t}$) and revenue ($GREV_{i,t}$), all measured in percent of GDP. The set of macroeconomic controls ($C_{i,t}$) includes the short-term interest rate ($ISN_{i,t}$), the inflation rate ($CPI_{i,t}$), the real GDP growth rate ($GROWTH_{i,t}$) and a dummy ($EURO_{i,t}$) that is equal to 1 from the year onwards that country i joined the Eurozone. This set of controls and, in particular, the inclusion of a short-term interest rate as a control for the cycle and monetary policy are in line with the existing literature (Ardagna et al., 2007; Baldacci and Kumar, 2010; Faini, 2006; Gruber and Kamin, 2012, among others), but not innocuous. The inclusion of the short-term interest rate can be interpreted as an attempt at "holding monetary policy constant". However, this can, of course, mean many different things: this might refer to the path of the money supply, adherence to a Taylor rule or the inflation target (Woodford, 2011). Our results are hence informative about the response of long-term government bond yields to fiscal policy over and above any central bank reaction as captured by the short-term interest rate (Canzoneri et al., 2002).[19]

[18] See Figure A.1 for a graph of the long-term government bond yield.

[19] Thus, as regards the theoretical links between bond yields and fiscal policy discussed in Section 1.2, the effects identified below reflect the response of the term premium (and of shifts to expected future short-term interest rates) to fiscal policy,

Based on the discussion in Section 1.2, the central question that this chapter seeks to explore is whether, econometrically speaking, the coefficient on government current spending is positive and significantly larger than that on government investment. In addition, total revenue should enter negatively. We would also expect both the short-term interest rate and the inflation rate to enter positively individually, but perhaps not significantly so when included jointly, since they may be capturing related information. The coefficient on the real growth rate is ambiguous: higher current real growth may reflect higher future growth and hence higher inflation expectations, which would suggest a positive coefficient. However, higher future growth might also reduce perceived default risk, since this would make any given fiscal policy stance more sustainable, which would suggest a negative coefficient. Finally, the coefficient on Eurozone membership is also ambiguous: on the one hand, on the assumption that joining the Eurozone provides governments with a lender of last resort, membership should reduce yields. On the other hand, upon joining the Eurozone, governments can no longer monetise or inflate away their debt, which could both reduce perceived inflation risk and increase perceived default risk (Bernoth et al., 2004).

1.3.3 Identification

In the reduced-form regression approach employed in this chapter, the valid identification of the effects of fiscal policy on bond yields hinges on ensuring that potential sources of endogeneity of the fiscal variables are investigated and dealt with appropriately. Endogeneity might arise in this setting from (i) potential reverse causation from interest rates to fiscal policy decisions and (ii) the potential simultaneity of fiscal variables and interest rates with respect to both the economic cycle and institutional factors. The former is addressed by applying instrumental variable methods and by shifting the timing of dependent and fiscal explanatory variables relative to each other in order to confirm the robustness of

since the current short-term interest rate – via which the mechanisms analysed by most macroeconomic models are usually assumed to play out – is included as a control. Also, note that any central bank reaction function as captured by a regression of the short-term interest rate on any of the fiscal variables and controls does not yield significant coefficients on fiscal variables in our sample, in line with the findings of Ardagna et al. (2007).

our main results. The latter is dealt with by including macroeconomic explanatory variables in all specifications to control for the cycle and by examining the robustness of results to splitting expenditure and revenue measures into their cyclical and structural components, to changes in the set of controls as well as to the inclusion of additional explanatory variables that reflect time-varying institutional factors.[20] Time-invariant institutional factors that might cause simultaneity are addressed by the use of country fixed effects in all specifications.

In addition to accounting for the above-mentioned potential scope for endogeneity, several econometric issues need to be addressed. There is evidence of both heteroskedasticity and serial correlation in the error term, which is dealt with by employing throughout standard errors that are robust in this context.[21] Furthermore, the dependent variable – the secondary-market long-term government bond yield – exhibits a close degree of co-movement across countries and, in particular, a clear common downward trend since at least the 1990s (see Figure A.1). In line with the literature (see, for example, Ardagna et al., 2007; Gruber and Kamin, 2012) and as mentioned in Section 1.3.2 above, year fixed effects are therefore introduced in our main specifications, in order to address the possibility that this downward trend in yields is not fully captured by the country-specific fundamentals included in our specifications, such as inflation or growth rates. Additionally, because a formal test of cross-section dependence (Pesaran, 2004) rejects the null hypothesis of cross-sectional independence for some, though not all, specifications, we report standard errors that are consistent not just in the presence of heteroskedasticity and serial correlation, but also in the presence of a range of forms of cross-section dependence (Driscoll and Kraay, 1998).

[20]Especially given the forward-looking nature of government bond yields, highly worthwhile future research might explore the bond yield effects of surprise components in investment, current spending and revenue relative to projected values. At the time of writing, however, forecasts of the budget deficits components were not available for a sufficiently high number of country-year observations.

[21]Standard errors are adjusted according to the order of serial correlation found in residuals, namely first or second, but not higher, in case of central specifications of interest. The Arellano-Bond (1991) test is used to investigate the presence of serial correlation here, since it is consistent in the presence of heteroskedasticity, runs on the undifferenced errors – in contrast to, for example, Wooldridge-based tests (2010) – and can be applied to the general class of linear GMM regressions, which subsumes OLS.

1.4 Results

1.4.1 Main findings

This section presents key results from estimating a model of the type presented in Equation 1.2. In essence, we investigate here whether bond markets accord importance to the composition of government budget deficits, in the sense of distinguishing deficits due to current spending and deficits due to investment.[22]

Table 1.1 contains Fixed Effects ("FE") estimates of a set of main specifications of interest. We report Driscoll-Kraay (1998) standard errors.[23] Column (1) estimates a specification that is common in the literature: here, only the primary deficit is included to reflect the fiscal policy stance, which amounts to imposing the restriction that all components of this deficit measure enter equally in absolute terms. The deficit enters significantly and with the anticipated positive sign: more expansionary fiscal policy, as reflected in a higher primary budget deficit relative to GDP, is associated with significantly higher government bond yields. Its coefficient is of a magnitude that is in line with the literature (see, for example, Gruber and Kamin, 2012), yet that suggests an effect that is very small in absolute terms: an increase in the primary budget deficit, relative to GDP, of one standard deviation would increase yields by about 10 basis points, based on column (1). Column (2) includes both the primary deficit and the government investment component of the deficit. The highly significant coefficient on the investment component implies that the restriction that the coefficients on all components of the primary deficit are equal in absolute value is strongly rejected. Column (3) then includes the full breakdown of the primary budget deficit into an accounting identity, as per Equation 1.1. The coefficient on government revenue is insignificant. The coefficient on government current spending has the anticipated positive sign and is statistically significant.

[22]Note that the primary deficit is a positive number when government expenditure exceeds government revenue and vice versa. All fiscal variables are included as ratios relative to GDP.

[23]In case of specifications reported in Table 1.1, the Arellano-Bond (1991) test indicates at most second-order serial correlation. All main results hold also when standard errors are clustered at the country level instead, as Table A.4 in Appendix A demonstrates for a key specification of interest.

Table 1.1: Baseline results

Dep. var.: gov. bond yield		**Including deficit decomposition**			
	(1)	(2)	(3)	(4)	(5)
Primary budget deficit	2.585**	3.846***			
	(1.110)	(0.983)			
Gov. investment		-37.175***	-31.351***	-19.649***	-25.937***
		(9.008)	(8.473)	(4.452)	(6.059)
Gov. current expenditure			5.085***	6.834***	4.213***
			(1.333)	(1.362)	(1.189)
Gov. total revenue			1.725	-5.459***	1.736
			(2.332)	(1.200)	(2.150)
Short-term interest rate	0.414***	0.375***	0.371***	0.433***	0.383***
	(0.033)	(0.042)	(0.044)	(0.035)	(0.043)
Inflation rate	-0.089***	-0.064***	-0.059**	-0.005	-0.048*
	(0.022)	(0.024)	(0.024)	(0.028)	(0.025)
Real growth rate	-0.161***	-0.166***	-0.156***	-0.017	-0.103***
	(0.037)	(0.033)	(0.032)	(0.020)	(0.036)
Real growth × "Trouble"					-0.100**
					(0.043)
Eurozone dummy	0.245*	0.189	0.190	-0.029	0.103
	(0.142)	(0.125)	(0.125)	(0.157)	(0.118)
2011 dummy × "Trouble"					2.309***
					(0.189)
2012 dummy × "Trouble"					2.268***
					(0.294)
R-squared	0.647	0.651	0.653	0.767	0.710
Observations	572	572	572	363	572

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 is adjusted to exclude the impact of year fixed effects. Column (4) is estimated on the sample before 2008. "Trouble" is equal to 1 for Cyprus, Hungary, Ireland, Italy, Latvia, Portugal and Spain.

In addition, the restriction that the coefficients on government current spending and government investment are equal is strongly rejected[24]: government investment enters not just with a smaller coefficient, but in fact negatively and highly significantly. This is a fascinating and, in its magnitude and significance, perhaps surprising result, since it implies that, ceteris paribus, higher government investment – which is a type of government expenditure and thus might have been expected to decrease creditworthiness from a creditors' perspective – is associated with lower bond yields. It suggests that markets tend to view government investment, on average, as favourable for growth or as having a positive return (see, for example, Durlauf et al. (2005) and Chapter 3 of this thesis).

[24]With a p-value from a Wald test of 0.00 in column (3).

The magnitudes of the estimated coefficients imply that an increase in the government budget deficit that is due solely to higher government investment would even decrease government borrowing cost.

Columns (4) and (5) address the fact that a key source of variation in this sample is that a substantial number of countries, but not all, were (directly or indirectly) embroiled in the recent European sovereign debt crisis. Affected countries witnessed large spikes in government bond yields at some point after 2008, often followed by fiscal austerity. To ensure that the large and highly significant negative effect of government investment on government bond yields is not an artefact of these particular and unusual circumstances, column (4) estimates the specification in column (3) on the sample before 2008. The coefficients on investment and current spending confirm the picture emerging from column (3) while, additionally, government revenue enters significantly and negatively, as originally anticipated. Next, we split the sample into "troubled" and stable countries[25] based on their crisis experience. We create a time-invariant dummy called "Trouble" that is equal to 1 for those countries in the first category, and interact it with all fiscal and macroeconomic explanatory variables as well as year fixed effects. When estimated using a variety of approaches, only the interaction terms with the real economic growth rate and with the year fixed effects for years 2011 and 2012 are significant, so we keep only these three interaction terms in the specification. The specification that includes these three interaction terms is our preferred one and results are reported in column (5). Coefficients on the fiscal variables of interest are fully robust – they again suggest that bond markets accord significant importance to the composition of the deficit.[26] It also appears that, from the perspective of bond markets, growth matters more in the "troubled" countries, likely reflecting the workings of a default risk channel.[27] Additionally, the highly significant interaction terms with

[25]"Troubled" countries are those directly affected by the sovereign debt crisis, as evidenced by receiving EU emergency assistance (Cyprus, Hungary, Ireland, Latvia, Portugal, Spain) or by being sufficiently implicated to publicly commit to structural reform and fiscal consolidation during the Euro Summit on the debt crisis in October 2011 (Italy). Note that Greece and Romania are not included in the sample. Results are robust to alternative definitions of the set of "troubled" countries.

[26]A Wald test of $\beta_{GCEX2} = \beta_{GINV}$ rejects this restriction with a p-value of 0.00.

[27]This effect can partially be attributed to growth mattering more for less stable countries over the entire sample period, and partially to growth mattering more for all countries during the crisis years. Results for the fiscal variables are very similar

year fixed effects in 2011 and 2012 suggest that, in these years, common factors were not so common: investors might have been penalising certain countries in 2011 and 2012 irrespective of at least those fundamentals included in the specifications estimated here.

1.4.2 Robustness

This section presents a range of robustness tests. We focus on exploring the robustness of our central result – the significance that government bond markets accord to the underlying composition of the government budget deficit – to addressing possible endogeneity in a number of ways. First, in line with the literature, we apply Two-Stage Least Squares ("2SLS") estimation methods to address the scope for endogeneity of the fiscal variables. Due to evidence of serial correlation in baseline specifications, the validity of using lagged values of fiscal variables as instruments for their contemporaneous values hinges here on the Hansen overidentification test not indicating the presence of any problems. 2SLS results, using the first and second lags of fiscal variables as instruments, for our preferred specification (column (5) in Table 1.1) are presented in Table 1.2 and are promising. A Hansen test does not reject the null hypothesis of joint validity of the instruments, with a p-value of 0.51. Hausman (1978) tests comparing coefficients estimated by OLS and by 2SLS do not reject the null hypotheses, for the coefficients of fiscal variables individually, of exogeneity. Furthermore, first-stage results suggest that first and, in part, second lags are informative instruments. Finally, there do not appear to be underidentification or weak identification issues (Kleibergen and Paap, 2006; Sanderson and Windmeijer, 2016).[28] Thus, endogeneity of the fiscal variables does not appear to be an issue from an econometric standpoint, enabling consistent inference using OLS and lending support to our central results discussed above.[29]

when these additional interactions are included.

[28]Newey-West standard errors are used to calculate these and Hansen test statistics since this facilitates computation, but additionally allowing for cross-section dependence does not affect conclusions. Note that the use of the F-statistic in first stages should be considered heuristic in the panel setting (Bazzi and Clemens, 2013).

[29]Results are very similar when two-step GMM is used instead of 2SLS.

Table 1.2: Robustness: Instrumenting fiscal variables

Dep. var.: gov. bond yield	**OLS**	**2SLS –**	**2SLS – 1st stages**		
		2nd stage	Current spending	Investment spending	Total revenue
	(1)	(2)	(3)	(4)	(5)
Gov. current expenditure	4.834***	11.055***			
	(1.361)	(2.429)			
Gov. investment	-26.294***	-21.506**			
	(7.445)	(8.514)			
Gov. total revenue	2.010	-1.352			
	(1.924)	(3.393)			
Gov. current exp., 1st lag			0.517***	-0.011	-0.009
			(0.045)	(0.010)	(0.025)
Gov. current exp, 2nd lag			0.180***	-0.028***	0.017
			(0.046)	(0.010)	(0.025)
Gov. investment, 1st lag			0.106	0.738***	-0.222**
			(0.205)	(0.047)	(0.113)
Gov. investment, 2nd lag			-0.094	-0.002	-0.093
			(0.202)	(0.046)	(0.111)
Gov. total revenue, 1st lag			0.098	-0.006	0.778***
			(0.081)	(0.019)	(0.045)
Gov. total revenue, 2nd lag			0.036	0.017	-0.046
			(0.080)	(0.018)	(0.044)
Short-term interest rate	0.345***	0.346***	0.001	-0.000	0.000
	(0.034)	(0.030)	(0.001)	(0.000)	(0.000)
Inflation rate	-0.043	-0.047*	-0.001*	0.000	-0.001**
	(0.027)	(0.025)	(0.001)	(0.000)	(0.000)
Real growth rate	-0.111***	-0.089***	-0.004***	0.000*	-0.002***
	(0.032)	(0.020)	(0.000)	(0.000)	(0.000)
Real growth × "Trouble"	-0.104**	-0.093***	0.000	0.000**	0.001*
	(0.041)	(0.025)	(0.001)	(0.000)	(0.000)
Eurozone dummy	0.136	0.210	0.001	-0.001	-0.000
	(0.145)	(0.169)	(0.004)	(0.001)	(0.002)
2011 dummy × "Trouble"	2.347***	2.297***	-0.019**	-0.003	-0.004
	(0.172)	(0.304)	(0.008)	(0.002)	(0.005)
2012 dummy × "Trouble"	2.295***	2.379***	-0.020**	-0.002	0.002
	(0.270)	(0.314)	(0.009)	(0.002)	(0.005)
Underid. test (p-value)[1]		0.00	0.00	0.00	0.00
Weak id. test (F-stat)[2]		43.06	74.62	102.39	120.09

Notes: $N = 545$. Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. (1) OLS / (2) 2SLS with country and year fixed effects. "Trouble" is equal to 1 for Cyprus, Hungary, Ireland, Italy, Latvia, Portugal and Spain. 1: H0: equation is underidentified. 2 H0: instruments are weak. Both Kleibergen and Paap (2006) / Sanderson and Windmeijer (2016). Test statistics are computed using Newey-West standard errors.

Second, Table 1.3 addresses concerns about simultaneity stemming from underlying macroeconomic conditions by investigating whether the cyclical components of government revenue and current spending enter differently than their structural components. The structural components of revenue and expenditure correspond to discretionary spending, while the cyclical ones reflect automatic stabilisers. Note that the macroeconomic models discussed in Section 1.2 typically focus on the interest rate response to discretionary government spending changes. However, the default risk channel also mentioned above might plausibly reflect worry both about discretionary spending as well as automatic stabilisers, since both can ultimately result in insolvency. Data on cyclically adjusted government revenue and current expenditure, but not investment, are also provided by AMECO, though for a smaller subset of country-year observations. Column (1) presents results from estimating our preferred specification on this subset. When current expenditure and total revenue are split into their cyclical and structural components, as in column (2), only the structural component is significant in the case of expenditure and neither is significant in the case of revenue, in line with results above. The large standard errors on the coefficients of cyclical components suggest that these components may be highly collinear with the included macroeconomic controls, yet are reassuring insofar as they indicate that these control variables are in fact adequately controlling for cyclical conditions.

Third, Table 1.4 presents a range of further robustness tests that, among other things, continue to explore the scope for reverse causation and simultaneity stemming from time-varying institutional factors. Columns (1) and (2) shift the timing of information sets. Column (1) uses a fourth-quarter average instead of an annual average of the dependent variable, the long-term bond yield. This is in order to reflect the fact that information about the budget deficit for year t emerges gradually over the course of the year and is finalised only towards the end, so that here, information sets are matched more closely. Column (2) uses fiscal variables from period $t-1$ instead of t to deal with the potential for reverse causation from interest rates to fiscal policy decisions. In both cases, results are highly robust.

Table 1.3: Robustness: Cyclical and structural components

Dep. var.: gov. bond yield	**Baseline**	**Split**
	(1)	(2)
Gov. current expenditure	5.993***	
	(1.298)	
Gov. current exp., structural component		5.347***
		(1.157)
Gov. current exp., cyclical component		9.185
		(6.092)
Gov. investment	-22.318***	-20.402**
	(8.347)	(9.006)
Gov. total revenue	1.914	
	(2.935)	
Gov. total rev., structural component		2.161
		(2.801)
Gov. total rev., cyclical component		-30.306
		(58.158)
Short-term interest rate	0.421***	0.424***
	(0.051)	(0.054)
Inflation rate	-0.031	-0.033
	(0.030)	(0.035)
Real growth rate	-0.106***	-0.097**
	(0.036)	(0.044)
Real growth × "Trouble"	-0.087*	-0.088*
	(0.047)	(0.045)
Eurozone dummy	0.329*	0.352**
	(0.168)	(0.157)
2011 dummy × "Trouble"	2.235***	2.235***
	(0.208)	(0.209)
2012 dummy × "Trouble"	2.265***	2.240***
	(0.328)	(0.318)
R-squared	0.803	0.818
Observations	477	477

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 adjusted to exclude the impact of year fixed effects. "Trouble" is equal to 1 for Cyprus, Hungary, Ireland, Italy, Latvia, Portugal and Spain.

Column (3) adds an indicator that reflects the ideological stance of the governing party or coalition – specifically, the share of left-leaning parties in government[30] – with the objective of controlling for at least part of

[30]It measures the cabinet posts of social democratic and other left parties as a

time-varying institutional characteristics that might cause simultaneity. It enters insignificantly and does not affect our conclusions. Column (4) addresses the fact that the use of the three-month interbank rate as a control might introduce the effects of changes in banking risk and liquidity by instead including the monetary policy rate, typically an overnight rate, as a control. While the sample shrinks somewhat due to data availability, results are robust. Column (5) includes the gross debt ratio as an additional indicator of the fiscal policy stance. Although this is formally invalid due to its non-stationarity, main results are unaffected. Column (6) relates the bond yield spread relative to Germany to the usual set of fiscal and control variables, all expressed relative to Germany. This specification is similar to those used in a spread-based literature on fiscal sustainability, such as Hagen et al. (2011). Results are highly robust. Note that the presence of year fixed effects, which are commonly specified in the literature and throughout this chapter, means that this spread-based specification is exactly equivalent to relating the level of the yield to country-specific fiscal and control variables as before, on the sample that excludes Germany.[31] Lastly, column (7) includes available observations from before 1990, which increases the unbalancedness of the panel but leaves results unaffected.[32]

Finally, Table A.6 in Appendix A reports results from using "mean groups" estimation approaches, where coefficients of explanatory variables are allowed to be country-specific (Pesaran and Smith, 1995; Eberhardt and Teal, 2010; Eberhardt, 2013) and then averaged across countries. Results are sufficiently similar to pooled results to indicate that the pooling

percentage of total cabinet posts weighted by number of days in office (Armingeon et al., 2015) and ranges from 0 to 100%.

[31]This is because the inclusion of year fixed effects controls for the evolution of yields in a reference country such as Germany. It is interesting to note that in spite of this, explanatory variables used in research that investigates the fiscal policy determinants of bond yield spreads relative to a reference country (such as De Grauwe and Ji, 2013; Hagen et al., 2011) tend to differ from those used in research that does so for the level of the bond yield (such as Ardagna et al., 2007).

[32]The sign and significance of the coefficient on the inflation rate is unstable across specifications, and appears to depend on the sample period (cf. column (7)), the type of short rate included as a control (cf. column (4)) and the sample countries (cf. Table A.5 and Chapter 2). Such instability is present in the existing literature too (Baldacci and Kumar, 2010; Gruber and Kamin, 2012) and might reflect instability in the inflation process, that is, how increases in current inflation affect expectations of future inflation (and hence future short-term nominal interest rates) over the relevant 10-year horizon, given the current short-term rate.

Table 1.4: Robustness: Further tests

Dep. var.: gov. bond yield	**Q4 yield (dep. var.)**	**Lagged fiscals**	**Political factors**	**Policy rate**	**W/ debt ratio**	**Spreads vs. Germany**	**More unbal. sample**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Gov. current expenditure	7.139***	7.556***	4.148***	3.820***	1.573	4.492***	3.406***
	(1.803)	(1.335)	(1.270)	(0.675)	(1.256)	(1.322)	(1.028)
Gov. investment	-15.131**	-17.797**	-26.679***	-31.345***	-13.830**	-26.268***	-26.180***
	(6.647)	(7.981)	(8.307)	(6.007)	(6.033)	(7.202)	(7.194)
Gov. total revenue	0.983	0.511	1.447	2.008	0.898	1.433	0.806
	(1.397)	(1.979)	(2.144)	(1.834)	(2.074)	(2.072)	(1.704)
Left-wing share of gov.			-0.104				
			(0.076)				
Monetary policy rate				0.303***			
				(0.049)			
Debt ratio					1.225***		
					(0.262)		
Short-term interest rate	0.346***	0.371***	0.387***		0.403***	0.386***	0.388***
	(0.042)	(0.036)	(0.042)		(0.036)	(0.048)	(0.038)
Inflation rate	-0.011	-0.057**	-0.048*	0.004	-0.064**	-0.050*	-0.028
	(0.026)	(0.029)	(0.027)	(0.031)	(0.027)	(0.027)	(0.030)
Real growth rate	-0.080**	-0.129***	-0.106***	-0.086***	-0.108***	-0.106***	-0.095***
	(0.031)	(0.029)	(0.033)	(0.021)	(0.033)	(0.033)	(0.034)
Real growth rate × "Trouble"	-0.125***	-0.100**	-0.097**	-0.107***	-0.090**	-0.097**	-0.113**
	(0.032)	(0.043)	(0.042)	(0.039)	(0.041)	(0.043)	(0.048)
Eurozone dummy	0.176	0.190	0.157	-0.097	0.229	0.079	-0.102
	(0.182)	(0.132)	(0.156)	(0.134)	(0.148)	(0.150)	(0.147)
2011 dummy × "Trouble"	3.152***	2.107***	2.342***	2.331***	2.253***	2.304***	2.345***
	(0.156)	(0.198)	(0.192)	(0.234)	(0.165)	(0.186)	(0.185)
2012 dummy × "Trouble"	1.489***	2.263***	2.275***	2.505***	2.191***	2.270***	2.271***
	(0.215)	(0.283)	(0.298)	(0.355)	(0.254)	(0.282)	(0.290)
R-squared	0.682	0.706	0.697	0.682	0.712	0.677	0.801
Observations	572	560	543	508	571	548	654

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield except where otherwise noted. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 adjusted to exclude the impact of year fixed effects. "Trouble" is equal to 1 for Cyprus, Hungary, Ireland, Italy, Latvia, Portugal and Spain.

approach taken here is not misleading.[33,34]

1.4.3 Heterogeneity

Table 1.5 explores some aspects of possible temporal and spatial heterogeneity in estimated effects. Columns (1) and (2) in Table 1.5 address the conjecture that the recent financial crisis awoke bond markets from their "sleeping beauty" state of being to the realisation that government bonds do involve default and other risks, which means that effects of fiscal variables may have changed since the crisis. Column (1) is similar to column (4) of Table 1.1[35], and reports results from estimating the baseline specification on the sample prior to 2008, while column (2) does so on the sample from 2008 to 2014. Results are qualitatively unchanged. Note, however, the relatively small sample size and short time series available for the results reported in column (2). The real growth rate becomes more important and enters significantly negatively in column (2), which suggests the workings of a default risk channel and is in line with the conjecture that since the crisis, the spectre of government default has returned to investors' minds. This also demonstrates that imposing the restriction that coefficients on control variables are stable over time is not innocuous, although doing so does not affect our main conclusions reached.

[33]Results – not reported here – are also highly robust when alternative ways for controlling for the common downward trend in bond yields are applied, such as including linear trend segments or a mean bond yield in place of year fixed effects, or when the inflation rate is excluded as a control.

[34]Additional avenues that we explored but do not report here include adding inflation and GDP growth forecasts from the WEO for 1 to 5 years ahead to specifications, in order to more appropriately reflect the forward-looking nature of financial markets, but these forecasts were never significant and did not affect results. Furthermore, we used a measure of the output gap as an alternative control for the economic cycle, but results were unaffected. Additionally, measures of the effective exchange rate, sourced from BIS, were added to a range of baseline specifications, but did not change results. We explored dynamic models that include the lagged dependent variable, and found that the long-run effects of fiscal variables are very similar to those obtained in the static models reported here. Finally, the relevance of hitting the zero lower bound (ZLB) in short-term nominal interest rates, liberally defined as rates below 50 basis points, was assessed, but our main results were unaffected.

[35]Column (1) here additionally includes the interaction term between the growth rate and our "trouble" dummy.

Table 1.5: Heterogeneity

Dep. var.: gov. bond yield	**Pre-crisis sample**	**Post-crisis sample**	**Excl. EA 1998-2007**	**Non-EA obs.**	**EA obs.**
	(1)	(2)	(3)	(4)	(5)
Gov. current expenditure	6.679***	4.970***	4.808***	4.350**	2.840***
	(1.313)	(1.170)	(1.465)	(1.716)	(1.071)
Gov. investment	-19.577***	-44.705***	-24.869***	-14.145**	-56.436***
	(5.189)	(15.600)	(6.411)	(6.631)	(13.173)
Gov. investment × Crisis					
Gov. total revenue	-5.339***	6.295	2.211	1.595	7.112
	(1.408)	(4.558)	(1.802)	(1.942)	(6.068)
Short-term interest rate	0.428***	0.277***	0.362***	0.363***	
	(0.037)	(0.084)	(0.036)	(0.032)	
Inflation rate	-0.002	-0.017	-0.041	-0.057	-0.055
	(0.030)	(0.032)	(0.029)	(0.037)	(0.050)
Real growth rate	-0.013	-0.188***	-0.118***	-0.100**	-0.072***
	(0.027)	(0.030)	(0.037)	(0.043)	(0.023)
Real growth rate × "Trouble"	-0.020	-0.083	-0.091**	-0.111**	-0.120**
	(0.031)	(0.070)	(0.045)	(0.048)	(0.057)
Eurozone dummy	-0.162	-0.444	-0.007		
	(0.131)	(0.430)	(0.182)		
2011 dummy × "Trouble"		2.117***	2.073***	1.426***	2.675***
		(0.183)	(0.222)	(0.256)	(0.176)
2012 dummy × "Trouble"		1.956***	2.048***	1.040***	2.371***
		(0.266)	(0.299)	(0.285)	(0.398)
R-squared	0.767	0.618	0.727	0.675	0.276
Observations	363	209	459	351	221

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 is adjusted to exclude the impact of year fixed effects. "Trouble" is equal to 1 for Cyprus, Hungary, Ireland, Italy, Latvia, Portugal and Spain.

Columns (3) to (5) address the fact that the introduction of the Euro led to a convergence in government bond yields for Euro area countries, especially for the period from its introduction until the beginning of the financial crisis. Column (3) excludes observations from Euro area countries during the period from 1998 to 2007. Column (4) estimates a baseline specification on the sample of non-Euro area observations, while column (5) focusses on Euro area observations – specifically, it includes country i from the year immediately before it joined the Euro.[36] Results are robust.

[36]The short-term interest rate is equal across Euro area countries from the introduction of the Euro area onwards and hence not included in column (5). Interesting future research could investigate the role of fundamentals for Euro area countries' yields over time using "attention" functions as in Muellbauer (2013).

Thus, although Euro area countries are different in an important respect due to the introduction of the common currency, our central result of interest – the significant difference between the effects of government investment and government current expenditure for bond yields – is not driven by Euro area-specific developments.[37,38]

1.5 Conclusion

This chapter has sought to explore whether government bond markets accord importance to the composition of and hence reasons behind government budget deficits. We find that they indeed distinguish deficits due to government current expenditure from those due to government investment: bond markets charge significantly higher interest rates for current spending-driven deficits than investment-driven deficits, and thus penalise the former significantly more than the latter. Based on our preferred specifications, a higher deficit solely due to higher government investment would in fact decrease long-term government bond yields. These results imply that markets tend to view government investment, on average, as favourable for growth or as having a positive return.

These findings could have important policy implications. Insofar as the normative perspective on fiscal policy that financial markets provide is considered to be a useful indicator of the appropriateness, validity or sustainability of any given fiscal policy stance, these results suggest that austerity policies ought to focus more on government current expenditure than on government investment. They also suggest that fiscal rules – in contrast to the current implementation of the EU's Maastricht criteria, for example – should consider the underlying composition of government budget deficits, and thus distinguish budget deficits that are the result of government investment from those that are not.

Interesting avenues for future research emerge from this analysis. Using national sources, it might be possible to decompose the primary

[37]Table A.5 in Appendix A additionally estimates some central specifications on the intersection between this sample and the sample available for analysis in Chapter 2. Our main findings are unaffected.

[38]We also compared the effects of fiscal variables for countries with high or low debt or per capita GDP, or with AAA- or lower rated sovereign debt (as per Moody's or Fitch), but differences were minimal.

budget deficit in more detail – for example, one might distinguish the infrastructure, social housing or military expenditure components of government investment, and the wage, social transfers and education spending components of government current expenditure – and explore the effects of these components on bond yields in an analysis of the kind presented here. It would also be interesting to extend our model of bond yield determinants by considering the extent of attention that markets pay to fiscal and macroeconomic fundamentals, building on Muellbauer (2013). Finally, should data become available on forecasts of the investment, current spending and revenue parts of the deficit, it could be worthwhile to explore the relevance of the "surprise" components in these fiscal variables for bond yields.

Chapter 2

Government balance sheets and bond yields: do assets matter?

Government net worth – total assets less liabilities – has declined considerably relative to national income in a number of OECD countries in recent decades, including the United States, the United Kingdom, Japan and Germany. Notably, however, in thinking about the links between fiscal policy and bond markets, the focus of policy and academic debates has tended to be on the liabilities side of the government balance sheet. Typically, not much attention has been paid to the extent to which any increase in government debt is accompanied by government asset accumulation and hence affects government net worth. Using novel data on both sides of the government balance sheet both for a panel of OECD countries in recent decades and for the United States over the long term, we provide panel data and time series-based evidence that for bond markets, not all government debt is created equal: for explaining government borrowing cost empirically, (i) government assets are significant in addition to government liabilities, and (ii) it is government net worth rather than government liabilities that matters when both are included. The central country-specific fiscal factor driving bond yields hence appears to be government net worth.

2.1 Introduction

In February 2016, The Economist, a weekly news magazine, argued that now is the time for governments in mature economies to use fiscal tools to jolt economies from their low-growth state of being, given monetary policy's declining effectiveness at the zero lower bound. It claimed that the kind of "Swabian frugality" that Germany has been promoting is harmful, given cheap or even negative borrowing costs and that, crucially, "markets and ratings agencies will look more kindly on the increase in public debt if there are fresh and productive assets on the other side of the balance sheet". This chapter principally seeks to investigate the validity of this latter claim, using recent panel data for a set of OECD countries and long-term time series data for the United States on both sides of governments' balance sheets.

There is a substantial empirical literature that examines the effects of government debt and deficits on government bond yields. So far, however, this literature has largely ignored the extent to which any increase in debt is used to fund asset accumulation, which is reflected in government investment expenditure, the asset side of the government balance sheet and government net worth. This chapter instead takes seriously the reasons for which government debt is rising or falling. Our findings suggest that the asset side of the government balance sheet is significant for explaining government bond yields empirically in a variety of specifications, both for a panel of OECD countries in recent decades and for the United States over the long term. Hence, it seems that for bond markets, not all debt is created equal.

The disregard of the asset side of the government balance sheet[1] in the empirical literature and many policy discussions about debt and deficits comes in spite of striking concurrent developments (Atkinson, 2015) in government net worth, that is, total government assets less liabilities (Buiter, 1985). In the United States, government net worth declined from 80% of national income in the 1980s to 20% by 2010 (Piketty and Zucman, 2014). Based on the most recent data[2] available, net worth has even

[1] An exception is, for example, the IMF (2015), which argues for the relevance of balance sheet analysis for all sectors of the economy.

[2] The most recent available data comes from the US Federal Reserve (2017), while the data used here comes from Piketty and Zucman (2014) in the interest of consistency

entered negative territory since, and has thus continued on its trajectory from before 2010. Note that since 1870, net worth was below 10% of national income in only three periods previously: in the 1880s and in the aftermaths of World War I and World War II. It was in negative territory only twice previously: in the 1880s and after World War II. Figure 2.1 illustrates this.

A decline in government net worth is also apparent across a number of other OECD countries. This decline is not uniform – for example, Denmark bucked the trend – and cannot be ascribed everywhere to the same causes, with some governments shrinking their assets, others growing their liabilities and some doing both. Nonetheless, a remarkable reduction is apparent in many countries: government net worth has fallen from 68% of national income in 1990 to 9% in 2013 in Germany, from 103% in 1990 to -5% in 2013 in Japan, and from 66% in 1990 to 6% in 2010 and further since in the United Kingdom (Piketty and Zucman, 2014).[3] Figure 2.2 illustrates these facts. While such developments would be expected to spell trouble for individuals, corporates or banks, they seem to have gone largely unnoticed – at least in academic and policy debates – in the case of many sovereigns.

In considering both sides of the government balance sheet in an empirical analysis of the effects of fiscal policy on government borrowing cost, we build on an idea that is deeply grounded in economic intuition. For any type of agent in the economy – firms, banks, individuals or governments – when their liabilities grow, we need to take into account what is happening to their assets in order to be able to make any normative claim as to whether this growth is a good or a bad thing. Government assets comprise both financial assets such as currency, deposits, bonds and equity as well as non-financial assets such as buildings and roads. In the context of governments, balance sheets will reflect economic – and political – circumstance and necessity.

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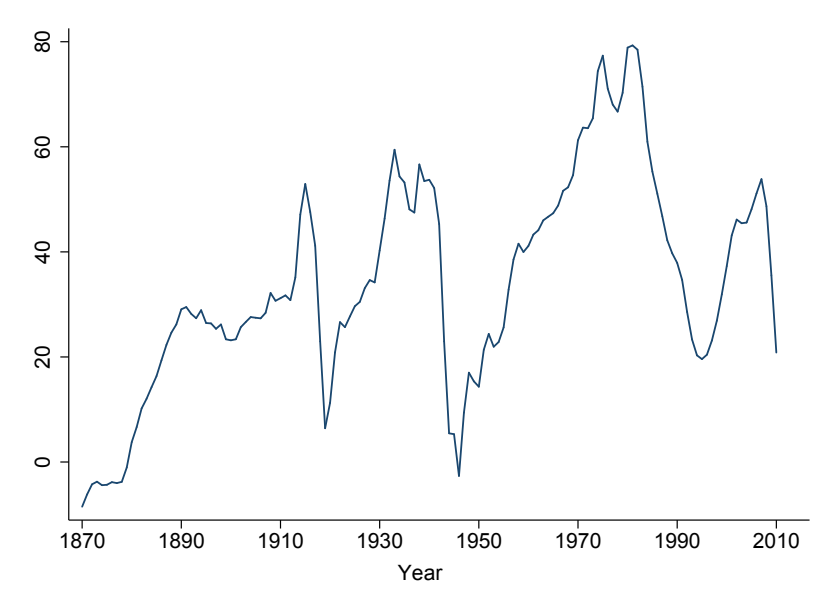
across countries and reaches only until 2010. Updated data were made available to us by Piketty and Zucman, which reflects this negative turn, yet does not reach as far back as the original release.

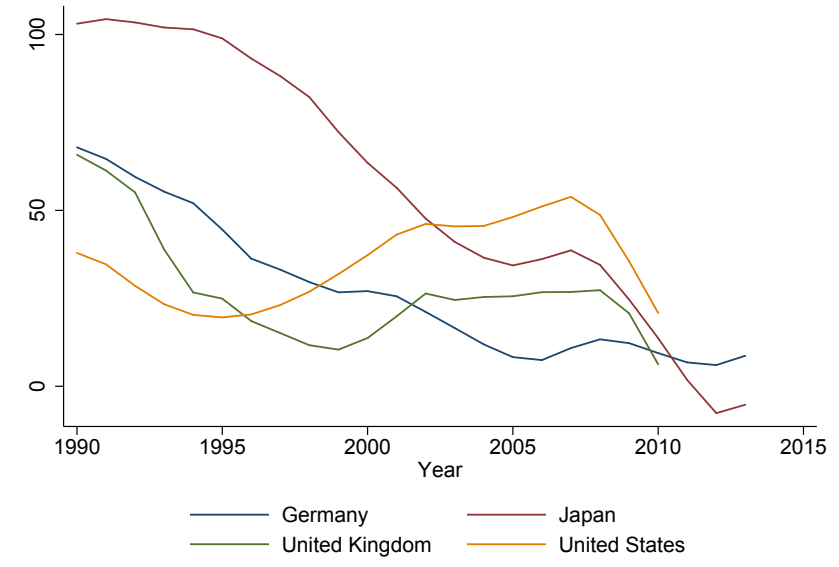
[3]"Germany" refers to West Germany until 1990, and to reunified Germany after.

Figure 2.1: United States government net worth, 1870-2010



In percent of national income
Source: Piketty and Zucman (2014)

Figure 2.2: Government net worth, selected countries, 1990-2014



In percent of national income
Source: Piketty and Zucman (2014)

We use government balance sheet data for a panel of 10 OECD countries from 1990 and for the United States from 1870, drawn from Piketty and Zucman (2014), to explore the empirical relevance of both the liabilities and the assets sides of the government balance sheet for government bond yields and hence fiscal sustainability. To the best of our knowledge, these data have not been used previously to study the matter at hand. Due to the stationarity and cointegration properties of the time series involved and in order to ensure regression balance, we use the first differences of government balance sheet variables, measured in percent of national income, in our main analysis, in a considerable but necessary departure from the existing literature.

Doing so, we find that, from the perspective of government bond markets, liabilities do matter – yet assets matter just as much: in our preferred specifications, an increase in liabilities that is wholly due to and thus wholly translates into asset accumulation is neutral for bond yields. In fact, government net worth is more informative for government borrowing cost empirically than are total government liabilities. Hence, the central country-specific fiscal factor driving bond yields appears to be government net worth, rather than government liabilities. These conclusions hold both for the panel of OECD countries in recent decades as well as for the United States over the long term.

Findings in this vein – which reflect the perspective of financial markets – could have important policy implications. They provide evidence against the imposition of indiscriminate brakes on the raising of additional debt and suggest that fiscal austerity policies ought to focus on constraining government borrowing when it does not contribute to the accumulation of government assets.

This chapter is organised as follows. Section 2.2 discusses the empirical literature and theory on the links between government bond yields and government balance sheets. Section 2.3 presents the panel analysis for a set of OECD countries, outlining the data and model used as well as central results. Section 2.4 proceeds analogously, covering the long-term time series analysis for the United States. Section 2.5 concludes.

2.2 Government balance sheets and interest rates

2.2.1 In the empirical literature

Most immediately, this research links to and extends the literature that analyses empirically the fiscal policy determinants of government bond yields for individual or panels of countries, such as, for example, Ardagna et al. (2007), Gruber and Kamin (2012) or Laubach (2009). It adds to this literature by explicitly taking into account both sides of the government balance sheet, and thus by investigating whether the extent to which any increase in debt is used to fund asset accumulation – which is reflected in government assets and government net worth – matters for the cost of government borrowing and hence fiscal sustainability. Furthermore, by reflecting the perspective of financial markets on government asset accumulation, this research also links back to the literature on the role of infrastructure in economic growth (see Durlauf et al. (2005) and Chapter 3 of this thesis).

Most of the literature on the fiscal determinants of long-term government bond yields can broadly be thought of along three main dimensions: first, whether the focus is on an individual country (Laubach, 2009) or a panel of countries (Ardagna et al., 2007); second, whether levels of bond yields (Gruber and Kamin, 2012), levels of short-term interest rates (Plosser, 1987), or spreads vis-à-vis a "risk-free" country (Afonso et al., 2015) or vis-à-vis a short-term rate (Beirne and Fratzscher, 2013) are used as the dependent variable; and third, whether unrestricted reduced-form regressions (Gruber and Kamin, 2012), restricted forms derived from a macroeconomic model (Evans, 1987a), simple or structural VARs (Dai and Philippon, 2006) or narrative approaches (Ramey and Shapiro, 1998) are used in estimation. In addition, a range of different measures of fiscal policy have been used and are theoretically plausible. These include stock variables such as the debt-to-GDP ratio or flow variables such as the budget deficit relative to GDP (see Chapter 1), and their current or projected values or the unexpected component of changes. The debt ratio comes in gross or net form, the latter involving the subtraction of government *financial* assets only.

The results from research across all dimensions mentioned above have not been fully conclusive. Indeed, in the case of studies focussing on an individual country in particular, results have ranged from finding significant effects of fiscal policy[4] – measured in various ways – to finding none at all[5]. However, our understanding of the reasons for the apparent inconclusiveness has improved (Gale and Orszag, 2003)[6] and – in spite or perhaps because of the alleged inconclusiveness – this literature has seen renewed interest in recent years, in particular with the European sovereign debt crisis raising the spectre of sovereign default again even in developed countries. This recent literature generally finds that more expansionary fiscal policy tends to raise long-term interest rates, but that effects are relatively small: most suggest that the effect of a one-percent increase in the debt ratio on the level of the yield in basis points is in the lower single digits (for example, Ardagna et al., 2007; Gruber and Kamin, 2012; Laubach, 2009).

Overall, as far as we are aware, no serious attempts have been made in this literature to consider fully the asset side of the government balance sheet, which is reflected in the level of or change in total government assets relative to national income. Kinoshita (2006) and Gruber and Kamin (2012) use net debt – that is, government gross liabilities less government *financial* assets – to reflect the fiscal policy stance, but do not discuss the implications of using this measure instead of a gross one.[7] Faini (2006) argues that it would be preferable to account for government total assets, but does not do so. Taking into account the (complete) asset side of the balance sheet in addition to regular stock measures of indebtedness

[4]Feldstein (1986) for the US; Canzoneri et al. (2002) for the US in reduced forms and in a structural VAR using both the actual deficit and projections of the deficit; Laubach (2009) for the US.

[5]Evans (1987b) for the US and Evans (1987a) for six developed countries separately; Plosser (1987) using a VAR for the US; Barro and Sala-i Martin (1990) for world real interest rates; Engen and Hubbard (2005) for the US when relating yields to contemporaneous measures of fiscal policy.

[6]Gale and Orszag (2003) find that studies that do not identify significant effects of fiscal policy typically do not use both long-term and short-term interest rates in their analysis. This is in line with the finding of Dai and Philippon (2006) that inflation and the output gap can typically account for changes in the short-term interest rate, but leave some dynamics of the long-term rate unexplained, which in turn can be explained by fiscal policy.

[7]Note that based on Piketty and Zucman (2014) data, government financial assets typically only account for between 20% (US) and 50% (Canada) of total government assets.

provides an insightful perspective on the reasons behind rising or falling government debt, and financial markets' perceptions of these reasons. This chapter hence adds to the existing literature by explicitly considering these reasons. To do so, we make use of a novel dataset recently published by Piketty and Zucman (2014), which has not been used previously in this type of analysis. It provides historical time series on government assets and liabilities, for the first time assembling valuations of both sides of governments' balance sheets using a consistent methodology for several countries and going back far in time.

2.2.2 In theory

Fundamentally, by the expectations hypothesis of the term structure of interest rates, the long-term nominal interest rate reflects expectations of future short-term nominal interest rates over the maturity horizon of the long rate. However, the empirical fact that yield curves typically slope (more or less) upwards – which, by this view of the world, implies that short-term interest rates are expected to trend upwards indefinitely (Gürkaynak and Wright, 2012) – suggests that we need to additionally allow for the presence of a (time-varying) term premium.

Textbook macroeconomic models tend to concern themselves with the impact of changes in government spending on short-term interest rates, and are discussed in more detail in Chapter 1. The dominant prediction from these models appears to be that fiscal expansions lead to higher interest rates, even when varying assumptions across a large number of modelling dimensions (Fatás and Mihov, 2001; Gale and Orszag, 2003). By the expectations hypothesis, effects on short-term interest rates will feed through to long-term interest rates to the extent that fiscal policy changes are perceived as being persistent.

The term premium is thought to reflect perceptions of default risk and inflation risk over the time horizon until maturity. Sovereign default risk is generally presumed to rise when fiscal policy becomes more expansionary, as reflected in, say, higher current debt levels relative to GDP or national income (Alesina et al., 1992; Ardagna et al., 2007; Laubach, 2010). The default risk premium should be related to the expected loss in case of default, which is determined by the probability of default times the

exposure at default. As a bank would do when setting the mortgage rate for an individual purchasing a property – comparing assets, the value of the property and the downpayment in cash, to liabilities, the magnitude of the loan required – it seems plausible that in case of governments, too, the asset side of the balance sheet matters in an evaluation of default probabilities.[8] Hence, we would expect that a stronger government balance sheet – as reflected in higher assets, ceteris paribus – should mean that a given increase in debt raises the probability of default by less. Higher government assets may also reduce default probabilities to the extent that government asset accumulation increases growth potential (Durlauf et al., 2005; Chapter 3), since higher current or expected future economic growth makes current debt levels more sustainable. Finally, an increase in government (liquid) assets may also reduce the probability of default directly, since these could be sold off in case of fiscal liquidity problems, or, in the same way, reduce exposure at default. Thus, the default risk channel suggests that an increase in government debt that is accompanied by asset accumulation leads to a smaller increase in interest rates than one that is not or, equivalently, that the coefficient on our measure of assets – in a regression with the bond yield as the dependent variable – is expected to be negative.

The inflation risk channel instead reflects the possibility that governments will attempt to monetise their debt through inflation (Gruber and Kamin, 2012; Gürkaynak and Wright, 2012).[9] However, insofar as any increase in government assets that accompanies a rise in debt adds to the economy's productive capacity, it should simultaneously reduce pressure on current and expected future inflation. Hence, investor expectations about the level of or change in government assets over the time horizon from today until the maturity of the bond should affect the magnitude of the inflation risk premium. Given the available data and their stationarity properties, in estimation, these expectations may be proxied by the change in the stock of assets from year $t-1$ to year t. Hence, inflation risk considerations

[8]However, note that in contrast to most mortgages, government debt is typically unsecured.

[9]A closely related channel, in an open economy context, works via expected depreciation (Ardagna et al., 2007). Since joining a currency union and relinquishing monetary control means that monetising one's debt is no longer possible, joining the Euro area might lower inflation risk while increasing perceived default risk of a country's government bonds (Bernoth et al., 2004).

also suggest that the coefficient on assets should be negative.

Based on the preceding discussion, this chapter thus asks whether, in a regression of the government bond yield on fiscal policy measures and controls, (i) when included jointly with gross liabilities, the coefficient on government assets is negative ("asset effect"), and (ii) more strongly, the coefficients on assets and liabilities are statistically equal in absolute terms, which would suggest that the effects of both assets and liabilities are summarised by the inclusion of government net worth ("net worth effect").

2.3 Panel data evidence for OECD countries

This section explores the presence of an "asset effect" and a "net worth effect" as introduced in Section 2.2.2 in a panel regression setting. Available data on government balance sheets cover 10 OECD countries over recent decades. We confirm the presence of both types of effect, finding that the central country-specific fiscal factor driving bond yields and hence government borrowing costs appears to be government net worth rather than government liabilities. Section 2.3.1 introduces the data used in our analysis. Time series properties and model specification are discussed in Section 2.3.2. Our main results for the OECD panel are presented in Section 2.3.3.

2.3.1 The data

The sample used for analysis here covers 10 highly developed and stable OECD countries, specifically Australia, Canada, Denmark, France, Germany, Japan, the Netherlands, Sweden, the United Kingdom and the United States, over a maximum time span from 1990 to 2014.[10] It combines government balance sheet data from Piketty and Zucman (2014) and interest rate and macroeconomic data from the OECD, IMF and Eurostat at annual frequency. Government refers to "general government", which includes central, local and state government and social security

[10]Note that the sample does not include countries that were directly affected by the recent sovereign debt crisis (termed "troubled" in Chapter 1).

funds.[11,12] Focussing on this relatively recent period has some important advantages. For one thing, financial liberalisation in the 1980s, particularly the abolition of capital controls, may have changed the relation between government bond yields and domestic fiscal variables. Furthermore, the relationship in more recent times is likely to provide more relevant evidence for current debates about the effects of fiscal policies. Finally, focussing on data after 1990 means we avoid structural breaks in the data for Germany as a result of reunification.

As the dependent variable, the 10-year constant-maturity nominal government bond yield is used, as in Chapter 1 and as is standard in the relevant literature (for example, Ardagna et al., 2007; Gruber and Kamin, 2012; Afonso et al., 2015). This is the average rate at which debt with an outstanding maturity of around 10 years is trading on secondary markets during the year of interest, or can equivalently be interpreted as a yearly average of readings of the government's yield curve at the 10-year mark. Figure B.1 in Appendix B displays the cross-section average of 10-year government bond yields together with individual-country yields for the panel since 1990. It clearly illustrates both a substantial degree of comovement and a significant downward trend in yields. How these issues are addressed econometrically is discussed below. Note that because we generally include in estimation a set of year fixed effects to account for the common component of this trend, we are effectively using the cross-sectionally demeaned bond yield in country i as the dependent variable.

Data on government balance sheet items are drawn from Piketty and Zucman (2014), who aggregate into a comprehensive dataset historical series on the balance sheets of all sectors of the economy, which many national statistical agencies have published retrospectively.[13] A multi-

[11]This is to be distinguished from the definition of "public sector", which additionally includes public financial and non-financial corporations (2008 SNA, ESA 2010). This distinction is discussed in more detail in Appendix D.

[12]Government balance sheet data are also available for the Czech Republic, but are not included here due to the very different historical context in which the Czech Republic found itself in the 1990s compared to the other 10 countries included in our sample. However, results are robust to the inclusion of the Czech Republic.

[13]Piketty and Zucman (2014) do not provide new data as such, but aggregate and, at times, adjust data from national statistical sources in a manner that is consistent across time and space. Plausibly, bond markets thus had access to information about developments in government assets prior to the release of this dataset.

tude of measurement and valuation issues remain, ranging from valuing intangible capital to non-listed state-owned enterprises, which Piketty and Zucman discuss in detail in the Data Appendix to their 2014 paper and we summarise in the Data Appendix to this thesis (see Appendix D). Notwithstanding, these data provide, to our knowledge, the best available information on government balance sheets that is comparable across time – and, to an extent, across space – and has not been used before to address the question at hand. In particular, we use total assets (GTA) and total liabilities (GLI) held by general government, both measured at market value in percent of national income in the analysis. Government total assets comprise non-financial assets such as buildings and roads as well as financial assets such as currency and deposits, loans, bonds, shares and other equity (see Appendix D for details).[14]

Three points regarding the scope of the general government balance sheet are worth noting. First, because, in principle, the general government sector includes social security funds, the general government's balance sheet does include insurance and pension schemes, and hence, for example, pension fund reserves, if there are any.[15] However, government guarantees for pension schemes (for example, in unfunded or "pay as you go" schemes) are considered contingent liabilities, and are not recorded as liabilities in general government accounts (Eurostat, 2004). An interesting future line of research could be to use estimates of such contingent government liabilities in regressions of the type presented here. Second, the inclusion of public-private partnerships in government balance sheets depends on which sector is bearing the economic risks involved, and is discussed in more detail in Section D.2.1 in Appendix D.[16] Third, government balance sheets do not include central bank balance sheets, so the effect of unconventional monetary policy on central banks' balance sheets is not reflected on the "general government" balance sheet. Graphs of government

[14]Assets cannot be decomposed further into, say, more or less economically productive assets or more or less liquid assets using the Piketty and Zucman (2014) data, but worthwhile future research might attempt such decompositions building on national sources.

[15]How precisely pension schemes are included in the general government balance sheet depends on their type and on which party assumes the financial risk involved, and is discussed in more detail in Section D.2.2 in Appendix D.

[16]As an aside, the United Kingdom's "private finance initiatives" are not included in the government balance sheet measures used here.

balance sheet items for the countries in the panel are presented in Figures D.4 to D.7 and D.10 to D.31 in Appendix D.

As controls for macroeconomics conditions, in line with the literature, a short-term interest rate (specifically, the three-month interbank rate), the CPI inflation rate as well as the year-on-year rate of real economic growth are used. Table B.1 in Appendix B provides summary statistics, units of measurement and sources.

2.3.2 Time series properties and model specification

In order to examine the stationarity properties of the series included in estimation, we use the Im et al. (2003; "IPS test") test, which estimates an augmented Dickey-Fuller equation for each variable and country. The resulting t-statistics are then averaged across countries, thus combining the results from N unit root tests performed on the data for N countries (Maddala and Wu, 1999). Series are cross-sectionally demeaned in testing in order to reflect the fact that all our main specifications include year fixed effects. Using the IPS test (2003), then, the levels of government assets, liabilities and net worth, in percent of national income, are found to be non-stationary, as Table 2.1 shows.

Table 2.1: OECD panel: Testing for unit roots

Im, Pesaran and Shin (2003) test, p-values				
	Bond yield	*Short rate*	*Growth*	*Inflation*
Level	0.95	0.88	0.00	0.00
Level, demeaned	0.05	0.00	0.00	0.00
	Assets	*Liabilities*	*Net worth*	
Level	0.80	0.90	0.61	
Level, demeaned	0.92	0.17	0.09	
First difference	0.00	0.00	0.00	
First diff., demeaned	0.00	0.00	0.00	

All fiscal variables are expressed as shares of national income. Lag length selection by AIC. Null hypothesis: all panels contain unit roots. "Demeaned": series are cross-sectionally demeaned.

For the first differences of these fiscal variables, measured in percent of national income, and for the levels of the long-term government bond yield, the short-term interest rate, the inflation rate and the real growth rate, the evidence is in favour of stationarity.[17] Note that, interestingly, both long- and short-term interest rate series are found to be non-stationary when they have not been cross-sectionally demeaned.[18] Hence, a valid regression set-up might relate (i) the bond yield to a linear combination of the levels of assets and liabilities, if the latter two are found to cointegrate, or (ii) the bond yield to assets and liabilities expressed in first differences, in both cases in a regression model in which year-specific fixed effects are included because – as mentioned above – we only find the bond yield and the short-term interest rate to be stationary when they are cross-sectionally demeaned, which is equivalent to including the year fixed effects.

Irrespective of effects on the stationarity properties of these series, the inclusion of year fixed effects is crucial in order to capture common elements in bond yields across countries, and discussed further below. Since there is no robust evidence that the levels of assets and liabilities relative to national income are cointegrated (see Table B.2 in Appendix B, using the Persyn-Westerlund (2008) or the Pedroni (1999) tests), we focus on a model that relates the bond yield to a set of stationary explanatory variables, which includes, most importantly, the first differences of government assets and liabilities, measured in percent of national income. This constitutes a departure from the existing empirical literature, which has typically specified year fixed effects and included the level of government debt relative to GDP or national income, though likely – at least in some cases – invalidly so. However, there is of course a close relationship between the first difference of government liabilities and the (non-primary)

[17]Fiscal variables are measured in percent of national income throughout this analysis. The first difference of these variables, accordingly, is the first difference of the relevant ratio, e.g., of liabilities to national income.

[18]This may, in part, explain why the evidence on the stationarity and cointegration properties of both fiscal variables and interest rates in the literature is extremely mixed, if rarely discussed in much detail. It has generated research that relates the two in $I(0)$ terms and research that relates the two in $I(1)$ terms (see Ardagna et al. (2007) for both). The conclusions from the IPS test are robust to different lag lengths. We reach similar conclusions regarding the stationarity properties of the data using other panel unit root tests, such as Pesaran's test (2004), although results here are more sensitive to the choice of lag length.

budget deficit/surplus, and the inclusion of a measure of the deficit in specifications of the type used here is ubiquitous in existing research (for example, Ardagna et al., 2007). The first difference of assets is related to the investment component of the budget deficit, although this would only be a close relationship if our measure of assets were limited to fixed assets. In any case, government investment expenditure has not typically been considered separately in this type of literature (for this, see Chapter 1).

We employ the following reduced-form regression model to investigate the effects of government balance sheet components on government bond yields for a panel of OECD countries:

$$y_{i,t} = \alpha_i + \beta \Delta F_{i,t} + \gamma C_{i,t} + \delta_t + \varepsilon_{i,t} \tag{2.1}$$

The dependent variable $y_{i,t}$ is the long-term bond yield. α_i is a country-specific fixed effect, which controls for time-invariant unobserved characteristics of country i that affect its borrowing cost, such as the quality of its fiscal institutions and governance (De Grauwe and Ji, 2013). $\Delta F_{i,t}$ is a vector of stationary fiscal policy variables of interest, while $C_{i,t}$ is a vector of stationary controls for current economic conditions. $\Delta F_{i,t}$ includes total government liabilities ($\Delta GLI_{i,t}$), total government assets ($\Delta GTA_{i,t}$), and/or government net worth ($\Delta GNW_{i,t}$), all measured in percent of national income and expressed in first differences to ensure regression balance. As mentioned previously, the term "first differences" here applies to the ratios of fiscal variables relative to national income, so that if we define any fiscal variable $X_{i,t}$ relative to national income $Y_{i,t}$ as $\widehat{X}_{i,t} \equiv \frac{X_{i,t}}{Y_{i,t}}$, then its first difference is $\Delta \widehat{X}_{i,t} = \widehat{X}_{i,t} - \widehat{X}_{i,t-1} = \frac{X_{i,t}}{Y_{i,t}} - \frac{X_{i,t-1}}{Y_{i,t-1}}$. $C_{i,t}$ includes the short-term interest rate ($ISN_{i,t}$), the inflation rate ($CPI_{i,t}$), the real growth rate ($GROWTH_{i,t}$) and a dummy for Euro area membership ($EURO_{i,t}$), which is equal to 1 from the year in which country i adopted the Euro onwards. δ_t is a year-specific fixed effect, accounting principally for the common long-term downward trend in bond yields. $\varepsilon_{i,t}$ is the error term.

Based on the findings of the existing literature, the sign of the coefficient on liabilities should be positive: more expansionary fiscal policy tends to be associated with higher government bond yields or perceived sovereign risk. Under the assumption of the presence of default risk and inflation

risk channels in the term premium component of government bond yields, the sign of the coefficient on assets should be negative (termed "asset effect" above). As regards the controls, the sign of the coefficient on the growth rate is ambiguous. On the one hand, higher current growth may suggest higher future growth and hence higher inflation expectations, while it also makes, ceteris paribus, any given level of indebtedness today more sustainable and thus reduces default risk. The short-term interest rate and the inflation rate should both affect the long-term yield positively when included separately, but might be capturing related information and thus might not both be significant when included jointly. Finally, the effect of Eurozone membership on domestic bond yields is also ambiguous – joining the Euro might be perceived to entail the presence of a credible lender of last resort, but also to involve the surrender of monetary autonomy and thus the ability to monetise debt (Bernoth et al., 2004).

Identification of the effects of government balance sheet variables on government bond yields is achieved in this reduced-form approach if sources of potential endogeneity of fiscal policy variables – including simultaneity with respect to the cycle or with respect to institutional factors, and reverse causation – can be dealt with appropriately. These are discussed in more detail in Chapter 1. In particular, controls for the state of the cycle are included and results are checked for robustness by including measures of time-varying institutional factors that might affect both the yield and fiscal policy.[19]

Finally, since there is evidence of cross-section dependence and serial correlation in the error terms from central specifications, we generally report Driscoll-Kraay (1998) standard errors, which are robust in the presence of heteroskedasticity, serial correlation and a range of forms of cross-section dependence.[20]

[19]The application of instrumental variable methods – an appropriate methodology to address the potential scope for endogeneity – in the absence of plausible external instruments is complicated by the fact that there is little persistence in the first differences of government balance sheet series, so that lags of first differenced fiscal variables are weak instruments for their contemporaneous values.

[20]Based on results from the Pesaran test (2004) for cross-section dependence and the Arellano-Bond test (1991) for serial correlation, applied to specifications in Table 2.2. There is typically evidence of no more than second-order serial correlation. Standard errors are always adjusted to reflect the highest order of serial correlation present in residuals from each specification. The conclusions of our analysis are unaffected by using White, Newey or clustered standard errors instead.

2.3.3 Results

Table 2.2 presents results from estimating a model of the type introduced in Equation 2.1 on data for a panel of 10 OECD countries over a time span from 1990 to 2014. The dependent variable is the annual average of the 10-year government bond yield. Column (1) replicates a specification that is common – in spirit[21] – in the existing literature, where the fiscal stance is reflected by government liabilities, in percent of national income. It confirms the commonly found small but statistically significant effect of higher government debt in increasing borrowing cost, as in Ardagna et al. (2007) or Gruber and Kamin (2012), for example: an increase in assets, liabilities or net worth, relative to national income, by one percentage point would have an effect of about 2 basis points on yields. Column (2) contains one of our key results of interest: when government assets are included jointly with liabilities, both affect the bond yield significantly, with effects working in opposite directions.

Table 2.2: OECD panel: Baseline results

Dep. var.: gov. bond yield		**Including assets**		
	(1)	(2)	(3)	(4)
Liabilities (Δ_t)	1.776**	2.218**	0.369	
	(0.824)	(0.864)	(0.387)	
Assets (Δ_t)		-1.850**		
		(0.872)		
Net worth (Δ_t)			-1.850**	-2.046**
			(0.872)	(0.876)
Short-term interest rate	0.347***	0.351***	0.351***	0.352***
	(0.029)	(0.029)	(0.029)	(0.030)
Inflation rate	0.050**	0.042	0.042	0.039
	(0.021)	(0.027)	(0.027)	(0.025)
Real growth rate	0.043**	0.026**	0.026**	0.021***
	(0.015)	(0.011)	(0.011)	(0.007)
Eurozone dummy	0.409***	0.410***	0.410***	0.410***
	(0.135)	(0.128)	(0.128)	(0.127)
Test $\beta_{\text{Assets}} + \beta_{\text{Liabilities}} = 0$, p-value		0.35		
R-squared	0.777	0.799	0.799	0.799
Observations	209	209	209	209

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 is adjusted to exclude the impact of year fixed effects. All fiscal variables are in shares of national income.

[21]Here and subsequently, all balance sheet variables are included in first differenced terms – in this respect only, this specification is uncommon in the existing literature.

The absolute values of these two coefficients are similar in magnitude, and a Wald test of the hypothesis that they are equal does not reject this restriction. Another way of testing this restriction in presented in Column (3), which includes both government liabilities and net worth and thus the same model as column (2): it is government net worth that matters, rather than liabilities, when both are included. Hence, an increase in government debt that is entirely due to government asset accumulation should leave bond yields unaffected. The model in columns (2) and (3) thus suggests the presence of both an "asset effect" as well as a "net worth effect", as stipulated in Section 2.2.2: government assets matter, and the effects of both assets and liabilities are summarised by the inclusion of government net worth. The restriction that assets and liabilities enter with coefficients that are equal in absolute magnitude is thus empirically appropriate and is imposed in column (4) by including government net worth, which enters negatively and significantly. Interestingly, after controlling for government balance sheet variables and macroeconomic fundamentals, for this set of highly stable countries, Eurozone membership appears to increase yields significantly. Overall, results suggest that in evaluating governments' fiscal stances, bond markets look beyond simple measures of indebtedness such as total liabilities and consider their underlying reasons, as evidenced in the government's asset and net worth positions.

Table 2.3 assesses the robustness of these findings. Columns (1) and (2) ask whether our findings are driven by unusual developments during the recent crisis. Column (1) demonstrates that our main result of interest is also present on the pre-crisis (pre-2008) sample. Column (2) adds a dummy for crisis years, equal to 1 for the 2008 to 2012 period, and includes those interaction effects between this indicator and fiscal variables that are significant.[22] Increases in liabilities appear to be met with significantly more suspicion during crisis years. Column (3) includes a measure of the political leaning of the government in power – specifically, the share of left-leaning parties in government[23] – with the aim of controlling for at least part of time-varying institutional characteristics that might cause simultaneity. The measure enters positively and significantly, suggesting,

[22]Results are robust to letting the crisis last until 2014 (end of the sample period).

[23]It measures the cabinet posts of social democratic and other left parties as a percentage of total cabinet posts, weighted by number of days in office (Armingeon et al., 2015), ranging from 0 to 100%.

Table 2.3: OECD panel: Robustness

Dep. var.: gov. bond yield	**Pre-crisis sample**	**Crisis interaction**	**Political factors**	**Q4 yield (dep. var.)**	**Excl. US**	**Excl. EA 1998-2007**	**Non-EA obs.**	**EA obs.**	**By asset type**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Assets (Δ_t)	-2.381**	-2.005**	-1.884*	-1.661*	-2.055*	-1.837*	-2.642**	-1.155***	
	(0.964)	(0.877)	(0.980)	(0.869)	(1.005)	(0.988)	(0.989)	(0.293)	
Financial assets (Δ_t)									-1.422*
									(0.741)
Non-financial assets (Δ_t)									-2.453*
									(1.293)
Liabilities (Δ_t)	1.840**	1.530	2.182**	2.132**	1.560**	2.195**	2.359**	2.772***	2.130**
	(0.789)	(1.107)	(0.951)	(0.774)	(0.695)	(0.907)	(0.903)	(0.875)	(0.810)
Liabilities (Δ_t) $\times$ Crisis dummy		3.186***							
		(0.766)							
Short-term interest rate	0.308***	0.346***	0.350***	0.354***	0.358***	0.353***	0.355***		0.351***
	(0.018)	(0.028)	(0.027)	(0.026)	(0.040)	(0.023)	(0.028)		(0.029)
Inflation rate	0.027	0.044	0.046*	0.005	0.031	0.037	0.032	0.053*	0.043
	(0.021)	(0.029)	(0.025)	(0.032)	(0.031)	(0.033)	(0.031)	(0.030)	(0.026)
Real growth rate	0.000	0.022**	0.024**	0.016	0.018	0.033***	0.021*	0.004	0.024**
	(0.013)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.008)	(0.010)
Eurozone dummy	0.396***	0.383***	0.391***	0.282**	0.505***	0.505***			0.413***
	(0.112)	(0.121)	(0.137)	(0.136)	(0.133)	(0.105)			(0.121)
Eurozone dummy $\times$ Crisis dummy		0.124**							
		(0.051)							
Left-wing share of gov.			0.140***						
			(0.033)						
Test $\beta_{\text{Assets}} + \beta_{\text{Liabilities}} = 0$, p-value	0.53	0.31/0.15[1]	0.44	0.32	0.42	0.37	0.44	0.03	0.14/0.71[2]
R-squared	0.807	0.830	0.795	0.747	0.812	0.795	0.775	0.243	0.799
Observations	156	209	205	209	189	179	163	46	209

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield except where noted otherwise. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 is adjusted to exclude the impact of year fixed effects. All fiscal variables are in shares of national income. For tests of coefficient equality, in absolute terms: 1 The first p-value refers to the test involving liabilities in non-crisis times; the second to that involving liabilities in crisis times. 2 The first p-value refers to the test involving financial assets; the second to that involving non-financial assets.

perhaps, that some ideological factors are present in bond market pricing for these countries and years. Results are robust, as we continue to find a significant negative coefficient on assets, and do not reject the restriction that it is government net worth that matters for explaining bond yields. Column (4) uses the fourth-quarter average of the long-term bond yield as the dependent variable, in an attempt to match investors' information sets more closely, since information about fiscal stock measures in year t tends to be released in final form toward the end of the year in question, or even after. Results are unaffected.

Column (5) investigates the possibility that our results are driven by the United States, for which we identify strong "asset" and "net worth" effects in the following section. Results are robust for the subsample excluding the United States. Columns (6) to (8) explore the possibility that results are driven by specific developments in Euro area countries, where government bond yields converged strongly after the introduction of the Euro. Column (6) excludes Euro area countries (France, Germany and the Netherlands) during the period from 1998 to 2007, while Column (7) fully excludes these countries from 1998 onwards. Column (8) focusses on Euro area countries from 1998 onwards only.[24] Results are robust, although the coefficient equality between assets and liabilities is rejected in column (8), with more importance being accorded to liabilities than assets (but note the very small sample size here). Thus, although Euro area countries differ from other countries due to the introduction of the common currency, our central result of interest – the relevance of both sides of the government balance sheet for bond yields – is not driven by Euro area-specific developments. Finally, column (9) decomposes total assets into financial and non-financial assets, both of which appear to be contributing to the overall effect of assets in decreasing yields.[25] Note that we do not reject the restriction that the coefficients on assets and liabilities are equal in absolute magnitude in Columns (1) to (7) of Table 2.3, and that results are robust to including net worth instead of

[24]Results are unaffected when treating Denmark as an "honourary" EA member. The short-term interest rate is equal across Euro area countries from the introduction of the Euro area onwards and hence not included in column (8).

[25]Appendix D to this thesis discusses how this distinction is made. The restriction that both types of assets affect bond yields equally is not rejected, with a p-value of 0.32.

assets and liabilities separately, as Table B.3 in Appendix B shows.[26]

Finally, in Table 2.4, we confirm the robustness of our central findings to the replacement of year fixed effects with the cross-sectional mean of the dependent variable.The inclusion of year fixed effects has so far served to capture a common, non-stationary component in bond yields across countries. We replace these year fixed effects with the mean of the dependent variable, for the remaining nine countries in the sample (excluding country i itself), in order to enhance the comparability of the panel regression model employed here to a time series model for the United States (presented next), in which we cannot include year fixed effects, but are able to include a cross-sectional mean bond yield from a set of comparable countries. Conclusions are unaffected.

Table 2.4: OECD panel: Baseline incl. the mean dependent variable

Dep. var.: gov. bond yield		**Including assets**		
	(1)	(2)	(3)	(4)
Liabilities (Δ_t)	2.769**	2.981**	0.676	
	(1.180)	(1.168)	(0.694)	
Assets (Δ_t)		-2.305***		
		(0.777)		
Net worth (Δ_t)			-2.305***	-2.719**
			(0.777)	(0.984)
Short-term interest rate	0.267***	0.278***	0.278***	0.279***
	(0.031)	(0.028)	(0.028)	(0.028)
Inflation rate	0.029	0.009	0.009	0.003
	(0.036)	(0.037)	(0.037)	(0.041)
Real growth rate	0.046*	0.023	0.023	0.014
	(0.023)	(0.017)	(0.017)	(0.015)
Eurozone dummy	0.452***	0.468***	0.468***	0.464***
	(0.104)	(0.095)	(0.095)	(0.094)
Test $\beta_{\text{Assets}} + \beta_{\text{Liabilities}} = 0$, p-value		0.34		
R-squared	0.777	0.799	0.799	0.799
Observations	209	209	209	209

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country fixed effects. The cross-sectional mean of the dependent variable, excluding country i, is included as an explanatory variable. R2 is adjusted to exclude the effect of the inclusion of the mean yield. All fiscal variables are in shares of national income.

[26]We also investigated dynamic models that include the lagged dependent variable, and found that the long-run effects of fiscal variables were very similar to those estimated in the static model reported here. Worthwhile future research might explore the roles of the public pension system and its liabilities, index-linked government debt, the share of externally held debt and the maturity of outstanding debt for government bond yields.

Overall, our analysis of the data for this set of OECD countries suggests that the central country-specific fiscal factor driving bond yields is government net worth, as markets look beyond simple measures of indebtedness, such as the gross debt ratio, in evaluating a country's fiscal stance.

2.4 Time series evidence for the United States

This section extends the analysis of the effects of both sides of the government balance sheet from a panel setting to a long-term time series setting. Data on government liabilities and assets are available for the United States from 1870 to 2010 from Piketty and Zucman (2014), as are data on long-term bond yields from Jorda et al. (2017), which renders possible a similar analysis for the United States to the one conducted for a panel of OECD countries above. The data used in the analysis here are introduced in Section 2.4.1. Section 2.4.2 discusses time series properties and the model we employ. Section 2.4.3 presents our main results for the United States over the long term.

2.4.1 The data

The sample used for analysis here covers the United States over the period from 1870 to 2010. The dependent variable is, as above, the 10-year nominal government bond yield, drawn from Jorda et al. (2017). Figure B.2 in Appendix B displays the United States' long-term bond yield over the 1870-2010 period, and clearly shows a substantial decline in the yield since the 1980s. Note that we generally include as an explanatory variable the mean of a set of comparable countries' bond yields, also drawn from Jorda et al. (2017), in order to achieve the comparability of estimation approaches across the panel regression analysis presented above and the time series analysis presented here.[27] This is discussed in

[27] Jorda et al. (2017) typically source data on long-term government bond yields from various national sources for the period before 1948, and from the IMF's International Financial Statistics after, where in turn annual averages of secondary market rates for 10-year bonds are usually reported for the countries in question here. Thus, in recent decades at least, comparability to the bond yield series used in the panel analysis above is high.

more detail in Section 2.4.2 below.

Data on government balance sheet items for the United States are again drawn from Piketty and Zucman (2014). As above, we use total assets (GTA) and total liabilities (GLI) held by general government relative to national income at market value in the analysis. Figure B.3 in Appendix B displays total assets, total liabilities and net worth (GNW) – total assets less total liabilities – in percent of national income from 1870 to 2010. Short-term interest rate and macroeconomic data – specifically, a short-term rate for surplus funds, the CPI inflation rate and real growth rate – come from Jorda et al. (2017) and Piketty and Zucman (2014) and are used as controls for cyclical conditions, in line with the literature. Table B.4 in Appendix B provides units, summary statistics and sources for included variables.

2.4.2 Time series properties and model specification

The conclusions reached regarding the time series properties of relevant series for the United States over the 1870 to 2010 period are comparable to the ones reached for the much shorter panel. As before, the levels of government assets, liabilities and net worth, measured in percent of national income, are found to be non-stationary, as Table 2.5 shows. Once again we do not find robust evidence that assets and liabilities are cointegrated, as Table B.5 in Appendix B shows.

Table 2.5: United States: Testing for unit roots

Augmented Dickey-Fuller test, p-values				
	Bond yield	*Short rate*	*Mean yield**	*Growth*
Level	0.49	0.25	0.72	0.00
	Assets	*Liabilities*	*Net worth*	*Inflation*
Level	0.60	0.61	0.06	0.00
First difference	0.00	0.00	0.00	

The test includes a constant. Lag length selection by AIC. Null hypothesis: the series contains a unit root. *A mean yield constructed from 14 comparable countries using data from Jorda et al. (2017)

For the first differences of government assets, liabilities and net worth, measured in percent to national income, and for the inflation rate and the real growth rate, the evidence presented in Table 2.5 is clearly in favour of stationarity.[28] Long- and short-term interest rates are found to be non-stationary, but, importantly, cointegrated with a cross-sectional mean bond yield – constructed using data from Jorda et al. (2017) for a set of comparable countries[29] – as Table B.6 in Appendix B shows. The inclusion of this mean bond yield can be interpreted as an attempt to control for the cross-country common non-stationary component of the yield, which is achieved by the inclusion of year fixed effects (or a cross-sectional mean yield, as per Table 2.4) in the panel setting above. Hence, a valid regression approach could relate the bond yield to this mean yield, the short-term interest rate and the fiscal variables expressed in first differences. Thus, we are able to apply a regression model in the time series context here that corresponds very closely to the one used in the panel analysis above.

We employ the following reduced-form regression model to investigate the effects of government balance sheet components on government bond yields for the United States over the long term:

$$y_t = \alpha + \beta \Delta F_t + \gamma C_t + \delta \overline{z}_t + \varepsilon_t \tag{2.2}$$

Analogously to the model estimated in the previous section, the dependent variable is the long-term bond yield (y_t), while α is a constant, ΔF_t a vector of stationary fiscal policy variables, and C_t a vector of controls for current economic conditions. ΔF_t again includes total government liabilities (ΔGLI_t), total government assets (ΔGTA_t), and/or government net worth (ΔGNW_t), all measured in percent of national income and expressed in first differences, while C_t again includes a short-term interest rate (ISN_t),

[28] As mentioned above, fiscal variables are measured in percent of national income throughout this analysis. The first difference of these variables, accordingly, then is the first difference of the relevant ratio, e.g., of liabilities to national income.

[29] Data on a range of other macroeconomic variables, but not government assets, are available from this database. The data used here are long-term interest rates for Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland and the United Kingdom. The United States are excluded, as are Spain and Portugal, since interest rate series in the latter two follow markedly long-term different trends than in the other countries included. Conclusions are robust to using a mean in which the United States series is included in addition, and to using a mean from which Germany is excluded.

the inflation rate (CPI_t) and the real growth rate ($GROWTH_t$). $\overline{z}_t$ is the mean bond yield constructed from a set of comparable countries over the 1870 to 2010 period. The rationale for the inclusion of $\overline{z}_t$ is that it captures a common component in interest rates across countries. β, γ and δ are (vectors of) coefficients, and ε_t is the error term.

Finally, for central specifications, the Breusch-Godfrey test and Durbin's alternative test both indicate a high, but not unlimited order of serial correlation in the error term.[30] There is also evidence of heteroskedasticity in residuals. Hence, we generally use and report Newey-West (1987) standard errors, which are robust in this context.

2.4.3 Results

Table 2.6 presents results from estimating a model of the type introduced in Equation 2.2 on data for the United States from 1870 until 2010. The dependent variable is the long-term bond yield. Column (1) confirms, for the United States over the long term, an effect of the type and magnitude commonly found in the literature – for example, in Engen and Hubbard (2005) or Laubach (2009) for the United States – and also identified for the OECD panel in Section 2.3.3 above. Ceteris paribus, increasing government liabilities tend to be associated with significantly higher bond yields.[31] Furthermore, column (2a) shows that there are both an "asset effect" and a "net worth effect", as identified in the panel setting above: government liabilities matter, but government assets matter just as much: both enter with coefficients that are not statistically different in absolute magnitude. Column (2b) confirms that this finding is not driven by the pronounced spikes in assets and liabilities in 1932 and 1946 (see Figure D.31). These reflect the Great Depression and the war economy and are "dummied out" here.[32]

[30] For some of the specifications in Table 2.6, there is evidence of up to twelfth order serial correlation. Standard errors are adjusted accordingly.

[31] We depart from the literature by including liabilities in first differenced terms.

[32] Conclusions from formal tests for structural breaks and coefficient instability depend on the method used. Results from a Quandt Likelihood Ratio statistic ("QLR test"; Quandt, 1960) are sensitive to the extent of trimming. Based on coefficient estimates from recursive regressions, 1929, 1933, 1945, 1946, 1980 and 2007 suggest themselves as possible break years, and the null hypothesis of coefficient stability is rejected at each of these years except 1980. Results are qualitatively robust – as regards the signs and significance of government assets and liabilities – to allowing

Table 2.6: United States: Baseline results, full sample

Full sample		**Including assets**			
Dep. var.: gov. bond yield	(1)	(2a)	(2b)	(3)	(4)
Liabilities (Δ_t)	2.097*	3.725**	4.068**	-0.914	
	(1.260)	(1.675)	(1.682)	(1.196)	
Assets (Δ_t)		-4.639**	-4.173*		
		(2.273)	(2.520)		
Net worth (Δ_t)				-4.639**	-3.897**
				(2.273)	(1.766)
Short-term interest rate	0.277***	0.290***	0.286***	0.290***	0.289***
	(0.061)	(0.065)	(0.066)	(0.065)	(0.064)
Real growth rate	0.000	-0.023	-0.025	-0.023	-0.018
	(0.012)	(0.014)	(0.017)	(0.014)	(0.012)
Inflation rate	0.000	0.005	0.007	0.005	0.003
	(0.019)	(0.016)	(0.019)	(0.016)	(0.017)
Mean bond yield	0.696***	0.686***	0.686***	0.686***	0.685***
	(0.071)	(0.066)	(0.068)	(0.066)	(0.065)
Year dummy, 1932			-1.011**		
			(0.399)		
Year dummy, 1946			-0.654*		
			(0.367)		
Test $\beta_{\text{Assets}} + \beta_{\text{Liabilities}} = 0$, p-value		0.45	0.94		
R2	0.675	0.688	0.694	0.688	0.688
Observations	140	140	140	140	140

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield. Newey-West standard errors are reported in brackets below coefficient estimates. R2 adjusted to exclude the effect of the inclusion of the mean yield. All fiscal variables are in shares of national income.

Column (3) also tests the presence of the "net worth effect", equivalently to column (2a), by including both government net worth, which enters significantly, and government liabilities, which enter insignificantly. Column (4) then imposes the (empirically appropriate) restriction that the coefficients on assets and liabilities are equal in absolute terms by including government net worth, which affects borrowing cost negatively and significantly.

Table 2.7 estimates the specifications reported in Table 2.6 on the postwar sample, to ensure that the effects identified are not an artefact of times long gone. Although the sample shrinks substantially, the central features of our results remain unaffected.

coefficients to take different values before and after these years and to including dummy variables for these years.

Table 2.7: United States: Baseline results, postwar sample

Postwar sample		**Including assets**		
Dep. var.: gov. bond yield	(1)	(2)	(3)	(4)
Liabilities (Δ_t)	10.440***	11.883***	2.482	
	(3.426)	(2.894)	(5.025)	
Assets (Δ_t)		-9.401**		
		(4.289)		
Net worth (Δ_t)			-9.401**	-10.907***
			(4.289)	(2.362)
Short-term interest rate	0.433***	0.488***	0.488***	0.498***
	(0.073)	(0.068)	(0.068)	(0.064)
Real growth rate	0.065	0.001	0.001	-0.021
	(0.047)	(0.052)	(0.052)	(0.027)
Inflation rate	-0.005	0.041	0.041	0.045
	(0.067)	(0.048)	(0.048)	(0.045)
Mean bond yield	0.467***	0.405***	0.405***	0.409***
	(0.110)	(0.095)	(0.095)	(0.094)
Test $\beta_{\text{Assets}} + \beta_{\text{Liabilities}} = 0$, p-value		0.62		
R2	0.878	0.899	0.899	0.898
Observations	64	64	64	64

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield. Newey-West standard errors are reported in brackets below coefficient estimates. R2 adjusted to exclude the effect of the inclusion of the mean yield. All fiscal variables are in shares of national income.

Thus, we confirm the presence of both an "asset effect" and a "net worth effect" for the United States during the postwar period as well as over a longer horizon, analogously to those identified for a panel of OECD countries in recent decades in the previous section. Interestingly, effects of government balance sheet variables for the United States, especially during the post-war period, are considerably larger in magnitude than those identified for the set of OECD countries. This might, in part, be due to the inclusion of year dummies or mean yields in all specifications, which, for OECD countries, might be picking up the effect of the United States' yield spilling over into domestic yields. This in turn might dilute the effects of domestic factors on domestic yields outside of the United States.

Table 2.8 assesses the robustness of these findings. Column (1) explores the effects of the recent financial crisis starting in 2008, by limiting the sample to the post-war pre-crisis period. Results are robust, in the sense that there is no statistically significant difference in the effects of government assets and liabilities, in absolute terms, on bond yields. Column (2) examines the role of financial crises over the past century in driving

results, by including a crisis dummy and those interaction terms between explanatory variables and the dummy that enter significantly.[33] The effects of both sides of the government balance sheet, but of liabilities in particular, appear to be magnified during financial crises, which suggests that – not surprisingly perhaps – bond markets perceive there to be a link between sovereign risk and financial crises. Column (3) again deals with one potential source of time-varying unobservables – political factors – that may cause simultaneity by affecting both bond yields and fiscal variables. To control for this, we add a dummy variable that indicates whether the current president is leaning to the left or centre rather than to the right ideologically, sourced from Brambor et al. (2013).[34] This indicator enters insignificantly, in contrast to our findings for the OECD panel, and results are unaffected. Column (4) uses as the dependent variable the linear cointegrating combination of the bond yield, the mean bond yield from a set of comparable countries and the short-term interest rate, which leaves results unaffected.[35] Lastly, column (5) decomposes total government assets into financial and non-financial assets, both of which appear to be contributing to the overall effect of government assets in reducing yields.[36]

Note that the restriction that the coefficients on government assets and liabilities are equal in absolute value is not rejected in the specifications displayed in columns (1) and (3) to (5), and all results presented are robust to including government net worth instead of assets and liabilities, as Table B.7 in Appendix B demonstrates.

[33]This dummy is the systemic financial crisis indicator by Jorda et al. (2017), which is equal to 1 in 1873, 1893, 1907, 1929, 1984 and 2007. We experimented with additionally including the early 1930s and 2008 as crisis years, but results were unaffected.

[34]This is not simply an indicator for whether the acting president is Democratic or Republican – both Democratic and Republican presidents are, at times, categorised as centrist rather than left or right wing, respectively.

[35]Results are also unaffected when "demeaned" versions of the bond yield and the short-term interest rate are used as dependent and control variables, respectively. "Demeaned" here means that a mean yield or mean short-term interest rate, using data from Jorda et al. (2017) and constructed for a set of comparable countries, has been subtracted from the original series. Furthermore, results are robust to whether or not the mean bond yield for a set of comparable countries used in all specifications actually includes the United States' yield or not. These results are available upon request.

[36]The restriction that both asset types affect yields equally is not rejected, with a p-value of 0.88.

Table 2.8: United States: Robustness

Dep. var.: gov. bond yield	**Post-war, pre-crisis**	**Crisis interaction**	**Political factors**	**Lin. coint. comb.**	**By asset type**
	(1)	(2)	(3)	(4)	(5)
Assets (Δ_t)	-12.789***	-4.477**	-4.535*	-4.383**	
	(4.524)	(2.233)	(2.389)	(1.993)	
Assets (Δ_t) × Crisis dummy		-14.578*			
		(7.597)			
Financial assets (Δ_t)					-5.399
					(4.391)
Non-financial assets (Δ_t)					-4.498
					(2.926)
Liabilities (Δ_t)	16.637***	3.541**	3.730**	3.508**	3.752**
	(5.135)	(1.577)	(1.707)	(1.413)	(1.569)
Liabilities (Δ_t) × Crisis dummy		38.606**			
		(17.039)			
Short-term interest rate	0.497***	0.333***	0.283***		0.290***
	(0.071)	(0.060)	(0.066)		(0.066)
Real growth rate	-0.008	-0.022	-0.022	-0.023	-0.023
	(0.052)	(0.017)	(0.015)	(0.014)	(0.015)
Inflation rate	0.085*	0.001	0.010	0.008	0.004
	(0.047)	(0.014)	(0.019)	(0.018)	(0.017)
Mean bond yield	0.325**	0.636***	0.684***		0.687***
	(0.123)	(0.057)	(0.068)		(0.073)
Crisis dummy		-0.885**			
		(0.346)			
Left-wing or centrist head of gov.			-0.113		
			(0.157)		
Test $\beta_{\text{Assets}} + \beta_{\text{Liabilities}} = 0$[1]	0.43	0.38/0.00[2]	0.53	0.47	0.74/0.67[3]
R2	0.915	0.769	0.690	0.690	0.699
Observations	61	140	140	140	140

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield. Newey-West standard errors are reported in brackets below coefficient estimates. R2 adjusted to exclude the effect of the inclusion of the mean yield. All fiscal variables are in shares of national income. 1 p-values are reported. 2 The first p-value refers to the test involving assets and liabilities in non-crisis times; the second to that involving assets and liabilities in crisis times. 3 The first p-value refers to the test involving financial assets; the second to that involving non-financial assets.

2.5 Conclusion

We provide evidence that the extent to which any increase in government debt is used to fund government asset accumulation, which is reflected in the asset side of the government balance sheet and government net worth, matters for government bond yields empirically. This is true both for a panel of OECD countries in recent decades as well as for the United States over the long term. Note that throughout the analyses presented

here, we depart from existing research insofar as all government balance sheet variables are included in first-differenced rather than level terms in order to ensure regression balance.

Quantitatively, in our preferred specifications in both analyses, an increase in government debt that is solely due to government asset accumulation – for example, to finance a new railway – leaves yields unaffected. Thus, from the perspective of bond markets, not all government debt is created equal: markets discriminate between debt increases that are accompanied by government asset accumulation and those that are not. The central country-specific fiscal factor driving government bond yields – and hence government borrowing cost and fiscal sustainability – is government net worth rather than government liabilities.

Findings in this vein could have important policy implications. Our findings reflect a view on fiscal policy from the perspective of financial markets, but to the extent that this view is deemed pertinent, they speak against the imposition of indiscriminate brakes on the raising of additional government debt and suggest that fiscal austerity policies ought to focus on constraining government borrowing when it does not contribute to the accumulation of government assets.

A range of interesting topics for possible future research emerge from this analysis. For one thing, it could be informative to decompose government assets into more or less economically productive assets or into more or less liquid assets, using national sources, since these components might plausibly have differential implications for yields. It could also be interesting to explore the relevance of contingent pension liabilities in an analysis of this kind, if estimates become available for sufficiently many countries and years. Expanding the analysis presented here by considering the extent of attention paid to fiscal and macroeconomic fundamentals by markets, building on Muellbauer (2013), might also shed more light on the underlying drivers of our results. Finally, the roles of index-linked government debt, the share of externally held debt and the maturity profile of outstanding debt might be important additional dimensions to consider in an analysis of the fiscal policy determinants of government bond yields.

Chapter 3

Government asset accumulation and economic growth

The analysis in this chapter finds that there is an economically and statistically significant difference in the growth effects of government investment and government consumption. Our empirical approach is twofold. First, we explore the predictive relevance of government investment and government current spending or consumption for future income, both for a set of OECD countries and globally. Second, we examine the effects of government investment and government consumption in a standard empirical growth model in the spirit of Solow (1956), using econometric methods suitable for addressing possible endogeneity on data for 151 countries since 1960. Results from both approaches point to a positive contribution of government investment to economic growth, a negative one of government consumption, and a statistically significant difference between the effects of the two. These findings imply that the composition of government expenditure – and hence government budget deficits and balance sheets – impacts future growth prospects.

3.1 Introduction

The American economist Lawrence Summers recently claimed that "public investment really is a free lunch", as it is a way for "governments to strengthen both the economy and their own financial positions" (Financial Times, October 6, 2014). This thesis has so far investigated the second part of his argument, namely the links between fiscal sustainability and government asset accumulation. We found that it is the extent to which a budget deficit or debt increase is accompanied by government asset accumulation that matters, and hence that the distinction between government investment and government current spending or consumption is crucial from the perspective of bond markets. This chapter focusses on the first part of Summers' claim. Does government investment affect economic growth and if so, given our findings so far, does it do so in a way that is significantly different from the way in which government current expenditure or consumption affect growth?[1]

Investigating what bond markets "think" of government budget deficits or debt and the extent to which these are driven by government asset accumulation – which was undertaken in Chapters 1 and 2 of this thesis – implicitly involves taking a *normative* view of fiscal policy. Bond markets plausibly look more favourably upon budget deficits or debt increases that are accompanied by government asset accumulation than those that are not because they either (i) assume government investment is helpful for future growth, which makes any given fiscal policy stance more sustainable and hence decreases default risk ("growth channel"), or (ii) take government investment to add to the economy's capacity,

[1]The terms "public investment" and "government investment" are often used interchangeably, although by definition in international statistical conventions, the "public sector" includes public financial and non-financial corporations in addition to "general government" institutions, which in turn comprise central, local and state government institutions and social security funds (2008 SNA, ESA 2010). The focus of this chapter, as in preceding ones, is on *government* investment. Furthermore, "government current spending" and "government consumption" are both frequently used to refer to that portion of expenditure that does not amount to investment. Roughly speaking, consumption is a subset of current spending, excluding, relative to the latter, social benefits and subsidies. Both measures exclude interest payments of the government on its outstanding debt. The focus of the predictive regressions for OECD countries will be on government *current spending* to enable a direct comparison to results in Chapter 1. For more standard growth regressions, estimated on a "world" sample of 151 countries, the focus will be on government *consumption* for data availability reasons. Appendix D discusses these distinctions in more detail.

which reduces inflationary pressure and hence inflation risk ("inflation channel").[2] It seems a natural and worthwhile next step, then, to explore the workings of these channels in a *positive* analysis: do different types of government expenditure – specifically, government investment, which adds to government assets, and government current spending or consumption, which do not – affect economic growth and/or inflation differently? Our focus here will be on growth effects, but a worthwhile future analysis could investigate corresponding inflation effects.

Why should the distinction between government investment and government current spending or consumption matter in the first place? Most fundamentally, the former amounts to capital formation and thus affects government assets and the economy's future production possibilities, while the latter does not. The former leaves behind bridges, roads and so on, the latter "only memories" (Thoma, 2013). Hence, it seems plausible that there might be an economically salient difference between government investment and government consumption – from the perspective of government bond markets and hence for fiscal sustainability for one thing (see Chapters 1 and 2), but perhaps also in their impact on economic growth. This latter possibility is the focus of the analysis presented in this chapter.

Impetus to investigating the growth effects of government asset accumulation is provided by the fact that both government net worth – the balance of government assets and liabilities – and government investment have declined relative to national income or GDP in many OECD countries recently (Atkinson, 2015; IMF, 2014; Piketty and Zucman, 2014). These declines are linked: any part of a budget deficit not used to finance investment will have contributed to the reduction in net worth. It also seems likely that the focus of fiscal policy on austerity following the financial crisis played a part: in aiming to reduce debt and deficits, policy makers seldom appeared to explicitly take into account the implications of different government spending types for government asset accumulation.[3]

There are long-standing literatures that investigate empirically the effects of total investment, private investment, government investment

[2] A closely related channel works via expected depreciation (Ardagna et al., 2007).

[3] It might also be easier politically, in the short term at least, to reduce investment spending (e.g., on road maintenance) than to reduce consumption spending (e.g., on wages of government employees).

and government consumption, among many other potentially relevant explanatory variables, on economic growth in the spirit of Solow (1956). A common – although not unanimous – conclusion appears to be that total investment has a positive and significant effect on growth (see Mankiw et al. (1992) or Islam (1995), and Barro (2012) for a different view), while the evidence for government investment and government consumption is more mixed (Devarajan et al. (1996) and IMF (2014) on investment; Attanasio et al. (2000) and Caselli et al. (1996) on consumption). Few have explicitly explored the possible difference in the growth effects of different government expenditure types. Note that, even though this literature is typically described as conducting "growth regressions", the majority of analyses investigates level effects rather than growth rate effects – that is, in the usual model set-up, explanatory variables only affect the *levels* of the parallel equilibrium growth paths to which countries are thought to converge under the hypothesis of conditional convergence, but not their *slopes* (Durlauf et al. (2005); see Bond et al. (2010) for an exception). In keeping with much of the existing literature, our analysis also focusses on these level effects.

Thus, in this chapter, we use data from the European Commission DG ECFIN's Annual Macroeconomic database (AMECO) for 31 OECD countries, exactly as in Chapter 1, as well as data from the IMF (2017) and the World Bank for 151 countries globally to explore the growth effects of government investment and government current spending or consumption. Our empirical approach is twofold. First, we investigate the relevance of different government expenditure types as predictors of future income per capita in a predictive regression model. We find that government investment predicts future income significantly more positively than government current or consumption expenditure do, both for the set of OECD countries considered in Chapter 1 and globally. To merely establish consistency with our conclusions from previous chapters, this finding is sufficient: it is all that is needed for bond markets to rationally view government budget deficits that are due to government investment or government debt increases that are accompanied by government asset increases more favourably than those that are not. But in order to shed some light on the causal mechanisms underlying the significant difference in the predictive relevance of government investment and government

consumption for future income, second, we also examine their effects in a standard empirical growth model in the spirit of Solow (1956), while addressing possible bias, endogeneity and measurement error. Building on Islam (1995) and Bond et al. (2001), we use Two-Stage Least Squares ("2SLS") estimation on annual data and System Generalised Method of Moments ("GMM") estimation on data in five-yearly intervals for 151 countries globally. We robustly conclude in this set-up, too, that government investment and government consumption have significantly different implications for economic growth: we find that government investment aids growth, while government consumption hinders growth.

Results from both approaches are consistent with our conclusions from Chapters 1 and 2, and in particular with the hypothesis that the effects of fiscal policy on bond yields identified there are working, at least in part, via a "growth channel". Our findings suggest that the composition of government expenditure – and hence government budget deficits and government balance sheets – affects an economy's growth path, and thus that bond markets are justifiedly distinguishing investment-driven from consumption-driven budget deficits or debt increases. To the best of our knowledge, the possible difference in the growth effects of government investment and consumption has not been investigated for a set of OECD countries specifically, globally at the scale that the IMF (2017) data allow, or using an appropriate econometric methodology to address the scope for endogeneity in a standard growth framework.

The remainder of this chapter proceeds as follows. Section 3.2 discusses our data, estimation samples and the stationarity properties of key series. Section 3.3 introduces our econometric approach for and results from the analysis of the predictive relevance of different government expenditure types for future income. Section 3.4 focusses on estimating standard empirical growth models. After a brief synthesis of the existing literature, we present our model and results first for annual data and then for data in five-yearly intervals. Section 3.5 offers some conclusions and suggests possible avenues for future research.

3.2 The data

This section discusses the samples we use for econometric analysis in this chapter, as well as the stationarity properties of the series contained therein. We use two main samples for analysis, one focussing on a set of OECD countries – in order to achieve direct comparability to our results from earlier chapters – and one on 151 countries globally.

3.2.1 The OECD sample

Our OECD sample covers the same countries that the analysis in Chapter 1 focusses on, that is, 31 OECD countries over the period from 1960 to 2014. For this set of countries as well as for the "world" sample discussed next, data on real GDP per capita, government investment and private investment come from the IMF (2017), while data on population growth and inflation come from the World Bank. Data on government current spending, total government revenue and short-term interest rate are drawn from AMECO.[4]

3.2.2 The "world" sample

The available data from the IMF (2017) include real GDP per capita and private and government investment flows for 170 countries. We combine this with data from the World Bank on government consumption and population growth, the overlap of which with the IMF data covers 164 countries. Note that private investment, government investment and government consumption are all always measured in percent of GDP.

From this set, countries are dropped due to either frequent missing values in relevant series or heavy resource dependence, so that our main results are based on a sample of 151 countries. Thus, we exclude periods and countries with frequent missing values or gaps in relevant series, or with

[4]The sample used in Chapter 2 is almost fully included in this set of countries. The only country not covered by the AMECO data, and hence not included in the Chapter 1 sample but included in Chapter 2, is Australia. Predictive regression results presented below are robust to the inclusion of Australia wherever this is possible. In Chapter 1, we focus on the period after 1990. Results presented in Section 3.3.3 are robust to available omitting data prior to 1990. Results are also robust to using data on government investment drawn from AMECO rather than the IMF.

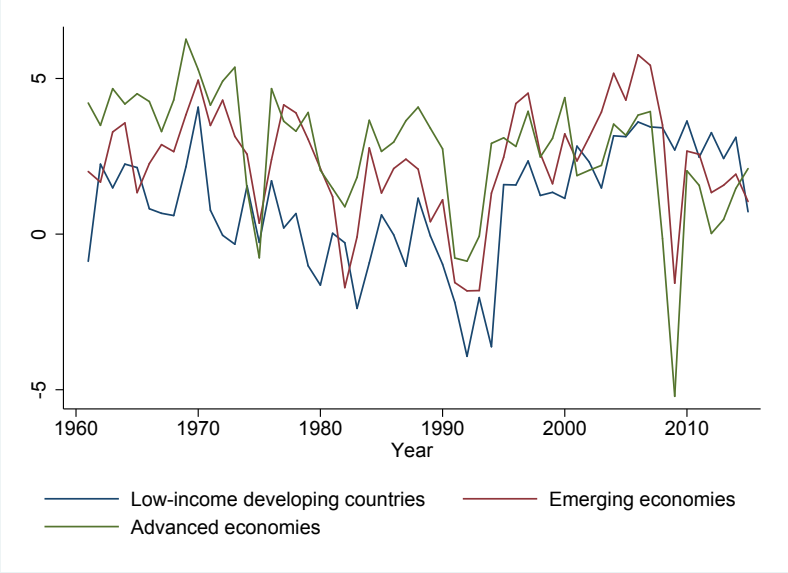
too short time series available. Specifically, we drop Cape Verde, Ethiopia and Zambia, as there are fewer than 10 consecutive time series observations available for each of these. We confirm the robustness of our results to excluding countries for which fewer than 25 time series observations are available. We also exclude from the analysis a set of resource-dependent countries, where GDP is, to a large extent, the result of resource extraction rather than value added and one would not expect a Solow-type model to approximate the growth process well (Mankiw et al., 1992). Specifically, we drop from the sample countries for which, on average over the sample period, more than 70% of exports (as a share of merchandise exports) are fuel exports, and those for which, on average over the sample period, more than 30% of GDP derives from natural resource rents, both based on data from the World Bank. These criteria are chosen such that the countries we exclude on their basis are consistent with those countries excluded by Mankiw et al. (1992) and Bond et al. (2010), based on their respective sample periods. Thus, we exclude Bahrain, Botswana, Gabon, Iran, Iraq, Kuwait, Oman, Saudi Arabia, the United Arab Emirates and Venezuela. We confirm the robustness of our results to additionally excluding a set of further resource-rich countries, namely Algeria, Angola, Azerbaijan, the Republic of Congo, Equatorial Guinea, Liberia, Nigeria, Qatar, Trinidad and Tobago and Yemen, yielding a sample that covers 141 countries.

Tables C.1 and C.2 in Appendix C contain summary statistics, units and sources for key included variables. Table C.3 in Appendix C lists the countries and time periods in the largest sample we use in estimation.

Figures 3.1 to 3.4 graph our main series of interest, depicting unweighted cross-sectional means for three different country groups, as per the IMF's World Economic Outlook grouping.

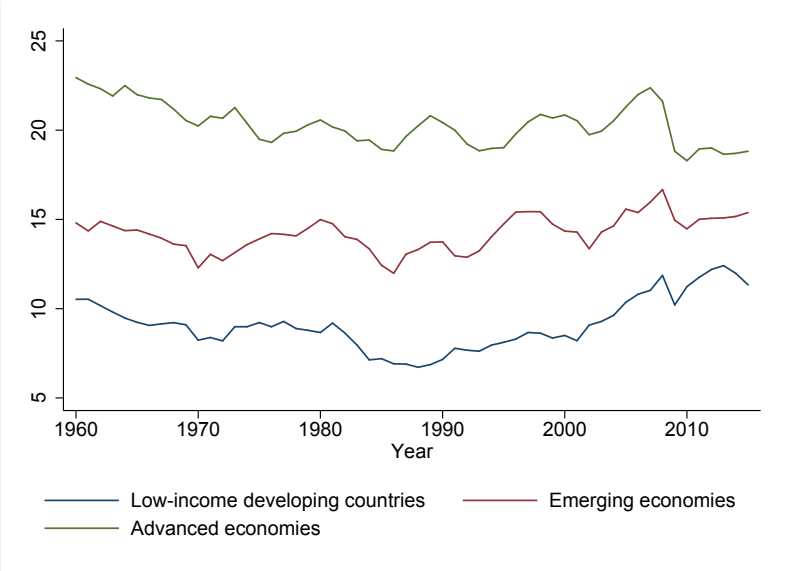
Figure 3.1 shows the growth rate of real GDP per capita and suggests a substantial degree of co-movement in GDP growth between country groups, in particular between advanced and emerging economies. Figure 3.2 depicts private investment as a share of GDP and demonstrates that the private investment share is substantially higher the more advanced the country (group).

Figure 3.1: Year-on-year growth in real GDP per capita



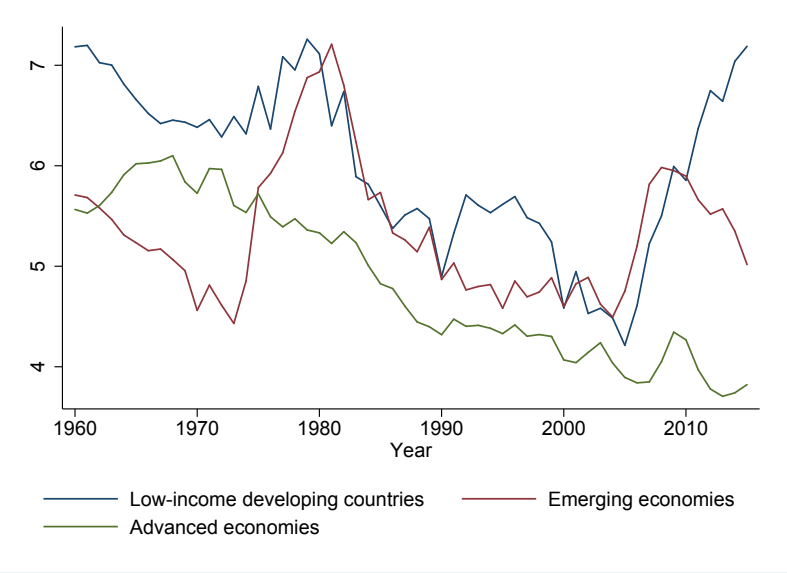
In percent. Country grouping per the IMF's World Economic Outlook.
Source: IMF (2017)

Figure 3.2: Private investment as a share of GDP



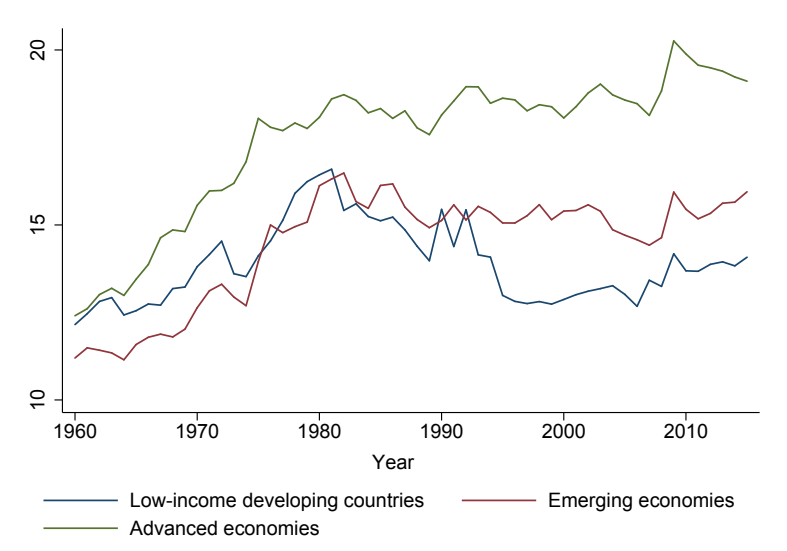
In percent. Country grouping per the IMF's World Economic Outlook.
Source: IMF (2017)

Figure 3.3: Government investment as a share of GDP



In percent. Country grouping per the IMF's World Economic Outlook.
Source: IMF (2017)

Figure 3.4: Government consumption as a share of GDP



In percent. Country grouping per the IMF's World Economic Outlook.
Source: World Bank

Figure 3.3 displays government investment as a share of GDP, a gradual decline in the government investment share since the 1960s for the group of advanced economies[5] and somewhat of a recent resurgence in case of lower-income countries. Finally, Figure 3.4 shows government consumption as a share of GDP and an upward trend in government consumption for both advanced and emerging economies, which is less present for low-income developing countries.

3.2.3 Time series properties

To investigate the stationarity properties of the data, standard panel unit root tests are applied to series in the two samples. Table 3.1 presents results for both samples. For the sample of 31 OECD countries, we use the panel unit root test developed by Im, Pesaran, and Shin (2003; "IPS test"), which combines the t-statistics from tests for each country individually, in line with our approach in Chapters 1 and 2.

Table 3.1: OECD and "world" samples: Testing for unit roots

p-values	OECD sample	"World" sample
Variable	**IPS test**	**ADF test**
Government current spending	0.00	n/a
Government consumption	0.00	0.00
Government investment	0.00	0.00
Government revenue	0.01	n/a
Short-term interest rate	0.00	n/a
Inflation rate	0.00	0.00
Real GDP per capita, log	0.94	0.00
Real GDP per capita, log, w/ trends*	0.00	0.00
Real GDP, log	0.62	0.00
Real GDP, log, w/ trends*	0.00	0.00

Null hypothesis: all panels contain unit roots ($\phi_i = 0 \; \forall \, i$). Series are cross-sectionally demeaned. For the ADF test, modified inverse chi-squared test result reported for ADF test as $N = 151$. *Country-specific linear time trends.

[5]The IMF (2014) also notes a trend decline in public investment in advanced economies from around 4% of GDP in the 1980s to around 3% of GDP today.

For the sample of 151 countries globally, we use the Augmented Dickey-Fuller test (Dickey and Fuller, 1979; Choi, 2001; "ADF test"), which combines the p-statistics from tests for each panel individually. We choose this test for the "world" sample because one of its test statistics – the modified inverse chi-squared – is recommended for use when the panel dimension N is large ($N = 151$ here; Choi, 2001). Tests are applied to demeaned series to reflect the fact that the models we use always include year or period fixed effects.[6]

The evidence is strongly in favour of stationarity for almost all key series of interest, in line with our conclusions in previous chapters. The only exceptions are the log levels of GDP and GDP per capita, which appear to be non-stationary for the set of OECD countries considered. However, since the models that we estimate on the OECD subsample always allow for unobserved country-specific heterogeneity in long-run average growth rates in the form of country-specific linear time trends, the relevant test results to consider for the OECD sample are log GDP and log GDP per capita when such trends are allowed for, which suggest that these series are stationary.

3.3 Predictive regressions

This section investigates the predictive relevance of different government expenditure types for future income per capita. Our initial focus here is on the set of OECD countries for which Chapter 1 examined the relevance of government budget deficit composition from the perspective of bond markets. We present our model in Section 3.3.1, our main questions of interest in Section 3.3.2 and our results in Section 3.3.3.

3.3.1 Model specification

Our starting point for the analysis is a standard predictive or forecasting regression model.

[6]This is equivalent to estimation in terms of deviations from the cross-sectional mean. All conclusions are robust to testing the log transformation of the relevant series.

It can be written as

$$y_{i,t} = \sum_{k=1}^{p} \alpha_k y_{i,t-k} + ... + \sum_{k=1}^{p} \beta_k X_{i,t-k} + \gamma_i + \delta_t + \phi_i t + \varepsilon_{i,t} \qquad (3.1)$$

where p reflects the number of lags of the dependent and explanatory variables included. $y_{i,t}$ represents the logarithm of the level of GDP per capita or total GDP, measured in constant price international dollars, of country i at time t. The vector $X_{i,t-k}$ contains a set of explanatory variables $x^j_{i,t-k}$. Note that in this predictive model set-up, all explanatory variables are included non-contemporaneously, that is, lagged at least once ($k \geqslant 1$). β_1 to β_p are vectors of coefficients. γ_i are country-specific fixed effects that allow for time-invariant unobserved heterogeneity in income levels, while $\phi_i t$ are country-specific linear time trends that allow for unobserved heterogeneity in long-run average growth rates. δ_t are year-specific fixed effects that will capture elements in productivity and GDP growth that are common across countries. $\varepsilon_{i,t}$ is the error term.

The set of explanatory variables $X_{i,t-k}$ comprises both a set of fiscal variables of interest – most importantly, government investment $x^{igov}_{i,t-k}$ and government current spending or consumption $x^{cgov}_{i,t-k}$ – as well as a set of macroeconomic control variables. Specifically, the set of control variables is derived from conventional growth theory (discussed in more detail in Section 3.4.2 and Appendix C.2), thus including private investment $x^{ipri}_{i,t-k}$ and the population growth rate $x^{pop}_{i,t-k}$ (plus 0.05), as per the canonical Solow (1956) growth model and its empirical implementation by Mankiw et al. (1992). We also test the robustness of our results to using a set of control variables derived from our bond yield model presented in Chapters 1 and 2 above, thus comprising government revenue $x^{rgov}_{i,t-k}$, a short-term interest rate $x^{isn}_{i,t-k}$ and the inflation rate $x^{cpi}_{i,t-k}$, or to using all control variables jointly.[7] Throughout, all fiscal and investment variables are measured in logarithms and in percent of GDP.

As an aside, note that when we use government current spending as a measure of government non-investment expenditure and the set of macroeconomic controls derived from our bond yield analysis, our regression model includes a full accounting decomposition of the primary government budget deficit into its constituent parts, like in Chapter 1. This means

[7]Data availability constrains this exercise to the sample of OECD countries.

that in these specifications, we are testing the validity of the restriction that all components of the budget deficit affect future growth equally, which the inclusion of the deficit rather than its constituent parts would amount to.

In the model presented in Equation 3.1 above, the long-run predictive effect of variable x_{it}^{j} for future income per capita is calculated as

$$\vartheta^{j} \equiv \frac{\beta_1^j + ... + \beta_p^j}{(1 - \alpha_1 - ... - \alpha_p)}. \tag{3.2}$$

We choose the lag length of our model to be $p = 3$, based on a combination of results from a sequence of tests of the joint significance of first, second, third and higher lags of variables included on the right-hand side of the regression and a more formal lag length selection approach using the Akaike Information Criterion (AIC). However, we test the robustness of our main results to using shorter lag lengths.

3.3.2 Main questions of interest

We examine here whether there is a significant difference in the predictive relevance of government investment and government current spending or consumption for future income. In doing so, we assess whether the effects of fiscal policy on bond yields identified in Chapters 1 and 2 are working, at least in part, via a "growth channel", according to which bond markets view government asset accumulation as helpful for future economic growth, which decreases the default risk inherent in any given fiscal policy stance. In Chapters 1 and 2 we find that, from the perspective of bond markets, it is the extent to which a government budget deficit or debt increase is accompanied by government asset accumulation that matters.

In particular, we ask here whether (i) government investment and government current spending or consumption predict future income significantly differently and (ii) government investment is more helpful, in a predictive sense, for future income than government current spending or consumption. Thus, in the context of the predictive regression model introduced above, we test whether

$$\vartheta^{igov} \neq \vartheta^{cgov} \text{ and } \vartheta^{igov} > \vartheta^{cgov}. \tag{3.3}$$

The presence of these differences would mean that the composition of government expenditure matters, in a predictive sense, for an economy's total future growth path.

Note that because of the focus of Chapter 1 of this thesis on an accounting decomposition of the government budget deficit into government investment, government current spending (comprising all non-investment expenditure) and government revenue, we here also use government current spending as a measure of government non-investment expenditure for the sample of OECD countries. However, much of the existing empirical growth literature has focussed on government consumption instead, which is a subset of government current spending. Furthermore, data availability for government current spending is poor for non-OECD countries. Hence, we also present estimates in which government consumption is used as a proxy for government non-investment spending for OECD countries, and focus on government consumption for the "world" sample.[8] Similarly, results from estimating standard growth models, mostly estimated on the "world" sample and presented in Section 3.4, will also focus on government consumption, in keeping with the existing literature and for data availability reasons.

3.3.3 Results

Here, we present results from estimating a model as introduced in Equation 3.1 above. The total predictive effects of fiscal and investment variables for future income are calculated as per Equation 3.2. As mentioned previously, here and subsequently, we focus on level effects rather than growth rate effects.

Table 3.2 contains results for the set of 31 OECD countries on which the analysis in Chapter 1 is based, reporting long-run coefficients for central variables of interest. Table C.4 in Appendix C contains more detailed regression results. Throughout, these results point to a significant difference[9] in the predictive relevance for future income per capita of government investment and government non-investment expenditure, which

[8]Table D.4 in Appendix D outlines the distinction between government current spending and government consumption in detail.

[9]In this and subsequent tables, we report the result of the test $\vartheta^{igov} - \vartheta^{cgov} = 0$.

is measured either as government current spending, in line with Chapter 1, or as government consumption, in line with much of the empirical growth literature. Government current and consumption expenditure predict future income significantly negatively, while government investment is associated positively with future income, although not always significantly so. Thus, in a predictive sense, government investment appears to be significantly more helpful for future income than either type of government non-investment expenditure for this set of OECD countries. This result is robust to changes in the lag structure (columns (2) and (3)); to omitting available data from before 1990, in line with Chapters 1 and 2 (column (4)); to replacing government current expenditure by government consumption expenditure (column (5)); to adjusting the set of macroeconomic control variables to reflect those used in our model of bond yield determinants in Chapters 1 and 2 instead of those commonly employed in the empirical growth literature in the spirit of Solow (1956) (columns (6) and (7)); and to replacing the dependent variable to be total real GDP rather than real GDP per capita (column (8)). Furthermore, results suggest that private investment predicts future income positively and highly significantly.

Interestingly, too, the fact that the two expenditure components of the primary government budget deficit – which are included jointly with the revenue component in columns (6) and (7), so that here, a full decomposition of the budget deficit is included in the regression – enter with coefficients that are significantly different suggests that the components of the deficit do not have a uniform predictive effect on future income. Instead, these results imply that the predictive relevance of the primary government budget deficit for future income depends on the deficit's underlying composition.

Next, we extend this analysis to our "world" sample, which covers 151 countries. For data availability reasons[10], in doing so, we focus on government consumption rather than current spending and on "growth model" control variables.[11] Table 3.3 presents results, again reporting long-run coefficients for central variables of interest. Table C.5 in Appendix C

[10]Data on government revenue and short-term interest rates were not available for many non-OECD countries in many years.

[11]Table Table 3.2 shows that our conclusions for the OECD sample are robust to employing growth model control variables and to replacing government current spending by government consumption.

Table 3.2: Predictive regressions: OECD sample

OECD sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gov. investment	0.018*	0.018	0.005	0.024**	0.022**	0.013	0.021	0.029***
	(0.011)	(0.012)	(0.010)	(0.010)	(0.010)	(0.020)	(0.015)	(0.011)
Gov. non-inv. exp.*	-0.304***	-0.296***	-0.243***	-0.309***	-0.323***	-0.470***	-0.389***	-0.282***
	(0.059)	(0.068)	(0.060)	(0.073)	(0.081)	(0.095)	(0.088)	(0.053)
Private investment	0.094***	0.169***	0.072***	0.088***	0.116***		0.159***	0.128***
	(0.022)	(0.034)	(0.023)	(0.021)	(0.025)		(0.035)	(0.021)
Government revenue						0.225***	0.123*	
						(0.082)	(0.067)	
Test $\vartheta^{igov} = \vartheta^{cgov}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dependent variable	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	Total GDP
*Non-inv. exp. incl. as	Current exp.	Current exp.	Current exp.	Current exp.	Consumption	Current exp.	Current exp.	Current exp.
Controls	Solow model	Solow model	Solow model	Solow model	Solow model	Yield model	Combined	Solow model
Lag length (p)	3	1	2	3	3	3	3	3
Observations	636	698	667	570	636	636	636	636

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. p is the number of lags of dependent and control variables included. Not all estimated coefficients are reported. Country fixed effects, year fixed effects and country-specific linear time trends are included. Solow model controls: private investment and the population growth rate. Yield model controls: government revenue, the inflation rate and a short-term interest rate. Column (4) omits available observations from before 1990.

Table 3.3: Predictive regressions: "World" sample

"World" sample	(1)	(2)	(3)	(4)	(5)	(6)
Gov. investment	0.045***	0.086***	0.051***	0.045***	0.042**	0.055***
	(0.015)	(0.018)	(0.015)	(0.017)	(0.017)	(0.015)
Gov. consumption	-0.153***	-0.235***	-0.152***	-0.088*	-0.094*	-0.151***
	(0.043)	(0.056)	(0.041)	(0.051)	(0.048)	(0.041)
Private investment	0.086***	0.124***	0.087***		0.120***	0.085***
	(0.024)	(0.035)	(0.027)		(0.033)	(0.024)
Test $\vartheta^{igov} = \vartheta^{cgov}$	0.00	0.00	0.00	0.02	0.01	0.00
Dependent variable	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	Total GDP
Controls	Solow model	Solow model	Solow model	Yield model*	Combined	Solow model
Lag length (p)	3	1	2	3	3	3
Observations	5,851	6,153	6,002	5,181	5,181	5,851

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. p is the number of lags of dependent and control variables included. Not all estimated coefficients are reported. Country fixed effects, year fixed effects and country-specific linear time trends are included. Solow model controls: private investment and the population growth rate. *Yield model controls: here, this means that private investment and the population growth rate are excluded as controls, and the inflation rate is included. Government revenue and short-term interest rates were not available for a sufficiently high number of country-year observations for countries outside the OECD.

contains more detailed regression results. As before, we make adjustments to the lag structure of the model used (columns (2) and (3)), to the set of control variables (columns (4) and (5)) and the dependent variable (column (6)). Throughout, government investment predicts future income positively and highly significantly, while government consumption predicts future income negatively and significantly. Thus, globally, the difference in the predictive relevance of government investment and government consumption stems from both types of government expenditure significantly predicting future income, albeit in opposite directions. Put differently, government investment is more strongly associated with higher future income for the global sample than for the set of OECD countries, perhaps because the stock of government capital per capita is much higher in OECD than non-OECD countries (cf. Figure C.1). As above, private investment predicts future income positively and highly significantly.[12]

Figure 3.5 and Figure 3.6 graph the cumulative changes in the predicted paths of (log) real GDP per capita emerging from column (5) in Table 3.2 and column (1) in Table 3.3 in response to a permanent one-unit change in (log) government investment and (log) government consumption, respectively, in percent of GDP in period $t = 0$, holding all other explanatory variables constant. We can see graphically here that for the set of OECD countries, the total predictive effect of government investment for future growth is smaller, while the predictive effect of government consumption for future growth is larger, in absolute terms, than for the "world" sample.

The significant difference in the predictive relevance of government investment and government non-investment expenditure for future income, with the former predicting future growth significantly more positively than the latter, is in line with our hypothesis presented in Equation 3.3 and our conclusions from Chapters 1 and 2. Plausibly, thus, the effects of fiscal policy on bond yields identified there are working, at least in part, via the expectation that government asset accumulation is helpful for future growth, which reduces default risk.

[12]This is an interesting result in its own right (cf. Attanasio et al., 2000).

Figure 3.5: Predictive effects of government investment

Effect on future GDP per capita of a permanent one-unit change in the log of government investment

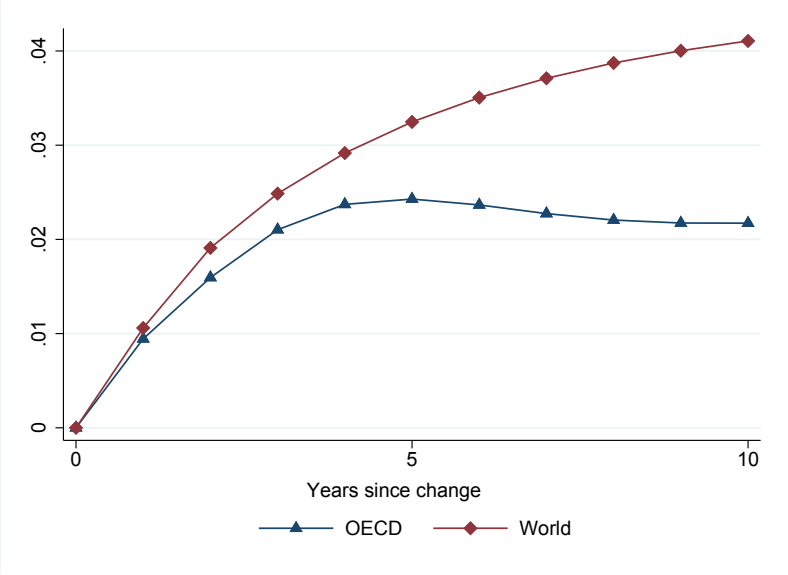
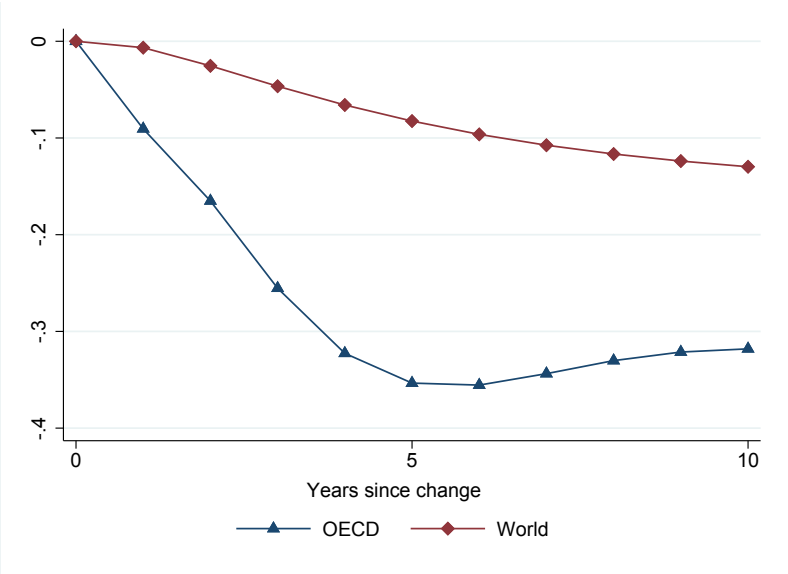


Figure 3.6: Predictive effects of government consumption

Effect on future GDP per capita of a permanent one-unit change in the log of government consumption



To merely establish consistency with our conclusions in Chapters 1 and 2, this significant difference, present both for the set of OECD countries and globally, is sufficient. It is all that is needed for bond markets to rationally view government investment as more beneficial for future growth than government current spending – and accordingly penalise government budget deficits due to investment less than deficits due to current spending, or an increase in government debt that is accompanied by asset accumulation less than one that is not. However, in the following, we move beyond the predictive perspective and estimate conventional growth models using econometric methods suitable for addressing possible endogeneity.

3.4 Conventional growth models

This section extends the analysis of the growth effects of government investment and government consumption from a predictive regression setting to a set of models and estimation approaches that are common in the existing empirical growth literature. In doing so, we move beyond predictive relevance towards a more causal interpretation of effects by addressing possible bias and endogeneity. For data availability reasons and in line with the existing literature, our proxy for government non-investment expenditure here is government consumption. After briefly synthesising the existing empirical literature on investment and fiscsal determinants of growth in Section 3.4.1, we outline our model, econometric approach, main questions of interest and results for annual data and 2SLS-based estimation in the spirit of Islam (1995) in Section 3.4.2. Section 3.4.3 proceeds analogously, for consistency with the literature focussing on data in five-yearly intervals and system GMM as proposed by Bond et al. (2001).

3.4.1 The literature

The existing empirical literature on growth determinants in the spirit of Solow (1956) has used time series (Aschauer, 1989), cross section (Mankiw et al., 1992) and panel data (Islam, 1995) as well as single-equation reduced forms (ibid.) and VARs (Kamps, 2005) to investigate, among many other

potentially relevant explanatory variables, the roles of total investment, private investment, government investment or government consumption in economic growth. As mentioned in the introduction, this literature is typically described as conducting "growth regressions", but mostly focusses on explaining level rather than growth rate effects – that is, in the usual econometric specification, explanatory variables affect the levels, but not the slopes of the parallel equilibrium growth paths to which countries are thought to converge (Durlauf et al., 2005; see Bond et al., 2010, for an exception).

As the theoretical basis for most empirical analyses, the Solow (1956) model or its augmented version that includes human capital following Mankiw et al. (1992) are used. Appendix C.2 derives and discusses a baseline version of the Solow model for application in this type of analysis. Here, we do not attempt to provide a comprehensive overview of methodologies applied and conclusions drawn in the vast empirical literature on growth determinants – Durlauf et al. (2005) is recommended in this regard – but merely highlight some central dimensions across which econometric approaches and findings using panel data vary and, in the subsequent sections, to discuss where our analysis sits along these dimensions. Thus, in the empirical growth literature that uses panel regression techniques, analyses differ in a number of key aspects:

(i) The sample of countries that is used. For example, the focus might be on all countries in the world for which data are available (Attanasio et al., 2000), a set of OECD countries (Auerbach et al., 1994) or a set of developing countries (Devarajan et al., 1996);

(ii) The precise set of explanatory variables of interest that is investigated. Variables relevant to our analysis include total investment as well as private investment, government investment or government consumption. Above and beyond these, a host of proxies and indicators for financial development and globalisation, geography, human capital, institutions and population have been used in the literature, but will not be considered in detail here (see Durlauf et al. (2005) Appendix B for a comprehensive overview);

(iii) The frequency of the data employed – for example, whether annual or, say, data in five- or ten-yearly intervals is used (see Islam (1995) for both) – and, relatedly, the extent of dynamics allowed for in econometric specifications[13];

(iv) Whether or not unobserved time-invariant country-specific heterogeneity in income levels is allowed for in the form of country-specific fixed effects. Accordingly, analyses differ in whether variation within a country over time or across countries (or both) is used to identify the effects of interest (see Barro (2012) for both), but also whether the resulting potential sources of bias on the coefficient estimates of right-hand-side variables are addressed. Some have also allowed for country-specific heterogeneity in growth rates (Bond et al., 2010); and

(v) The extent to and way in which possible endogeneity is addressed in estimation and, hence, whether estimation is conducted using Ordinary Least Squares ("OLS"; Islam, 1995), Two-Stage Least Squares ("2SLS"; Barro, 2012), its generalisation, the Generalised Methods of Moments ("GMM"; Caselli et al., 1996, Bond et al., 2001) or a Maximum-Likelihood approach ("ML"; Moral-Benito, 2012, who combines it with Bayesian model averaging).

Perhaps unsurprisingly given the pertinence of the questions posed, existing analyses also differ as regards their conclusions. As Durlauf et al. (2005) put it*: "Even when the study of growth is viewed in terms of a collective endeavor, the various papers cannot easily be distilled into a consensus that would meet standards of evidence routinely applied in other fields of economics."* Disregarding differences in – and possible issues with – authors' samples and econometric methodologies, the lack of consensus becomes clear when comparing just a few central contributions to the literature. Caselli et al. (1996) conclude that total investment has a positive and significant effect on growth, while its effect is positive

[13]Islam (1995) argues that the main equation of interest emerging from a Solow-type model is valid over shorter periods of time, while Durlauf and Quah (1999) claim that misspecification is greater at higher frequencies.

and insignificant based on the analysis of Barro (2012). Furthermore, Aschauer (1989) and Kamps (2005) find positive and significant growth effects of government investment, while Devarajan et al. (1996) finds a negative and significant effect – recent evidence though appears to have more consistently tended towards finding positive effects (see, for example, IMF (2014) or Abiad et al. (2015)). Government consumption, in turn, is negative and significant for growth in Barro (1991), positive and significant in Caselli et al. (1996) when using their preferred estimation approach, and negative and insignificant in Barro (2012).

The dataset assembled for our analysis (IMF (2017) and World Bank) covers more country-year observations than any prior analysis of this type of question, with series for many of the 151 countries starting in 1960 and reaching until 2015. It also includes private and government investment as well as government consumption, so that the effects of both types of government spending (consumption and investment) and both types of investment (private and government) on growth can be investigated simultaneously. Hence, it enables us to at least attempt to reassess some of these conflicting findings. Furthermore, we employ econometric approaches that effectively address possible sources of bias and endogeneity present in coefficient estimates from previous analyses.

Since both data structures usually employed in the existing literature on growth determinants – annual data as well as data in five- or ten-yearly intervals – come with their own sets of econometric advantages and issues, we present, discuss and estimate a standard growth model first on annual data and then on data in five-yearly intervals in the following.

3.4.2 Estimation on annual data

This section focusses on the estimation of a model on annual data using 2SLS. We concentrate on the "world" sample here, but present as robustness tests results for the OECD sample introduced above.

3.4.2.1 Our model

When using data at annual frequency, we employ a typical growth regression model in the spirit of Solow (1956) as implemented by Islam

(1995), for example.[14] Appendix C.2 derives and discusses in detail a baseline Solow model of this kind. It can be written as

$$\Delta y_{i,t} = (\alpha - 1)y_{i,t-1} + \beta X_{i,t} + \gamma_i + \delta_t + \phi_i t + \varepsilon_{i,t} \tag{3.4}$$

Equivalently, it can be rewritten as a dynamic model for the level of $y_{i,t}$, provided $\mid \alpha \mid < 1$, as

$$y_{i,t} = \alpha y_{i,t-1} + \beta X_{i,t} + \gamma_i + \delta_t + \phi_i t + \varepsilon_{i,t}. \tag{3.5}$$

Our subsequent discussion and analysis focus on this version of the model. $y_{i,t}$ represents the log level of GDP per capita, measured in constant price international dollars, of country i at time t.[15] The vector $X_{i,t}$ comprises a set of explanatory variables $x^j_{i,t}$, including the log of the investment ratio as a share of GDP as well as the log of the population growth rate (plus 0.05[16]), as per the canonical Solow (1956) growth model and its empirical implementation by Mankiw et al. (1992). Correspondingly, β is a vector of coefficients. As in Equation 3.1, γ_i are country-specific fixed effects that allow for time-invariant unobserved heterogeneity in income levels, while $\phi_i t$ are country-specific linear time trends that allow for unobserved heterogeneity in long-run average growth rates.[17] δ_t are

[14]It is worth noting that these growth regressions rely on a log-linear approximation of the law of motion of a Solow-type model, as described in Appendix C.2, but also that the available empirical evidence appears to suggest that this approximation is reasonably accurate, as Durlauf et al. (2005) point out.

[15]Based on the hypothesis of conditional convergence and given that we are controlling for a number of time-invariant (unobserved) and time-varying (observed) characteristics of countries, we would expect there to be a negative association between growth rates today and initial income, and hence $\alpha < 1$. Convergence is discussed in Appendix C.2 in more detail. α can be given a "speed of convergence" interpretation, but can here simply be thought of as reflecting the degree of persistence in GDP.

[16]This is a commonly used approximation of the term $\log(n + g + \delta)$, where n denotes the rate of growth in the labour force, g the rate of technological progress and δ the rate of depreciation. We use the population growth rate as a proxy for n and assume that $g + \delta$ is constant across time and countries, imposing $g + \delta = 0.05$ following Mankiw et al. (1992). All results presented in this chapter are robust to using the rate of growth of the working age population as a proxy for n instead.

[17]As Durlauf et al. (2005) point out, the use of country fixed effects in this set up can, in part, be motivated by the Mankiw et al. (1992) implementation of the Solow model, which implies that one determinant of the level of the steady-state growth path is the initial level of efficiency or technology, the cross-section heterogeneity in which is usually regarded as unobservable.

year-specific effects that will capture elements in productivity and GDP growth that are common across countries.[18] $\varepsilon_{i,t}$ is the error term.

In order to be able to investigate our main question of interest – namely, whether there is a difference in the growth effects of government investment and government consumption – we implement two modifications to $X_{i,t}$ relative to its baseline as per Mankiw et al. (1992) or Islam (1995), for example. First, we decompose total investment $x_{i,t}^{itot}$ into its private component $x_{i,t}^{ipri}$ and its government component $x_{i,t}^{igov}$. Second, we additionally include in $X_{i,t}$ the government consumption-to-GDP ratio $x_{i,t}^{cgov}$. The theoretical basis for including government consumption in a growth regression of this type is that it might be one possible factor that affects an individual country's steady state level of income, as per the hypothesis of conditional convergence (see Appendix C.2 for details). Barro (1991) argues that government consumption is unlikely to directly affect private productivity, but might reduce saving and growth through distortionary effects of the taxation required to raise government revenue (which can then be used to fund government consumption as well as government investment). Drèze and Malinvaud (1994) additionally mention two further possible channels through which government consumption might (negatively) impact growth. One operates via rigidities in the labour market stemming from social insurance, the other via increases in government deficits and government debt (to which government investment would equally contribute), although the verdict on the effects of government debt on growth is arguably still outstanding.

Note that in the Solow-type empirical framework employed here, government consumption – like the other explanatory variables included – would have an effect of the level of the path for $y_{i,t}$, but no effect on its slope, that is, no growth rate effect.[19]

[18] Note that country and year dummies might also capture country- and year-specific components of measurement errors, as Bond et al. (2001) point out.

[19] As Atkinson (1995) argues, effects on the *rate* of growth stemming from government consumption – specifically, via the set up of the social security and transfer system – emerge theoretically only if we assume that the rate of technological progress is endogenous. Note that in the original Solow model, there is no government sector.

3.4.2.2 Econometric approach

In addition to addressing the implications of including country-specific fixed effects in our model, an appropriate econometric approach will need to take into account the possible presence of (i) bias in the coefficient estimate of the lagged dependent variable, (ii) endogeneity of explanatory variables as a result of reverse causation and/or omitted variables, and (iii) endogeneity as a result of measurement error.

As an additional complicating factor, there is evidence of positive first-order serial correlation in residuals from key specifications of interest.[20] Hence, if we assume that the error process takes the MA(1) form $\varepsilon_{i,t} = e_{i,t} + \phi e_{i,t-1}$, where $\phi > 0$ and $e_{i,t}$ itself is serially uncorrelated, then the statement that explanatory variable $x^j_{i,t}$ is treated as potentially endogenous should here be taken to refer to potential endogeneity with respect to $e_{i,t}$, rather than $\varepsilon_{i,t}$. Thus, we allow for $E(x^j_{i,t}e_{i,s}) \neq 0 \, \forall i$ and $s \leqslant t$, and instrument for $x^j_{i,t}$ by including $x^j_{i,t-2}$, but no earlier lags, in the instrument set. Similarly, the statement that $x^j_{i,t}$ is treated as predetermined here refers to $e_{i,t}$ rather than $\varepsilon_{i,t}$. Thus, we allow for $E(x^j_{i,t}e_{i,s}) \neq 0 \, \forall i$ and $s < t$, and instrument for $x^j_{i,t}$ by including $x^j_{i,t-1}$, but no earlier lags, in the instrument set.

(i) Bias in the coefficient on the lagged dependent variable

By construction of the model presented in Equation 3.5, $E[y_{i,t-1}\gamma_i] > 0$ will be true, and so pooled OLS ("POLS") estimation in the presence of fixed effects γ_i will result in a coefficient estimate $\hat{\alpha}_{OLS}$ on the lagged dependent variable that is biased upwards. In principle, the "Fixed Effects" ("FE") estimator can be used address this issue, since it is consistent as the number of time series observations T tends to infinity ($T = 41$ for the "world" sample on average). However, due to the presence of positive first-order serial correlation in residuals from central specifications of interest, the estimated coefficient $\hat{\alpha}_{FE}$ will also be biased upwards, since the lagged dependent variable then is correlated not only with γ_i, but also with the $e_{i,t-1}$ component of $\varepsilon_{i,t}$ (Arellano, 2003).

[20] Note that here, time-invariant unobserved country-specific heterogeneity is addressed by including country-specific fixed effects, rather than by first differencing. Hence, the serial correlation present here is not the result of first-differencing, but appears to be a feature of $\varepsilon_{i,t}$ in Equations 3.4/3.5.

(ii) Endogeneity as a result of reverse causation or omitted variables

Identification is also complicated by the fact that private investment, government investment, government consumption and the population growth rate may all be endogenous in this setting. Statistically speaking, this means that current values of these variables might be correlated with current or past shocks to growth, so that possibly

$$E[x^j_{i,t} e_{i,s}] \neq 0 \ \forall i \text{ and } s \leqslant t$$

Economically speaking:

- **Private investment** might be endogenous as a result of reverse causation (by a simple accelerator effect, according to which growth stimulates private investment, or because richer countries might tend to save and invest more than poorer countries) or omitted variables (for example, lower interest rates might cause both growth and private investment to increase).

- **Government investment and consumption** might be endogenous as a result of reverse causation: on the one hand, higher growth increases tax revenue, which generally facilitates higher government spending. Time-to-build considerations might suggest that investment is "less endogenous" than consumption, to the extent that this is a meaningful statement: compare, for example, the time it takes to hire an additional teacher to the time it takes to build an additional school. On the other hand, government consumption might be less endogenous than total current, non-investment expenditure of government, since so-called "automatic stabilisers" such as unemployment benefits, which tend to increase countercyclically, are not included in government consumption (see Appendix D). However, government consumption might also be endogenous as a result of omitted variables: for example, over the medium term, industrialisation and financial globalisation might result in both higher growth and the need for more social security (Atkinson, 1995).

- **Population growth rates** might, in principle, also be endogenous, for example as a result of reverse causation (richer countries may tend to have lower birth rates) or omitted variables (the education system), although these processes likely take a long time to feed through and so these sources of endogeneity might be regarded as less of a concern here. However, we initially treat population growth as potentially endogenous too, since doing so also addresses possible measurement error (see below).

(iii) Endogeneity as a result of measurement error

Measurement error in the dependent and lagged dependent variables, in theory, leads to the growth rate of income between periods t and $t-1$ being overstated (measured with positive error) if the level of income in $t-1$ is understated (measured with negative error), and vice versa. Hence, in the presence of measurement error there will be a negative correlation between $\Delta y_{i,t}$ and $y_{i,t-1}$, in the language of our model as presented in Equation 3.4. This would negatively bias our estimate of α and therefore bias our conclusion towards confirming the presence of conditional convergence as evidenced by $\alpha - 1 < 0$ or $\alpha < 1$. In practice, however, the presence in the specification of explanatory variables that might also be measured with error as well as the possibility of serial correlation of the error term $\varepsilon_{i,t}$ renders the direction of bias ambiguous (Temple, 1998; Durlauf et al., 2005). At the same time, use of data on actual income rather than steady-state income may introduce a measurement error that may be correlated with investment rates. This is likely to be true if periods of high growth along the transition path are associated with periods of high investment, and vice versa, as Bond et al. (2010) point out. Furthermore, data quality in general might be an issue, especially in countries with less established administrative institutions and for variables such as population growth rates[21], which are extrapolated from censuses that are usually conducted at most once or twice a decade. To address these issues, some authors employ measurement error diagnostics (Temple, 1998), while others use instrumental variable approaches (Barro, 1991). In our case, treating all right-hand-side explanatory variables as potentially endogenous allows for the possibility of serially uncorrelated measurement error, and suitably

[21]This is also particularly true for human capital, the measurement of which is notoriously difficult and complicates studying the augmented Solow model empirically.

lagged instruments can still validly be used as instrumental variables (Bond et al., 2001). Nonetheless, the scope for measurement error in income as well as all explanatory variables used here remains a caveat to any conclusions drawn from this type of analysis.

In order to address all three issues in the context of annual data, we employ 2SLS estimation. Specifically, we treat the lagged dependent variable – due to the presence of first-order serial correlation – as endogenous, and explanatory variables as potentially endogenous, using suitable own lags of these variables as well as suitable lags of (log) inflation and (log) trade as a share of GDP as external instruments, following Bond et al. (2010). Throughout, we adjust standard errors to account for possible heteroskedasticity, serial correlation and cross-section dependence.

3.4.2.3 Main questions of interest

Building on our finding that bond markets penalise investment-driven budget deficits significantly less than consumption-driven budget deficits, we here once again ask whether, in their impact on economic growth, (i) the effects of government investment and government consumption are significantly different and (ii) government investment is significantly more helpful than government consumption. Hence, we test the following hypotheses:

$$\beta^{igov} \neq \beta^{cgov} \text{ and } \beta^{igov} > \beta^{cgov} \tag{3.6}$$

Since our approach here involves the estimation of a relatively standard empirical growth model, we also aim to replicate common findings from the existing literature that has investigated the predictions of the Solow (1956) model empirically. These include, most importantly, a significantly negative coefficient on initial income and hence a coefficient on the lagged dependent variable that is significantly less than 1 (as per Equation 3.5, $\alpha < 1$), a significantly positive coefficient on the total investment ratio ($\beta^{itot} > 0$) and a significantly negative coefficient on the population growth rate ($\beta^{pop} < 0$). Confirming these would suggest that our sample and methods are sufficiently standard to yield plausible results when compared to those of the existing literature.

3.4.2.4 Results

Table 3.4 presents results from estimating a typical growth model as presented in Equation 3.5, which allows for unobserved country-specific heterogeneity in income levels and long-run average growth rates, using annual data and OLS with Fixed Effects ("FE") as well as 2SLS. The estimation sample contains 151 countries. We report Driscoll-Kraay (1998) standard errors throughout, which are consistent in the presence of heteroskedasticity, serial correlation and cross-section dependence.[22]

2SLS-based results are presented in columns (3) to (6). Suitable lags of right-hand side variables as well as inflation are used as instruments. Columns (3) and (4) treat the lagged dependent variable as endogenous and all other explanatory variables as potentially endogenous, for reasons outlined in Section 3.4.2.2 above. First-stage regression results for column (4) are reported in Table C.6 in Appendix C and suggest that instruments are sufficiently informative. Columns (5) and (6) continue to treat the lagged dependent variable as endogenous, but the other right-hand side variables of the regression – specifically, all fiscal and investment variables and the population growth rate – as predetermined.[23] Based on a sequence of individual and joint Hansen difference tests, doing so appears valid econometrically, so that these are our preferred results. Furthermore, across all four columns, neither Hansen tests of instrument validity nor underidentification or weak identification tests raise any cause for concern. Interestingly, Hausman (1978) tests comparing FE and 2SLS coefficient estimates in columns (1) and (3) or (5) or columns (2) and (4) or (6) do not reject the null hypothesis of exogeneity when applied to coefficients individually, but do so when applied to coefficient estimates jointly. Hence, allowing for the endogeneity of the explanatory variables through 2SLS methods is the appropriate approach.[24] For the remainder of this section,

[22] As mentioned previously, there is evidence of positive first, but no higher-order, serial correlation in residuals from baseline specifications. Thus, we expect the coefficient on the lagged dependent variable to be biased upwards in FE estimation.

[23] As discussed in Section 3.4.2.2, the terms "predetermined" and "endogenous" refer to the serially uncorrelated innovation component $e_{i,t}$ of the MA(1) error term. In estimation, we hence use first and subsequent lags of included explanatory variables as instruments when treating them as predetermined, and second and subsequent lags when treating them as endogenous.

[24] The Hausman test of coefficients jointly continues to reject the null hypothesis even when the lagged dependent variable is – incorrectly – treated as exogenous. Thus, the rejection hinges not just on the bias of the lagged dependent variable, which is

Table 3.4: Standard growth model, annual data: Baseline results

"World" sample	**FE**		**2SLS: endog.**		**2SLS: predet.**	
Dep. var.: GDP p.c.$(\log)_t$	(1)	(2)	(3)	(4)	(5)	(6)
GDP per capita $(\log)_{t-1}$	0.891***	0.894***	0.862***	0.865***	0.861***	0.862***
	(0.016)	(0.016)	(0.020)	(0.020)	(0.020)	(0.020)
Population growth rate	-0.040***	-0.038***	-0.076***	-0.073***	-0.050***	-0.050***
	(0.009)	(0.009)	(0.015)	(0.016)	(0.011)	(0.012)
Total investment	0.048***		0.051***		0.046***	
	(0.006)		(0.009)		(0.009)	
Government consumption	-0.033***	-0.034***	-0.037***	-0.037***	-0.027***	-0.029***
	(0.006)	(0.006)	(0.012)	(0.012)	(0.010)	(0.010)
Private investment		0.025***		0.034***		0.027***
		(0.004)		(0.008)		(0.007)
Government investment		0.015***		0.012**		0.015***
		(0.003)		(0.006)		(0.004)
Test $\beta^{igov} = \beta^{cgov}$, p-value		0.00		0.00		0.00
Underident. test, p-value[1]			0.04	0.04	0.02	0.02
Overident. test, p-value[2]			0.16	0.21	0.12	0.17
Weak ident. test, F-stat.[3]			15.66	12.45	30.19	44.37
Hansen diff. test, p-value[4]					0.25	0.34
Test for AR(1), p-value[5]	0.00	0.00	0.00	0.00	0.00	0.00
Test for AR(2), p-value[5]	0.85	0.87	0.27	0.26	0.32	0.31
Observations	5,085	5,085	5,085	5,085	5,085	5,085

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. Country and year fixed effects and country-specific linear trend terms included. All fiscal variables are in log shares of GDP. Population growth rate plus 0.05 and in log. Instruments in columns (3)-(4)/(5)-(6): lags 2/1 to 4/3 of included explanatory variables, lags 2 to 4 of the dependent variable and lags 2 and 3 of log inflation plus 1. 1: H0: equation is underidentified; Kleibergen and Paap (2006). 2: H0: instruments are jointly valid; Hansen J statistic. 3: H0: instruments are weak; Kleibergen and Paap (2006). 4: H0: once-lagged instruments are valid. 5: H0: no serial correlation of order indicated.

we therefore focus on 2SLS-based estimation results.

Irrespective of whether central explanatory variables are treated as potentially endogenous or predetermined, results in columns (3) to (6) are in line with the findings of the existing literature that estimates growth regressions in the spirit of Solow (1956). The coefficients on the lagged dependent variable, the population growth rate and total investment as a share of GDP all correspond to the typical conclusions of the literature as regards their magnitudes, signs and significance. Importantly, furthermore, results in columns (4) and (6) strongly suggest significantly different growth impacts of different types of government expenditure: government investment is significantly helpful for growth, while government consumption is significantly detrimental for growth.

Table 3.5 presents robustness tests, building on column (6) in Table 3.4. Relative to the full sample used for estimation in Table 3.4, column (1) additionally excludes a set of resource-dependent countries beyond those excluded by Bond et al. (2010) and Mankiw et al. (1992), based on the criterion discussed in Section 3.2.2 above. Column (2) excludes countries for which there are fewer than 25 consecutive observations in the estimation sample. Column (3) uses a wider measure of private investment that additionally includes private-public partnership investment, which is excluded from the other results presented here. Column (4) drops government consumption as an explanatory variable. Column (5) focusses on the sample of OECD countries used in Chapter 1 and Section 3.3 above. The statistically significant difference between the growth effects of the two types of government spending is present across all specifications. As before, in the case of the world sample, this difference is driven by both types of government expenditure significantly affecting growth, albeit in opposite directions; in the case of the OECD sample, this difference is driven more by the negative effect of consumption than by the positive effect of investment. This may be due to the fact that the stock of government capital per capita is much higher in OECD than non-OECD countries (cf. Figure C.1).

Finally, it is important to note that our econometric approach here may be considered unusual in two respects. On the one hand, the existing empirical growth literature has not typically allowed for country-specific

expected in this set-up given the presence of first-order serial correlation.

Table 3.5: Standard growth model, annual data: Robustness

2SLS (predet.) Dep.var.: GDP p.c.$(\log)_t$	**Excl. oil producers**	**Exl. short time series**	**Incl. PPP investment**	**Excl. gov. cons.**	**OECD sample**
	(1)	(2)	(3)	(4)	(5)
GDP per capita $(\log)_{t-1}$	0.865***	0.882***	0.862***	0.864***	0.865***
	(0.019)	(0.019)	(0.020)	(0.021)	(0.028)
Population growth rate	-0.051***	-0.047***	-0.050***	-0.044***	-0.070***
	(0.011)	(0.012)	(0.012)	(0.012)	(0.020)
Private investment	0.020***	0.026***	0.025***	0.026***	0.024**
	(0.004)	(0.007)	(0.006)	(0.007)	(0.012)
Government investment	0.016***	0.010***	0.015***	0.013***	0.004
	(0.003)	(0.004)	(0.004)	(0.004)	(0.007)
Government consumption	-0.019**	-0.030***	-0.029***		-0.068***
	(0.009)	(0.010)	(0.010)		(0.020)
Test $\beta^{igov} = \beta^{cgov}$, p-value	0.01	0.00	0.00		0.00
Underident. test, p-value[1]	0.03	0.02	0.02	0.01	0.03
Overident. test, p-value[2]	0.15	0.23	0.17	0.12	0.19
Weak ident. test, F-stat.[3]	34.73	81.70	37.67	57.80	20.79
Hansen diff. test, p-value[4]	0.28	0.51	0.35	0.28	0.16
Observations	4,930	4,324	5,085	5,085	1,272

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. Country and year fixed effects and country-specific linear trend terms included. All fiscal and investment variables are in log shares of GDP. Population growth rate plus 0.05 and in log. "World" sample used in columns (1) to (4). Instruments: lags 1 to 3 of included explanatory variables, lags 2 to 4 of the dependent variable and lags 2 and 3 of log inflation plus 1. 1: H0: equation is underidentified; Kleibergen and Paap (2006). 2 H0: instruments are jointly valid; Hansen J statistic. 3 H0: instruments are weak; Kleibergen and Paap (2006). 4: H0: once-lagged instruments are valid.

heterogeneity in long-run average growth rates, which the inclusion of country-specific linear trend terms in our model allows for. Hence, we confirm the robustness of our main results to excluding these trends in Table C.7 in Appendix C. However, our preferred model remains the one in which this kind of heterogeneity is allowed for, since tests of the joint significance of the country-specific linear trend terms strongly reject the null hypothesis they should be omitted. Moreover, a Hausman test comparing the model that includes these trend terms to the equivalent one where these trend terms have been dropped suggests that the former is the preferred model. On the other hand, since Islam (1995), estimating a model of this type using *annual* data has not been common – in order to deal with short-term business cycle fluctuations that may confound such an analysis, recent research has either tended to use either models with richer dynamics (Bond et al., 2010) or data that are averaged over longer intervals (Caselli et al., 1996; Bond et al., 2001). Hence, for consistency with the existing literature, results based on data in five-yearly intervals are presented next.

3.4.3 Estimation on data in five-yearly intervals

This section focusses on the estimation of a model on data in five-yearly intervals using System GMM. The objective of using data in longer-term intervals is the smoothing out of shorter-term business cycle fluctuations. We focus on the "world" sample here due to the fact that the estimation methods we employ require a greater number of observations than those available for the subset of the OECD considered in Chapter 1 and in results above.

3.4.3.1 Our model

The model used here is very similar to the one employed in the analysis of annual data in Section 3.4.2, and has frequently been applied in this form in the existing empirical growth literature (for example, Bond et al., 2001; Caselli et al., 1996). Based on data in five-yearly non-overlapping intervals, it can be written as

$$y_{i,t} = \alpha y_{i,t-5} + \beta \frac{1}{5} \sum_{k=t-4}^{t} X_{i,k} + \gamma_i + \delta_t + \varepsilon_{i,t}. \tag{3.7}$$

Thus, explanatory variables of interest are averaged over the period from $t-4$ to t.[25] The dependent variable and the set of explanatory variables are otherwise unchanged to our model for annual data presented in Equation 3.5. Beyond the underlying data structure, the central difference to the model used for annual data is that here, we allow for country-specific unobserved heterogeneity in income levels, but not in long-run average growth rates.[26] This is because implementing the latter in this context would mean focussing on the twice-differenced version of the model presented in Equation 3.7, the estimation of which using GMM is challenging due to weak instrument issues.

3.4.3.2 Econometric approach

The small number of time periods available for each country when using data in five-yearly intervals creates a further econometric issue that needs addressing. One way of dealing with the problem of upward bias in the estimated coefficient on the lagged dependent variable $\hat{\alpha}_{POLS}$ – which was raised in Section 3.4.2 above, and is the result of unobserved time-invariant heterogeneity (γ_i) in the context of pooled OLS ("POLS") estimation – can be the "Fixed Effects" ("FE") estimator, in the absence of serial correlation at least. However, since the average number of time series observations available for each country drops to around 8 here, the issue of Nickell (1981) bias arises in FE estimation, and the estimated coefficient $\hat{\alpha}_{FE}$ on the lagged dependent variable will be biased downwards. Thus, the POLS and FE estimates of the coefficient on the lagged dependent variable become upper and lower bounds, respectively, to assess the plausibility of the corresponding GMM estimate $\hat{\alpha}_{GMM}$. Furthermore, as discussed

[25] Approaches in the literature differ as regards the precise timing and averaging of the explanatory variables in a set-up like this. For example, Islam (1995) regresses GDP at time t on GDP at time $t-5$ and investment averaged over $t-5$ to t (i.e., over six years). We instead average our explanatory variables over the period $t-4$ to t (five years), but test robustness to averaging over the period from $t-5$ to $t-1$.

[26] That is, we drop the term $\phi_i t$ from the model as introduced in Equation 3.5. The existing literature using data in five- or ten-yearly intervals has not previously incorporated this kind of heterogeneity, as far as we are aware.

in detail in Section 3.4.2.2 above, the explanatory variables included in our model might all be endogenous as a result of reverse causation, simultaneity or measurement error.

The system GMM approach, as recommended by Bond et al. (2001) for use in this context, effectively enables us to deal with all of these sources of bias and inconsistency. The system GMM approach uses restrictions on initial conditions to infer additional moment conditions – above and beyond those used for first-differenced GMM[27] – that are relevant even when series are persistent. These restrictions in essence require that the observations at the start of the sample are distributed in a way that is representative of steady-state behaviour (Bond et al., 2001; Durlauf et al., 2005).[28] Specifically, we use a two-step system GMM approach in which the lagged dependent variable is treated as endogenous and all explanatory variables are treated as potentially endogenous, and in which – in addition to appropriate own lags of these variables – we use suitable lags of (log) inflation and (log) trade as a share of GDP as external instruments, following Bond et al. (2010). The finite-sample correction to the two-step covariance matrix as per Windmeijer (2005) is applied.

3.4.3.3 Results

Table 3.6 presents results from estimating a growth model as per Equation

[27]While first-differenced GMM (as in Caselli et al. (1996)) is, in principle, a valid approach to deal with these issues, its use may create problems of its own, namely potentially large finite sample bias as a result of weak instruments, since the lagged levels of persistent series might be weak instruments for subsequent first differences, as pointed out by Bond et al. (2001). Thus, with system GMM, we use suitably lagged levels as instruments for the first-differenced transformation of the model presented in Equation 3.5, as well as suitably lagged first differences as instruments for the untransformed model in levels. Weak instrument issues may also arise in a system GMM setting, however (Bun and Windmeijer, 2010).

[28]To be able to validly apply system GMM, we require that the first differences Δy_{it} and Δx^j_{it} are not correlated with γ_i (which can be tested using Sargan tests of overidentifying restrictions), i.e., $E[\Delta y_{it}\gamma_i] = 0$ and $E[\Delta x^j_{it}\gamma_i] = 0$ – this holds in case of stationary means within countries across time of the y_{it} and x^j_{it} series. This, in turn, might be plausible for investment rates or population growth rates, as Bond et al. (2001) argue, but less so for income per capita ($y_{i,t}$): here, however, the inclusion of year dummies controls for the common component in growth in per capita GDP, which is in line with the frequently employed assumption of common technological progress across countries in empirical investigations of the Solow growth model. Furthermore, even if means are not stationary, so long as the data generating process for per capita GDP has been operating for long enough, any influence of initial conditions will be negligible, so that $E[\Delta y_{it}\gamma_i] = 0$ as required anyway (Bond et al., 2001).

3.7 on data in five-yearly non-overlapping intervals, following Caselli et al. (1996) and Bond et al. (2001). Our central questions of interest are unchanged compared to Section 3.4.2.3.

Columns (1) and (2) are POLS estimates, where country fixed effects are not included, in contrast to all other results presented so far. Columns (3) and (4) are estimated using OLS while including country fixed effects ("FE"). This is a useful exercise to determine the plausible bounds for the coefficient on the lagged dependent variable for subsequent GMM-based estimation, for reasons discussed in Section 3.4.3.2 above. Columns (5) to (8) are estimated using system GMM, treating the lagged dependent variable as endogenous throughout, and the population growth rate, investment and fiscal variables as endogenous in columns (5) and (6) and as predetermined in columns (7) and (8).[29] Note that first-order serial correlation in the residuals of the equation in differences is expected in this set-up (Roodman, 2009). The signs and significance of the effects of the population growth rate and total investment as a share of GDP appear plausible and in line with the literature (see columns (5) and (7)). Furthermore, importantly, the coefficient on the lagged dependent variable sits comfortably between the bounds implied by the POLS and FE estimates, and – as Table C.8 in Appendix C shows – Hansen and Hansen difference tests give little reason for concern regarding the validity of the instruments used. Moreover, separate Hansen difference tests of the inclusion of first lags of explanatory variables as instruments in columns (7) and (8) at no point reject the null hypothesis of instrument exogeneity.

Hence, treating explanatory variables as predetermined rather than endogenous appears valid econometrically, so columns (7) and (8) are our preferred results. Overall, results thus appear promising from an econometric standpoint. Importantly, results also once again point to differential growth impacts of different types of government spending: gov-

[29] In estimation, due to the presence of MA(1) serial correlation in residuals of the equations in first differences (which is expected here, as it is introduced by the first-differencing transformation), when treating explanatory variables as predetermined, we include their first and higher-order lags as instruments for the equation in first differences. When treating them as endogenous, we include their second and higher-order lags as instruments (cf. Section 3.4.2.2). The dependent variable – the lag of which is treated as endogenous throughout – is included twice lagged as an instrument for the equation in first differences; its once lagged first difference is included as an instrument for the equation in levels.

Table 3.6: Standard growth model, five-yearly data: Baseline results

"World" sample	OLS				System GMM			
Dep. var.: GDP p.c.$(\log)_t$	Pooled OLS		Fixed Effects		Endogenous		Predetermined	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GDP per capita $(\log)_{t-5}$	0.979***	0.979***	0.794***	0.799***	0.897***	0.917***	0.884***	0.906***
	(0.005)	(0.006)	(0.027)	(0.027)	(0.030)	(0.029)	(0.035)	(0.030)
Av. population growth$_{t,t-4}$	-0.138***	-0.136***	-0.163***	-0.153***	-0.626***	-0.640***	-0.486***	-0.502***
	(0.033)	(0.034)	(0.057)	(0.057)	(0.120)	(0.121)	(0.105)	(0.107)
Av. total investment$_{t,t-4}$	0.103***		0.164***		0.248***		0.289***	
	(0.015)		(0.025)		(0.045)		(0.048)	
Av. private investment$_{t,t-4}$		0.067***		0.091***		0.143***		0.165***
		(0.011)		(0.019)		(0.044)		(0.041)
Av. government consumption$_{t,t-4}$	-0.061***	-0.057***	-0.075***	-0.071**	-0.197***	-0.221***	-0.199***	-0.216***
	(0.014)	(0.015)	(0.027)	(0.028)	(0.076)	(0.083)	(0.061)	(0.066)
Av. government investment$_{t,t-4}$		0.029***		0.049***		0.070**		0.081***
		(0.008)		(0.014)		(0.030)		(0.029)
Test $\beta^{igov} = \beta^{cgov}$, p-value		0.00		0.00		0.00		0.00
Test for AR(1) in diff., p-value					0.00	0.00	0.00	0.00
Test for AR(2) in diff., p-value					0.29	0.62	0.27	0.61
Hansen statistic, p-value					0.13	0.25	0.19	0.30
Number of instruments					125	142	131	150
Observations	1,223	1,223	1,223	1,223	1,223	1,223	1,223	1,223

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Standard errors are reported in brackets below coefficient estimates. All fiscal variables in log shares of GDP. Explanatory variables are averages over 5 years. (1)-(4) are estimated using OLS, and White standard errors are reported. (1)-(2) include period fixed effects; (3)-(4) include period and country fixed effects. (5)-(8) are estimated using system GMM (robust two-step estimation), with period fixed effects included. Instruments used in columns (5)-(6)/(7)-(8), respectively, are lags 2 to 3/1 to 2 of included explanatory variables as well as, throughout, lags 2 and 3 of the dependent variable, av. log trade/GDP$_{t,t-4}$ and av. log inflation $+1_{t,t-4}$.

ernment investment is significantly helpful for growth, while government consumption is significantly detrimental for growth.

Table 3.7 presents some robustness tests, building on column (8) in Table 3.6. Relative to the full sample used for estimation in Table 3.6, column (1) additionally excludes a set of resource-dependent countries, based on the criteria discussed in Section 3.2.2 above. Column (2) uses averages of explanatory variables from period $t-1$ to $t-5$, instead of from period t to $t-4$. Column (3) uses a measure of private investment that includes private-public partnership investment, excluded otherwise. Column (4) drops government consumption. Throughout, results are highly robust.[30]

Table 3.7: Standard growth model, five-yearly data: Robustness

System GMM (predet.) "World" sample	**Excl. oil producers**	**Averages $t-1$ to $t-5$**	**Incl. PPP investment**	**Excl. gov. consumption**
Dep. var.: GDP p.c.$(\log)_t$	(1)	(2)	(3)	(4)
GDP per capita $(\log)_{t-5}$	0.910***	0.903***	0.919***	0.881***
	(0.032)	(0.032)	(0.033)	(0.035)
Av. population growth	-0.445***	-0.547***	-0.503***	-0.524***
	(0.081)	(0.108)	(0.114)	(0.161)
Av. private investment	0.127***	0.160***	0.135***	0.162***
	(0.046)	(0.047)	(0.049)	(0.045)
Av. gov. investment	0.098***	0.072**	0.096***	0.095***
	(0.030)	(0.028)	(0.032)	(0.029)
Av. gov. consumption	-0.114*	-0.166***	-0.188***	
	(0.065)	(0.052)	(0.071)	
Test $\beta^{igov} = \beta^{cgov}$, p-value	0.00	0.00	0.00	
Test AR(1) in diff., p-value	0.00	0.00	0.00	0.00
Test AR(2) in diff., p-value	0.21	0.49	0.44	0.17
Hansen statistic, p-value	0.43	0.31	0.24	0.20
Observations	1,164	1,145	1,223	1,223

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Standard errors are reported in brackets below coefficient estimates. All fiscal variables in $\log$ shares of GDP. Explanatory variables are averages over 5 years, over the period $t-4$ to t unless otherwise noted. System GMM estimates (robust two-step estimation), with period fixed effects included. Instruments used are lags 1 to 2 of included explanatory variables and lags 2 and 3 of the dependent variable, av. log trade/GDP$_{t,t-4}$ and av. log inflation $+1_{t,t-4}$.

[30]Results are also robust for the set of OECD countries considered above. However, due to the high number of instruments relative to observations when focussing on the OECD sample, Hansen test statistics are no longer meaningful and the validity of results is hard to ascertain. We therefore do not report these results.

Thus, findings from estimating conventional growth models using system GMM or 2SLS, as in the previous section, are consistent with our conclusions from predictive regressions above as well as those from Chapters 1 and 2. In particular, they lend support to the hypothesis that the effects of fiscal policy on bond yields identified there are working – at least in part – via the expectation that government asset accumulation will contribute to future economic growth.

3.5 Conclusion

In this chapter, we explored the growth effects of government investment and government current spending or consumption, allowing for unobserved country-specific heterogeneity in income levels as well as in long-run average growth rates wherever possible. In a predictive regression set-up, we find that government investment predicts future economic growth significantly differently and significantly more positively than government current or consumption expenditure do, both for the set of OECD countries considered in Chapter 1 and for a set of 151 countries globally. In a conventional growth model, which we estimate on our global sample using 2SLS and annual data or GMM and five-yearly data, thereby addressing possible endogeneity, we similarly conclude that government investment and government consumption have significantly different implications for economic growth: government investment aids growth, while government consumption hinders growth. Throughout, globally, the statistically significant difference between the growth effects of government investment and government consumption is driven by both types of government expenditure significantly affecting growth, albeit in opposite directions; in case of the set of OECD countries, this difference is driven more strongly by the negative effect of consumption.

These findings are consistent with our conclusions from Chapters 1 and 2, and suggest that the effects of fiscal policy on bond yields identified there are, at least in part, working via the expectation that government asset accumulation contributes to future economic growth and thus via a "growth channel". Findings also suggest that the composition of government expenditure – and government budget deficits and balance sheets – affects an economy's growth path, and hence that bond markets

are justifiedly distinguishing investment-driven from consumption-driven budget deficits or debt increases. Thus, there seems to be good reason why, from the perspective of bond markets, not all government debt and not all government budget deficits are created equal.

A number of interesting avenues for possible future research emerge from this analysis. It could be worthwhile to investigate the effects of government investment and consumption as well as private investment on measures of inequality, or the income shares or GDP of different deciles in the income distribution, since, plausibly, these spending types might have differential impacts on richer and poorer segments of society. Furthermore, a hotly debated issue in policy and academia (not least since Reinhart and Rogoff, 2010) are the effects of government debt and deficits on GDP growth in the short and long run. These effects, including their potentially non-linear features as well as their underlying causes as reflected in government investment or government assets, could be investigated using some of the frameworks presented above. A detailed investigation into the interactions between government investment and private investment might also be interesting in order to address the long-standing and lingering uncertainty about the extent to which government capital crowds in or crowds out private capital. Finally, as mentioned initially, alternative, nominal channels through which the effects of fiscal policy on bond yields may be working are (expected) inflation as well as (expected) depreciation. Hence, future research might investigate the predictive content of fiscal policy variables, including government investment and government consumption, for future inflation or exchange rates.

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Appendix A

Supplementary material to Chapter 1

A.1 Additional tables

Table A.1: Comparison of interest rate effects across models

Increase in current ("unproductive") government expenditure

Model	**Agents**	**Rigidity (p, w)**	**Mon. pol.**	C	L	I	Y	**Nom.** i
IS-LM (1)	NR	Prices sticky	exogenous	↑	↑	↓	↑	↑
NK (2)	R	Both sticky	Taylor rule	↓	↑	↓	↑	↑
RBC (3)	R	Both flexible	irrelevant	↓	↑	↑	↑	↑

Increase in investment ("productive") government expenditure

Production function with a non-zero elasticity of output with respect to public capital

Model	**Agents**	**Rigidity (p, w)**	**Mon. pol.**	C	L	I	Y	**Nom.** i
IS-LM	NR	Prices sticky	exogenous	↑	↑	↓ or ↑	↑	↑ less or ↓
NK (4)	R	Both sticky	Taylor rule	↓ or ↑	↑	↑	↑	↑ less or ↓
RBC (3)	R	Both flexible	irrelevant	↑	↑	↑	↑	↑ more

"NR": Non-Ricardian. "R": Ricardian. (1) as per Galí et al. (2007). (2) as per Smets and Wouters (2003) – Taylor rule with $\phi_y > 0$, $\phi_\pi > 0$. (3) as per Baxter and King (1993). (4) as per Linnemann and Schabert (2005) – Taylor rule with $\phi_y = 0$, $\phi_\pi > 0$. In IS-LM, money supply is assumed to be constant. In RBC case, impacts on C, L, I and Y are in equilibrium. In NK, the stickiness of both prices and wages is not required for these results to obtain.

Table A.2: Summary statistics for included variables

Variable	Mean	St. dev.	Min.	Max.	N×T
(1) Government bond yield (%)	4.84	2.12	0.55	14.00	572
(2) Short-term interest rate (%)	3.63	2.89	0.01	18.77	572
(3) Inflation rate (%, yoy)	2.44	2.13	-1.71	16.26	572
(4) Real growth rate (%, yoy)	2.33	3.20	-14.81	11.90	572
(5) Primary deficit (% of GDP)	-0.00	0.04	-0.21	0.29	572
(6) Non-primary deficit (% of GDP)	0.02	0.05	-0.19	0.32	572
(7) Gov. current exp. (% of GDP)	0.37	0.06	0.22	0.54	572
(8) Gov. investment (% of GDP)	0.04	0.01	0.02	0.07	572
(9) Gov. other cap. exp. (% of GDP)	0.01	0.02	-0.01	0.22	572
(10) Gov. total revenue (% of GDP)	0.42	0.07	0.30	0.59	572
(11) Gov. liabilities (% of GDP)	0.60	0.35	0.04	2.46	571

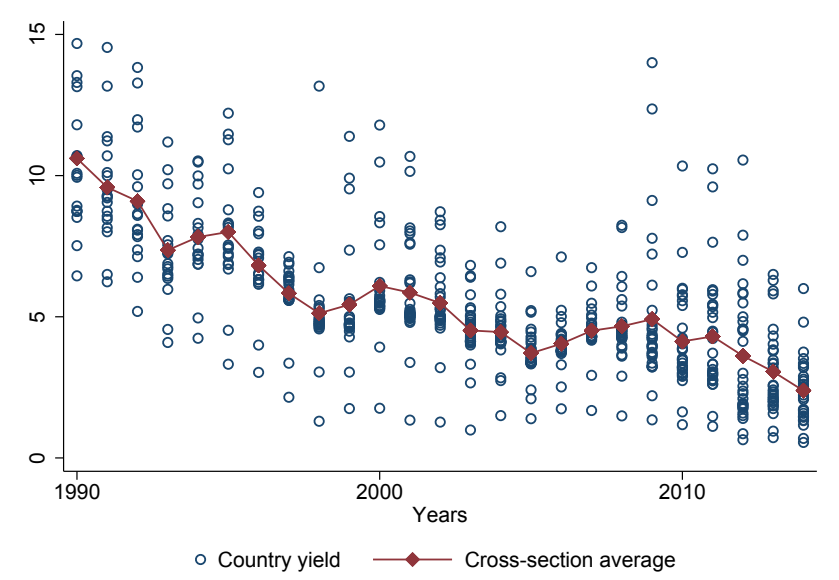
Sources: (1)-(4) OECD and AMECO; (5)-(11) AMECO. Countries included (31 in total): Austria, Belgium, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States.

Table A.3: Testing for unit roots

Im, Pesaran and Shin (2003) test	
Variable	**p-values**
Government bond yield	0.00
Primary budget deficit	0.00
Gov. current expenditure	0.00
Gov. investment	0.00
Gov. other cap. expenditure	0.00
Gov. total revenue	0.01
Gov. liabilities	0.32
Short-term interest rate	0.00
Inflation	0.00
Real growth rate	0.00

Im et al. (2003) test for unit roots. Lag length selected by AIC. Null hypothesis: all panels contain unit roots ($\phi_i = 0 \; \forall \, i$). Series are cross-sectionally demeaned.

Figure A.1: Long-term government bond yield, 1990-2014



In percent
Source: AMECO

Table A.4: Standard error adjustment

Standard errors:	**White**	**Newey-West**	**Clustered (country)**
Dep. var.: gov. bond yield	(1)	(2)	(3)
Gov. current expenditure	4.213***	4.213**	4.213**
	(1.467)	(1.518)	(1.824)
Gov. investment	-25.937***	-25.937***	-25.937***
	(5.680)	(6.628)	(7.247)
Gov. total revenue	1.736	1.736	1.736
	(2.220)	(2.592)	(2.942)
Short-term interest rate	0.383***	0.383***	0.383***
	(0.031)	(0.035)	(0.038)
Inflation rate	-0.048*	-0.048*	-0.048
	(0.025)	(0.028)	(0.029)
Real growth rate	-0.103**	-0.103**	-0.103**
	(0.045)	(0.046)	(0.047)
Real growth × "Trouble"	-0.100**	-0.100**	-0.100**
	(0.043)	(0.042)	(0.043)
Eurozone dummy	0.103	0.103	0.103
	(0.132)	(0.148)	(0.182)
2011 dummy × "Trouble"	2.309***	2.309***	2.309***
	(0.682)	(0.695)	(0.769)
2012 dummy × "Trouble"	2.268***	2.268***	2.268***
	(0.616)	(0.600)	(0.653)
R-squared	0.793	0.793	0.793
Observations	572	572	572

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield. Standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 adjusted to exclude the impact of year fixed effects. "Trouble" is equal to 1 for Cyprus, Hungary, Ireland, Italy, Latvia, Portugal and Spain.

Table A.5: Baseline results for sample used in Chapter 2

Dep. var.: gov. bond yield		**Incl. deficit decomp.**	
	(1)	(2)	(3)
Primary budget deficit	5.868**	6.405***	
	(2.549)	(2.388)	
Gov. investment		-32.866***	-19.281***
		(6.174)	(6.739)
Gov. current expenditure			6.665***
			(2.105)
Gov. total revenue			0.377
			(1.772)
Short-term interest rate	0.369***	0.318***	0.325***
	(0.039)	(0.034)	(0.028)
Inflation rate	0.098***	0.126***	0.124***
	(0.032)	(0.024)	(0.020)
Real growth rate	0.095***	0.066**	0.076***
	(0.037)	(0.031)	(0.027)
Eurozone dummy	0.366***	0.408***	0.366***
	(0.167)	(0.154)	(0.151)
R-squared	0.790	0.798	0.802
Observations	196	196	196

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is the annual average of the 10-year government bond yield. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 adjusted to exclude the impact of year fixed effects.

A.2 Robustness: "Mean groups" estimation

In a panel data context, applying the "mean groups" estimation approach generally involves estimating a separate regression for each group and then averaging estimated coefficients across groups (Pesaran and Smith, 1995; Eberhardt, 2013).

Table A.6 reports results from estimating a baseline specification – column (3) in Table 1.1 – using "mean groups" approaches, thus allowing all coefficients to be country-specific rather than pooling them across countries. The fact that year fixed effects are specified in pooled regressions is here

reflected by, for results reported in columns (1) and (2), demeaning all variables prior to estimation.

Column (1) reports unweighted means of country-specific regression coefficients. Column (2) reports the outlier-robust mean of country-specific regression coefficients. Column (3) (Eberhardt and Teal, 2010) is generated by first estimating a pooled regression that includes year fixed effects, and then including the estimated year fixed effects when subsequently running the country-specific regressions. Here, coefficients reported are again unweighted means of the country-specific regression results.

Table A.6: "Mean groups" estimation

Dep. var.: gov. bond yield	**Mean groups (MG)**	**Outlier-robust MG**	**Augmented MG**
	(1)	(2)	(3)
Gov. current expenditure	10.537*	4.727	8.899**
	(5.537)	(3.417)	(3.639)
Gov. investment	-21.211**	-22.367**	-24.491*
	(9.533)	(9.899)	(14.613)
Gov. total revenue	-2.363	-4.139	-6.409
	(4.148)	(3.704)	(5.036)
Short-term interest rate	0.270***	0.257***	0.448***
	(0.076)	(0.048)	(0.055)
Inflation rate	0.033	0.019	0.004
	(0.042)	(0.044)	(0.045)
Real growth rate	-0.081***	-0.085***	-0.073***
	(0.024)	(0.024)	(0.019)
Eurozone dummy	0.941	0.475	0.154
	(0.715)	(0.477)	(0.153)
Observations	572	572	572

Notes: Significance levels are denoted as * p<0.1; ** p<0.05; *** p<0.01. Standard errors are reported in brackets below coefficient estimates.

(1) and (2): on demeaned series to reflect use of year fixed effects in baseline specifications.

(3): on regular series since estimation procedure involves year fixed effects.

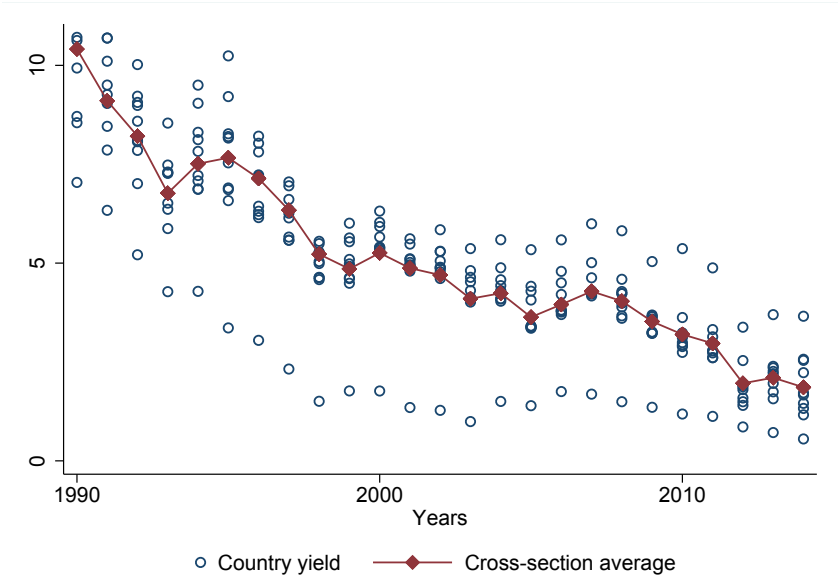
(1) and (2): Pesaran and Smith (1995); (3) Eberhardt and Teal (2010)

Appendix B

Supplementary material to Chapter 2

B.1 Additional tables, OECD panel analysis

Figure B.1: OECD panel: Gov. bond yields, 1990-2014



In percent
Source: ECB, OECD, national banks

Table B.1: OECD panel: Summary statistics for included variables

Variable	**Mean**	**St. dev.**	**Min.**	**Max.**	**N×T**
(1) Long-term bond yield (%)	4.82	2.14	0.72	10.69	209
(2) Short-term interest rate (%)	3.74	2.53	0.1	12.86	209
(3) Inflation rate (%, yoy)	1.92	1.36	-1.35	9.44	209
(4) Real growth rate (%, yoy)	1.21	2.62	-7.37	6.58	209
(5a) Liabilities, level (% of NI)	0.92	0.47	0.43	2.90	209
(5b) Liabilities, first diff. (% of NI)	0.02	0.06	-0.15	0.27	209
(6a) Assets, level (% of NI)	1.28	0.45	0.72	2.85	209
(6b) Assets, first diff. (% of NI)	0.01	0.05	-0.13	0.18	209
(7a) Net worth (% of NI)	0.36	0.33	-0.65	1.04	209
(7b) Net worth, first diff. (% of NI)	-0.01	0.06	-0.16	0.11	209

NI: national income. Sources: (1): BoJ, CNB, ECB, OECD; (2): Edvinsson (2014), Eurostat, IMF, OECD; (3): OECD; (4)-(8): Piketty and Zucman (2014) Countries included (10 in total): Australia, Canada, Denmark, France, Germany, Japan, Netherlands, Sweden, United Kingdom, United States.

Table B.2: OECD panel: Cointegration – assets and liabilities

Coint. rel.: Assets and liabilities	**Test statistic**			
Persyn-Westerlund test (p-values)	G_τ	G_α	P_τ	P_α
(not bootstrapped)	0.64	0.91	**0.01**	0.08
Pedroni test (test statistics)	panel-v	panel-ρ	panel-t (np)	group-t (p)
(normally distributed under H0)	0.82	0.22	0.56	1.99

Null hypothesis: no cointegration. Entries in bold indicate rejection of the null hypothesis. For Persyn-Westerlund test, statistics are transformations of the error-correction parameter. G statistics are weighted averages of panel parameters; P statistics use pooled information. Lag length selection by AIC. In Pedroni test, cross-section dependence is allowed for, and statistics diverge to negative infinity, except panel-v. "np": non-parametric. "p": parametric.

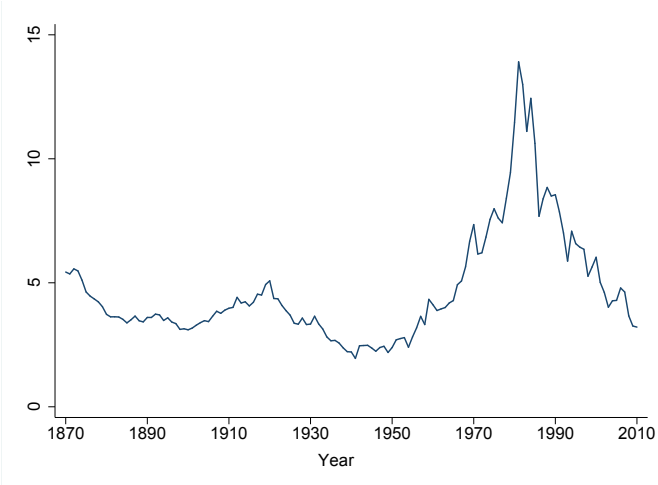
Table B.3: OECD panel: Robustness – net worth

Dep. var.: gov. bond yield	**Pre-crisis sample**	**Crisis interaction**	**Political factors**	**Q4 yield (dep. var.)**	**Excl. US**	**Excl. EA 1998-2007**	**Non-EA obs.**	**EA obs.**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net worth (Δ_t)	-2.013**	-1.399	-2.047**	-1.912**	-1.792**	-2.037**	-2.461**	-1.315***
	(0.741)	(1.254)	(0.968)	(0.821)	(0.757)	(0.956)	(0.897)	(0.320)
Net worth (Δ_t) × Crisis dummy		-2.367***						
		(0.742)						
Short-term interest rate	0.307***	0.348***	0.351***	0.355***	0.356***	0.353***	0.361***	
	(0.019)	(0.030)	(0.028)	(0.027)	(0.041)	(0.024)	(0.027)	
Inflation rate	0.032*	0.040	0.044*	0.000	0.035	0.038	0.036	0.044
	(0.016)	(0.026)	(0.024)	(0.030)	(0.027)	(0.029)	(0.028)	(0.028)
Real growth rate	0.008	0.018**	0.020**	0.010	0.024***	0.031***	0.026***	-0.015**
	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)
Eurozone dummy	0.397***	0.386***	0.392***	0.283**	0.502***	0.532***		
	(0.113)	(0.122)	(0.137)	(0.135)	(0.132)	(0.132)		
Eurozone dummy × Crisis dummy		0.143***						
		(0.050)						
Left-wing head of gov.			0.141***					
			(0.033)					
R-squared	0.804	0.832	0.794	0.746	0.812	0.801	0.775	0.138
Observations	156	209	205	209	189	179	163	46

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield except where noted otherwise. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. OLS with country and year fixed effects. R2 is adjusted to exclude the impact of year fixed effects. All fiscal variables are in shares of national income.

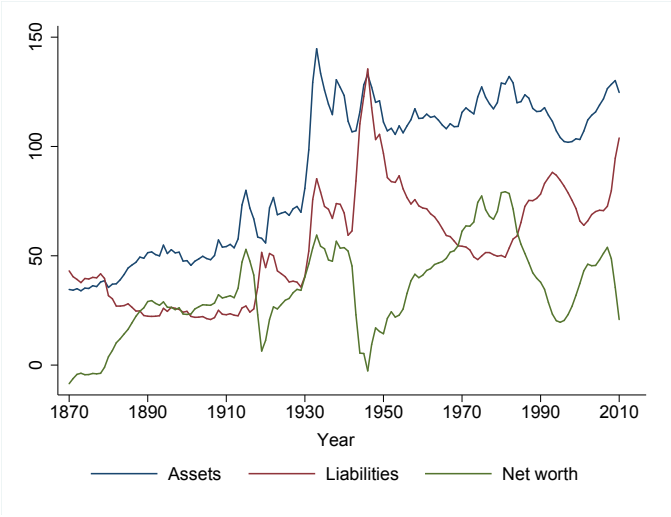
B.2 Additional tables, US time series analysis

Figure B.2: United States: Government bond yield, 1870-2010



In percent
Source: Jorda et al. (2017)

Figure B.3: United States: Gov. balance sheet components, 1870-2010



In percent of national income
Source: Piketty and Zucman (2014)

Table B.4: United States: Summary statistics for included variables

Variable	**Mean**	**St. dev.**	**Min.**	**Max.**	**N×T**
(1) Long-term bond yield (%)	4.68	2.28	1.95	13.91	140
(2) Short-term interest rate (%)	4.26	2.87	0.16	16.39	140
(3) Inflation rate (%, yoy)	2.17	4.73	-10.67	17.45	140
(4) Real growth rate (%, yoy)	5.82	7.47	-23.13	28.35	140
(5a) Liabilities, level (% of NI)	0.89	0.34	0.34	1.45	140
(5b) Liabilities, first diff. (% of NI)	0.01	0.06	-0.12	0.31	140
(6a) Assets, level (% of NI)	0.55	0.26	0.22	1.36	140
(6b) Assets, first diff. (% of NI)	0.00	0.06	-0.18	0.26	140
(7a) Net worth (% of NI)	0.34	0.20	-0.06	0.79	140
(7b) Net worth, first diff. (% of NI)	0.00	0.05	-0.22	0.12	140

NI: national income. Sources: (1)-(5): Jorda et al. (2017); (5)-(7): Piketty and Zucman (2014)

Table B.5: United States: Cointegration – assets and liabilities

Coint. relationship: Assets and liabilities		**Number of lags**			
Johansen-based (1995) test		**1**	**2**	**3**	**4**
(of number of cointegrating relationships)		0	1	0	0
Engle-Granger (1987) test	**0**	**1**	**2**	**3**	**4**
(of stationarity of residuals from reg.)	-1.72	**-3.34**	-2.74	-2.81	-2.47

Engle-Granger test null hypothesis: the series contains a unit root. MacKinnon 5% critical value is -3.34. Entries that are underlined indicate the AIC-selected optimal lag length. Entries in bold indicate rejection of the null hypothesis, and thus evidence that the residual is stationary and the series are cointegrated.

Table B.6: United States: Cointegration – interest rates

Coint. rel.: Yield, mean yield and short rate		**Test statistic**	**5% crit. value**
Johansen-based (1995) test			
(of number of cointegrating relationships;	rank 0	58.77	29.68
trace statistic)	rank 1	13.51*	15.41
	rank 2	3.10	3.76
Engle-Granger (1987) test			
(of stationarity of residuals from reg.)	$Z(t)$	**-4.30**	-3.80

Engle-Granger test null hypothesis: the series contains a unit root. Lag length selection by AIC. Entries in bold indicate rejection of the null hypothesis

Table B.7: United States: Robustness – net worth

Dep. var.: gov. bond yield	**Post-war, pre-crisis**	**Crisis interaction**	**Political factors**	**Lin. coint. comb.**
	(1)	(2)	(3)	(4)
Net worth (Δ_t)	-14.554***	-3.576**	-3.881**	-3.675**
	(4.264)	(1.659)	(1.806)	(1.525)
Net worth (Δ_t) × Crisis dum.		-20.805***		
		(7.064)		
Short-term interest rate	0.510***	0.315***	0.282***	
	(0.065)	(0.060)	(0.065)	
Real growth rate	-0.038	-0.020	-0.018	-0.018*
	(0.041)	(0.013)	(0.012)	(0.011)
Inflation rate	0.084*	0.007	0.009	0.007
	(0.047)	(0.016)	(0.020)	(0.017)
Mean bond yield	0.340***	0.641***	0.684***	
	(0.125)	(0.057)	(0.067)	
Crisis dummy		-0.654		
		(0.438)		
Left/centrist head of gov.			-0.119	
			(0.156)	
R2	0.912	0.745	0.689	0.055
Observations	61	140	140	140

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. The dependent variable is the annual average of the 10-year government bond yield. Newey-West standard errors are reported in brackets below coefficient estimates. R2 adjusted to exclude the effect of the inclusion of the mean yield. All fiscal variables are in shares of national income.

Appendix C

Supplementary material to Chapter 3

C.1 Additional tables

Table C.1: Summary statistics, annual data, "world" sample

Variable	Mean	St. dev.	Min.	Max.	NxT
(1) Growth in real GDP per capita (%, yoy)	0.02	0.05	-0.60	0.63	6,239
(2) Total investment (% of GDP)	0.20	0.10	0.00	0.98	6,239
(3) Private investment (% of GDP)	0.15	0.08	0.00	0.72	6,239
(4) Government investment (% of GDP)	0.05	0.04	0.00	0.41	6,239
(5) Government consumption (% of GDP)	0.15	0.06	0.02	0.64	6,239
(6) Population growth (%, yoy)	0.02	0.01	-0.04	0.18	6,239

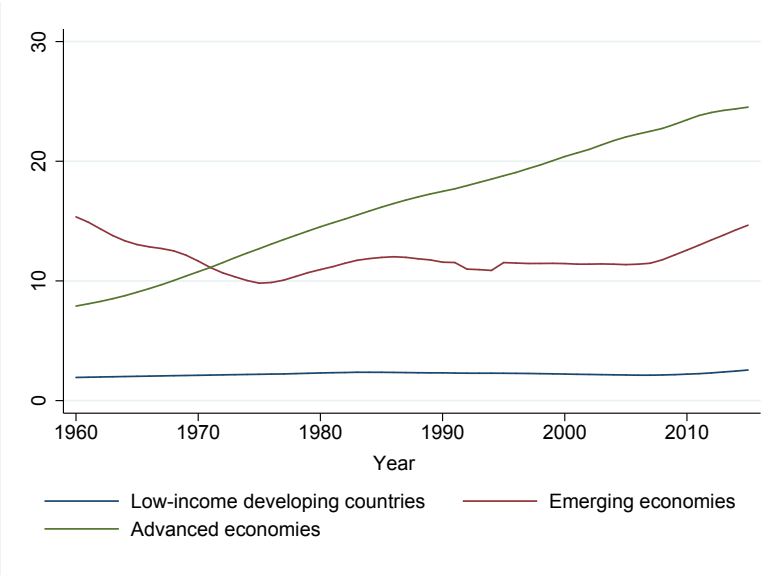
151 countries. Sources: (1)-(4): IMF (2017). (5)-(6): World Bank.

Table C.2: Summary statistics, five-yearly data, "world" sample

Variable	Mean	St. dev.	Min.	Max.	NxT
(1) Growth in real GDP per capita[1] (%)	0.11	0.17	-1.25	1.27	1,223
(2) Total investment[2] (% of GDP)	0.20	0.09	0.02	0.86	1,223
(3) Private investment[2] (% of GDP)	0.15	0.08	0.01	0.58	1,223
(4) Government investment[2] (% of GDP)	0.05	0.04	0.00	0.35	1,223
(5) Government consumption[2] (% of GDP)	0.15	0.06	0.04	0.56	1,223
(6) Population growth[2] (%, yoy)	0.02	0.01	-0.02	0.16	1,223

151 countries. Sources: (1)-(4): IMF (2017). (5)-(6): World Bank. 1 Over five-year periods. 2 Five-year averages.

Figure C.1: Government capital stock per capita



In '000 constant price international dollars.
Country grouping per the IMF's World Economic Outlook. Source: IMF (2017)

Table C.3: Countries included in the "world" sample

Albania (1980-2015)	Czech Republic (1991-2015)	Kyrgyz Republic (1991-2015)	Rwanda (1995-2015)
Algeria (1961-2015)	Denmark (1966-2015)	Lao P.D.R. (2000-2015)	Russia (1991-2015)
Angola (2000-2015)	Djibouti (1995-2007)	Latvia (1995-2015)	Senegal (1961-2015)
Antigua and Barbuda (1977-2015)	Dominica (1977-2015)	Lebanon (1989-2015)	Serbia (1995-2015)
Argentina (1987-2015)	Dominican Republic (1961-2015)	Lesotho (1961-1981)	Seychelles (1976-2015)
Armenia (1991-2015)	Ecuador (1961-2015)	Liberia (1965-1986)	Sierra Leone (2000-2015)
Australia (1961-2015)	Egypt (1965-2015)	Lithuania (1995-2015)	Singapore (1961-2015)
Austria (1961-2015)	El Salvador (1965-2015)	Luxembourg (1961-2015)	Slovak Republic (1991-2015)
Azerbaijan (1991-2015)	Equatorial Guinea (1987-2015)	Madagascar (1961-2015)	Slovenia (1995-2015)
Bangladesh (1973-2015)	Estonia (1995-2015)	Malawi (1961-2015)	South Africa (1961-2015)
The Bahamas (1990-2015)	Fiji (1961-2003)	Malaysia (1961-2015)	Spain (1961-2015)
Barbados (1980-2015)	Finland (1961-2015)	Mali (1985-2015)	Sri Lanka (1961-2015)
Belarus (1990-2015)	France (1961-2015)	Malta (1970-2015)	St. Kitts and Nevis (1977-2015)
Belgium (1961-2015)	FYR Macedonia (1991-2015)	Mauritania (1961-2015)	St. Lucia (1977-2015)
Belize (1980-2015)	Gambia, The (1977-2015)	Mauritius (1976-2015)	St. Vincent and the Gr. (1977-2015)
Benin (1961-2015)	Georgia (1991-2015)	Mexico (1961-2015)	Sudan (1963-2015)
Bhutan (1980-2015)	Germany (1970-2015)	Moldova (1995-2015)	Suriname (1975-2015)
Bolivia (1961-2015)	Ghana (1961-2015)	Mongolia (1981-2015)	Swaziland (1964-2015)
Bosnia and Herzegovina (2002-2015)	Greece (1961-2015)	Montenegro, Rep. of (2000-2015)	Sweden (1961-2015)
Brazil (1961-2015)	Grenada (1977-2015)	Morocco (1961-2015)	Switzerland (1980-2015)
Bulgaria (1980-2015)	Guatemala (1961-2015)	Mozambique (1980-2015)	Syria (1961-2007)
Burkina Faso (1961-2015)	Guinea (1986-2015)	Namibia (1980-2015)	Tajikistan (1991-2015)
Burundi (1961-2015)	Guinea Bissau (1970-2015)	Nepal (1975-2015)	Tanzania (1990-2015)
Cambodia (1993-2015)	Haiti (1991-2015)	Netherlands (1961-2015)	Thailand (1961-2015)
Cameroon (1965-2015)	Honduras (1961-2015)	New Zealand (1971-2015)	Togo (1961-2007)
Canada (1961-2015)	Hong Kong SAR (1961-2015)	Nicaragua (1961-2015)	Trinidad and Tobago (1961-2015)
Central African Republic (1961-2015)	Hungary (1991-2015)	Niger (1961-2015)	Tunisia (1965-2015)
Chad (1982-2015)	Iceland (1961-2015)	Nigeria (1981-2015)	Turkey (1961-2015)
Chile (1961-2015)	India (1961-2015)	Norway (1961-2015)	Uganda (1982-2015)
China (1961-2015)	Indonesia (1961-2015)	Pakistan (1961-2015)	Ukraine (1991-2015)
Colombia (1961-2015)	Ireland (1961-2015)	Panama (1961-2015)	United Kingdom (1961-2015)
Comoros (1980-2014)	Israel (1961-2015)	Paraguay (1991-2015)	United States (1961-2015)
Congo, Rep. of (2000-2015)	Italy (1961-2015)	Peru (1961-2015)	Uruguay (1961-2015)
Congo, Dem. Rep. of (1999-2015)	Japan (1961-2015)	Philippines (1961-2015)	Uzbekistan (1991-2015)
Costa Rica (1961-2015)	Jordan (1976-2015)	Poland (1990-2015)	Vietnam (1989-2015)
Cote d'Ivoire (1961-2015)	Kazakhstan (1992-2015)	Portugal (1961-2015)	Yemen (1990-2015)
Croatia (1995-2015)	Kenya (1961-2015)	Qatar (1994-2015)	Zimbabwe (1961-2007)
Cyprus (1975-2015)	Korea (1961-2015)	Romania (1990-2015)	

Table C.4: Predictive regressions: OECD sample, more detailed results

See notes to Table 3.2

OECD sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L.GDP	1.166***	0.697***	1.142***	1.166***	1.211***	1.142***	1.154***
	(0.136)	(0.078)	(0.130)	(0.123)	(0.117)	(0.114)	(0.131)
L2.GDP	-0.624***		-0.481***	-0.568***	-0.457***	-0.463***	-0.625***
	(0.121)		(0.107)	(0.095)	(0.113)	(0.106)	(0.120)
L3.GDP	0.082			0.048	-0.005	0.012	0.077
	(0.051)			(0.060)	(0.057)	(0.054)	(0.051)
L.Private investment	0.025*	0.051***	0.017	0.028*		0.026**	0.036**
	(0.015)	(0.013)	(0.013)	(0.017)		(0.013)	(0.014)
L2.Private investment	-0.009		0.008	-0.006		0.001	-0.008
	(0.017)		(0.014)	(0.019)		(0.017)	(0.017)
L3.Private investment	0.020			0.019		0.021	0.023
	(0.015)			(0.015)		(0.018)	(0.016)
L.Government investment	0.008	0.005*	0.007	0.009	0.007	0.010**	0.011*
	(0.006)	(0.003)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)
L2.Government investment	-0.006		-0.006	-0.005	-0.002	-0.001	-0.006
	(0.007)		(0.005)	(0.006)	(0.006)	(0.006)	(0.007)
L3.Government investment	0.005			0.003	-0.002	-0.003	0.007*
	(0.003)			(0.003)	(0.004)	(0.005)	(0.004)
L.Government non-inv. exp.	-0.040**	-0.090***	-0.035*	-0.090**	-0.117**	-0.124***	-0.036*
	(0.019)	(0.022)	(0.019)	(0.046)	(0.047)	(0.046)	(0.020)
L2.Government non-inv. exp.	-0.048***		-0.047***	0.031	0.060	0.075	-0.046***
	(0.017)		(0.018)	(0.075)	(0.065)	(0.064)	(0.017)
L3.Government non-inv. exp.	-0.026			-0.055	-0.062*	-0.071**	-0.029
	(0.023)			(0.035)	(0.033)	(0.028)	(0.025)
L.Government revenue					0.061*	0.054	
					(0.033)	(0.033)	
L2.Government revenue					-0.024	-0.035	
					(0.036)	(0.036)	
L3.Government revenue					0.020	0.020	
					(0.035)	(0.033)	
Dependent variable	Per capita GDP	Per capita GDP	Per capita GDP	Per capita GDP	Per capita GDP	Per capita GDP	Total GDP
Gov. non-inv. exp. incl. as	Current exp.	Current exp.	Current exp.	Consumption	Current exp.	Current exp.	Current exp.
Controls	Solow model	Solow model	Solow model	Solow model	Yield model	Combined	Solow model
R-squared	0.771	0.709	0.772	0.766	0.780	0.787	0.783
Observations	636	698	667	636	636	636	636

Table C.5: Predictive regressions: "World" sample, more detailed results

See notes to Table 3.3

"World" sample	(1)	(2)	(3)	(4)	(5)	(6)
L.GDP	1.098***	0.882***	1.094***	1.104***	1.089***	1.097***
	(0.028)	(0.013)	(0.030)	(0.027)	(0.027)	(0.028)
L2.GDP	-0.184***		-0.233***	-0.179***	-0.180***	-0.185***
	(0.028)		(0.028)	(0.035)	(0.033)	(0.028)
L3.GDP	-0.043**			-0.038*	-0.026	-0.044**
	(0.020)			(0.022)	(0.022)	(0.019)
L.Private investment	0.007	0.015***	0.009**		0.010**	0.008*
	(0.005)	(0.004)	(0.005)		(0.005)	(0.005)
L2.Private investment	0.004		0.003		0.005	0.003
	(0.003)		(0.003)		(0.004)	(0.004)
L3.Private investment	0.000				-0.001	0.000
	(0.004)				(0.005)	(0.004)
L.Government investment	0.011***	0.010***	0.011***	0.009**	0.009**	0.011***
	(0.003)	(0.002)	(0.003)	(0.004)	(0.004)	(0.003)
L2.Government investment	-0.003		-0.004	-0.004	-0.004	-0.003
	(0.003)		(0.003)	(0.004)	(0.004)	(0.003)
L3.Government investment	-0.002			0.000	0.000	-0.001
	(0.003)			(0.003)	(0.003)	(0.003)
L.Government consumption	-0.007	-0.028***	-0.004	0.004	0.003	-0.007
	(0.010)	(0.006)	(0.010)	(0.008)	(0.008)	(0.010)
L2.Government consumption	-0.012		-0.017**	-0.020*	-0.020*	-0.011
	(0.010)		(0.008)	(0.010)	(0.011)	(0.010)
L3.Government consumption	-0.002			0.005	0.007	-0.002
	(0.008)			(0.009)	(0.009)	(0.008)
Dependent variable	Per capita GDP	Per capita GDP	Per capita GDP	Per capita GDP	Per capita GDP	Total GDP
Controls	Solow model	Solow model	Solow model	Yield model*	Combined	Solow model
R-squared	0.848	0.845	0.848	0.848	0.842	0.849
Observations	5,851	6,153	6,002	5,181	5,181	5,851

Table C.6: Standard growth model, annual data: First stages for column (4) in Table 3.4

2SLS – 1st stages "World" sample	GDP per capita$_{t-1}$	Private investment	Government investment	Government consumption	Population growth
	(1)	(2)	(3)	(4)	(5)
L2. GDP per capita	1.065***	0.373**	0.579***	0.063	0.109***
	(0.027)	(0.159)	(0.174)	(0.045)	(0.034)
L3. GDP per capita	-0.167***	-0.305*	-0.131	-0.120	-0.088**
	(0.037)	(0.169)	(0.218)	(0.089)	(0.035)
L4. GDP per capita	-0.025	-0.127	-0.348*	0.141	0.033
	(0.023)	(0.119)	(0.197)	(0.093)	(0.027)
L2. Private investment	0.011**	0.500***	0.058***	0.020	-0.000
	(0.005)	(0.048)	(0.022)	(0.015)	(0.005)
L3. Private investment	0.003	-0.059	-0.025	-0.004	0.003
	(0.004)	(0.039)	(0.031)	(0.016)	(0.006)
L4. Private investment	-0.000	0.003	-0.003	-0.021	-0.008*
	(0.005)	(0.034)	(0.023)	(0.019)	(0.004)
L2. Government investment	0.010**	0.029	0.410***	0.013	-0.001
	(0.004)	(0.022)	(0.045)	(0.010)	(0.003)
L3. Government investment	-0.006	-0.036*	0.013	-0.005	0.008
	(0.004)	(0.020)	(0.042)	(0.010)	(0.005)
L4. Government investment	0.001	0.030*	0.038	0.005	-0.001
	(0.003)	(0.018)	(0.029)	(0.009)	(0.004)
L2. Government consumption	-0.004	-0.046	-0.049	0.591***	-0.016**
	(0.007)	(0.056)	(0.059)	(0.037)	(0.008)
L3. Government consumption	-0.014	0.012	-0.029	0.007	-0.003
	(0.011)	(0.048)	(0.067)	(0.041)	(0.011)
L4. Government consumption	0.007	-0.041	0.005	-0.049	0.016*
	(0.009)	(0.047)	(0.064)	(0.031)	(0.009)
L2. Population growth rate	-0.007	0.121***	0.151*	-0.051**	0.541***
	(0.007)	(0.034)	(0.084)	(0.025)	(0.104)
L3. Population growth rate	-0.018**	0.046	0.036	-0.027	-0.056
	(0.008)	(0.045)	(0.058)	(0.025)	(0.095)
L4. Population growth rate	-0.000	-0.043	0.040	0.058**	-0.115*
	(0.010)	(0.046)	(0.069)	(0.023)	(0.063)
L2. Inflation rate +1	-0.013***	-0.015	0.011	-0.028	0.005
	(0.004)	(0.017)	(0.047)	(0.032)	(0.003)
L3. Inflation rate +1	-0.003	-0.007	-0.027	-0.003	0.002
	(0.003)	(0.018)	(0.042)	(0.023)	(0.003)
Underidentification test, p-value[1]	0.00	0.00	0.00	0.00	0.00
Weak identification test, F-statistic[2]	277.26	26.49	25.21	63.19	21.69

Notes: 5,095 observations. Significance levels denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. Country and year fixed effects and country-specific linear trend terms included. All fiscal and investment variables are in $\log$ shares of GDP. 1 H0: equation is underidentified. 2: H0: instruments are weak. Both Sanderson and Windmeijer (2016).

Table C.7: Standard growth model, annual data: Without country-specific heterogeneity in growth rates

Dep. var.: GDP p.c.$(\log)_t$	**OLS**	**2SLS**	**2SLS**
	– "World" sample –		OECD
	(1)	(2)	(3)
GDP per capita $(\log)_{t-1}$	0.962***	0.956***	0.946***
	(0.006)	(0.006)	(0.015)
Population growth rate	-0.036***	-0.042***	-0.051***
	(0.007)	(0.009)	(0.018)
Private investment	0.018***	0.016***	0.012**
	(0.003)	(0.005)	(0.006)
Government investment	0.009***	0.006***	0.007
	(0.002)	(0.002)	(0.004)
Government consumption	-0.020***	-0.012*	-0.039***
	(0.005)	(0.007)	(0.010)
Test $\beta^{igov} = \beta^{cgov}$, p-value	0.00	0.00	0.00
Underident. test, p-value[1]		0.02	0.02
Overident. test, p-value[2]		0.29	0.29
Weak ident. test, F-stat.[3]		78.39	45.10
Hansen diff. test, p-value[4]		0.42	0.25
Observations	5,085	5,085	1,272

Notes: Significance levels are denoted as * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Driscoll-Kraay standard errors are reported in brackets below coefficient estimates. Country and year fixed effects included. All fiscal variables are in log shares of GDP. Population growth rate plus 0.05 and in log. Columns (1) and (2) on the "world" sample; column (3) on the OECD sample. Instruments in column (2): lags 1 to 3 of included explanatory variables, lags 2 to 4 of the dependent variable and lags 2 and 3 of log inflation plus 1. Instruments in column (3) identical, except that the first lag of private investment is excluded due to instrument validity issues. 1: H0: equation is underidentified; Kleibergen and Paap (2006). 2 H0: instruments are jointly valid; Hansen J statistic. 3 H0: instruments are weak; Kleibergen and Paap (2006). 4: H0: once-lagged instruments are valid.

Table C.8: Standard growth model, five-yearly data: Hansen and difference tests for included instruments

"World" sample, system GMM	**Hansen/difference tests, p-values**			
Column in Table 3.6 that test results below refer to:	(5)	(6)	(7)	(8)
GDP per capita $(\log)_{t-5}$	0.05/0.76	0.06/0.97	0.08/0.79	0.33/0.34
Av. population growth$_{t,t-4}$	0.10/0.53	0.22/0.49	0.12/0.70	0.23/0.63
Av. total investment$_{t,t-4}$	0.34/0.04		0.31/0.14	
Av. government consumption$_{t,t-4}$	0.14/0.32	0.18/0.67	0.17/0.48	0.17/0.86
Av. private investment$_{t,t-4}$		0.14/0.85		0.13/0.96
Av. government investment$_{t,t-4}$		0.14/0.83		0.20/0.75
Av. inflation$_{t,t-4}$	0.12/0.42	0.13/0.88	0.07/0.95	0.14/0.94
Av. trade$_{t,t-4}$	0.13/0.39	0.13/0.84	0.13/0.69	0.15/0.94
Null hypothesis: validity of overidentifying restrictions				

C.2 Basics of growth theory

This section provides a refresher on the canonical Solow growth model and thus the theoretical background for the second empirical approach implemented above. It draws heavily on the expositions of growth theory and empirical estimation of growth models by Mankiw et al. (1992), Islam (1995) and Bond et al. (2001).

C.2.1 The Solow growth model

"All theory depends on assumptions which are not quite true. That is what makes it theory." – Solow (1956)

The theoretical basis for the type of growth regression conducted above is the so-called "neoclassical" Solow growth model (1956). Its neoclassical character stems from its assumption of a standard aggregate production function with constant returns to scale, in which capital and labour combine to produce output, and in which, importantly, marginal returns to capital are decreasing.[1] As a result of diminishing marginal returns, the Solow model most fundamentally implies that the growth process of an economy converges to a steady state, in which output per capita, consumption and the stock of capital grow at constant rates.

Solow (1956) illustrates his general model with a Cobb-Douglas production function.[2] In Mankiw et al. (1992), it takes the form

$$Y(t) = F[K(t),\, A(t),\, L(t)] = K(t)^{\alpha}(A(t)L(t))^{1-\alpha} \tag{C.1}$$

where $Y(t)$ is output, $K(t)$ is capital, $A(t)$ is the level of technology and $L(t)$ is labour, and where $0 < \alpha < 1$.

Solow (1956) stipulates that saving is a constant fraction of output s, so that investment $I(t)$ is equal to

$$I(t) = sY(t) \tag{C.2}$$

[1] More formal definitions of what makes a production function "neoclassical" exist, requiring, e.g., quasiconcavity or the Inada conditions to hold.

[2] He does not explicitly include the level of technology $A(t)$, but Mankiw et al. (1992) do.

Hence, assuming $K(0)$ is given, capital accumulates according to

$$\dot{K}(t) = I(t) - \delta K(t) = sY(t) - \delta K(t) \tag{C.3}$$

where δ is the depreciation rate of capital. Thus, net investment is the rate of increase of the capital stock.

Furthermore, growth rates for technology and the labour force are assumed to be given exogenously as g and n, respectively, so that

$$\dot{A}(t) = gA(t) \text{ or } A(t) = A(0)e^{gt} \tag{C.4}$$

and

$$\dot{L}(t) = nL(t) \text{ or } L(t) = L(0)e^{nt} \tag{C.5}$$

Then, defining output and capital per "efficiency unit of labour" as

$$y(t) \equiv \frac{Y(t)}{A(t)L(t)} \text{ and } k(t) \equiv \frac{K(t)}{A(t)L(t)} \tag{C.6}$$

together with Equations C.3, C.4 and C.5, the equation of motion for capital in efficiency unit of labour terms becomes[3]

$$\dot{k}(t) = sk(t)^{\alpha} - (n + g + \delta)k(t) \tag{C.7}$$

Hence, k – the capital-labour ratio – converges to a steady-state value k^*, which is given by

$$k^* = (\frac{s}{n + g + \delta})^{\frac{1}{1-\alpha}} \tag{C.8}$$

The steady-state capital labour ratio k^* (here expressed in efficiency unit of labour terms but also otherwise) thus depends positively on the savings rate s and negatively on the rate of growth of the labour force n, the rate of technological progress g and the rate of depreciation δ.

[3]In "efficiency unit of labour" terms, the production function can be written as $y(t) = k(t)^{\alpha}$, and from the capital accumulation equation C.3, we derive $\frac{\dot{K}(t)}{A(t)L(t)} = sy(t) - \delta k(t) = sk(t)^{\alpha} - \delta k(t)$. Since $k(t) = \frac{K(t)}{A(t)L(t)}$, we also have $\dot{k}(t) = \frac{\dot{K}(t)A(t)L(t) - K(t)[\dot{A}(t)L(t) + A(t)\dot{L}(t)]}{[A(t)L(t)]^2} = \frac{\dot{K}(t)}{A(t)L(t)} - K(t)\frac{gA(t)L(t) + nA(t)L(t)}{[A(t)L(t)]^2} = \frac{\dot{K}(t)}{A(t)L(t)} - (g + n)k(t)$.

C.2.2 Estimating the Solow model in a cross-section context

To move towards a formulation of the model that can be estimated empirically, we convert the production function into per capita terms[4], assume the economy is at steady state ($k(t) = k^*$) and take logarithms, to arrive at

$$\ln \frac{Y(t)}{L(t)} = \alpha \ln k^* + \ln A(t) = \frac{\alpha}{1-\alpha} \ln s - \frac{\alpha}{1-\alpha} \ln(n+g+\delta) + \ln A(0) + gt \tag{C.9}$$

Equation C.9 makes clear two main empirically testable implications of the model: firstly, the steady state level of output per capita depends positively on the savings rate s, and negatively on the labour force growth rate n, and, secondly, the coefficients on the labour force growth rate n (proxied by the population growth rate in empirical applications) and the savings rate s (proxied by the investment ratio in empirical applications) are equal in absolute terms.

To estimate a model in this vein, Mankiw et al. (1992) stipulate that $\ln A(0) = a + \epsilon$, where ϵ is a country-specific shock, and assume that ϵ is independent of s and n, which, if true, renders valid estimation of this equation using OLS in a cross-country setting. They also assume $g + \delta = 0.05$, while n is proxied by the average rate of growth of the working-age population.

C.2.3 Estimating the Solow model in a panel context

Denoting by y^* the steady-state level of income per efficiency unit of labour, which is

$$y^* = (\frac{s}{n+g+\delta})^{\frac{\alpha}{1-\alpha}} \tag{C.10}$$

a Taylor approximation around the steady state[5] gives

[4]Thus, $\frac{Y(t)}{L(t)} = [\frac{K(t)}{A(t)L(t)}]^{\alpha} A(t) = k(t)^{\alpha} A(t)$.

[5]We define $\Gamma(k(t)) \equiv \frac{\dot{k}(t)}{k(t)} = sk(t)^{\alpha-1} - (n+g+\delta)$ based on the equation of motion for capital as per Equation C.3, and approximate around the steady-state k^* – where $G(k^*) = 0$ – using a first-order Taylor approximation, which gives $\Gamma(k(t)) \cong \Gamma(k^*) + \Gamma'(k^*)(k(t) - k^*)$. Since $\Gamma'(k^*) = (\alpha - 1)s(k^*)^{\alpha-1} \frac{1}{k^*}$, we have$\Gamma(k(t)) \cong$

$$\frac{d}{dt}\ln y(t) \cong -\lambda(\ln y(t) - \ln y^*) \tag{C.11}$$

where $\lambda \equiv (1-\alpha)(n+g+\delta)$ measures the speed of convergence, that is, the speed with which the economy returns to its steady state when $k(t) < k^*$ or $y(t) < y^*$.

Defining $z_t \equiv \ln y(t) - \ln y^*$, the homogeneous differential equation $\dot{z}_t = -\lambda z_t$ is solved as $z_t = e^{-\lambda t} z_0$, so that

$$\frac{d}{dt}\ln y(t) \cong (1-e^{-\lambda t})\ln y^* + e^{-\lambda t}\ln y(0) \tag{C.12}$$

So then, at some initial point in time $t_1 = 0$, with $\tau \equiv \Delta t = t_2 - t_1$, after substituting and rearranging[6] – and writing everything in terms of output per capita $\tilde{y}(t) \equiv \frac{Y(t)}{L(t)}$ – we have

$$\ln \tilde{y}(t_2) - \ln \tilde{y}(t_1) \cong (e^{-\lambda\tau}-1)\ln \tilde{y}(t_1) + (1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln s \tag{C.13}$$

$$-(1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln(n+g+\delta)$$

$$+(1-e^{-\lambda\tau})\ln A(0) + g(t_2 - e^{-\lambda\tau}t_1)$$

Note that the term $(1-e^{-\lambda\tau})\ln A(0)$ is time-invariant and hard to measure, but can be addressed in panel estimation by allowing for unobserved country fixed effects.

$-(1-\alpha)s(k^*)^{\alpha-1}\frac{k(t)-k^*}{k^*}$. Then, substituting $k^* = (\frac{s}{n+g+\delta})^{\frac{1}{1-\alpha}}$ gives $\Gamma(k(t)) \cong -(1-\alpha)(n+g+\delta)\frac{k(t)-k^*}{k^*}$.

Taking the first-order Taylor approximation of $\ln k$ around k^* yields $\ln k(t) \cong \ln k^* + \frac{k(t)-k^*}{k^*}$, so equivalently $\frac{k(t)-k^*}{k^*} = \ln k(t) - \ln k^*$ as well as $\frac{d}{dt}\ln k(t) = \frac{\dot{k}(t)}{k(t)}$) and $\Gamma(k(t)) \cong (1-\alpha)(n+g+\delta)(\ln k^* - \ln k(t))$. As per the production function in terms of efficiency units of labour, $\ln y(t) = \alpha \ln k(t)$, with which it is easy to show that $\Gamma(y(t)) \equiv \frac{\dot{y}(t)}{y(t)} = \alpha\Gamma(k(t))$, so that $\Gamma(y(t)) \equiv \frac{\dot{y}(t)}{y(t)} \cong -(1-\alpha)(n+g+\delta)(\ln y(t) - \ln y^*)$ and hence $\frac{d}{dt}\ln y(t) \cong -\lambda(\ln y(t) - \ln y^*)$.

[6] At some initial point in time $t_1 = 0$, with $\tau = \Delta t = t_2 - t_1$, we have $\ln y(t_2) \cong (1-e^{-\lambda\tau})\ln y^* + e^{-\lambda\tau}\ln y(t_1)$. Subtracting $\ln y(t_1)$ from both sides gives$\ln y(t_2) - \ln y(t_1) \cong (1-e^{-\lambda\tau})[\ln y^* - \ln y(t_1)]$. Then, we substitute $y^* = (k^*)^\alpha = (\frac{s}{n+g+\delta})^{\frac{\alpha}{1-\alpha}}$ into this expression and rearrange to get

$$\ln y(t_2) - \ln y(t_1) \cong (e^{-\lambda\tau}-1)\ln y(t_1) + (1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln s - (1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln(n+g+\delta)$$

So in panel data notation, our model thus is

$$\Delta y_{i,t} = (\alpha - 1) y_{i,t-1} + \beta X_{i,t} + \gamma_i + \delta_t + \varepsilon_{it} \tag{C.14}$$

With

$$\beta = \begin{pmatrix} \beta^s \\ \beta^n \end{pmatrix} \text{ and } X_{i,t} = \begin{pmatrix} x^s_{i,t} \\ x^n_{i,t} \end{pmatrix} \tag{C.15}$$

we have the following correspondences to and coefficient restrictions derived from the Solow model:

$$\begin{aligned} \Delta y_{i,t} &= \ln y(t_2) - \ln y(t_1) \\ y_{i,t-1} &= \ln y(t_1) \\ \alpha &= e^{-\lambda\tau} \\ \beta^s &= (1 - e^{-\lambda\tau}) \frac{\alpha}{1 - \alpha} \\ \beta^n &= -(1 - e^{-\lambda\tau}) \frac{\alpha}{1 - \alpha} \\ x^s_{i,t} &= \ln s \\ x^n_{i,t} &= \ln(n + g + \delta) \\ \gamma_i &= (1 - e^{-\lambda\tau}) \ln A(0) \\ \delta_t &= g(t_2 - e^{-\lambda\tau} t_1) \end{aligned} \tag{C.16}$$

Finally, $\varepsilon_{i,t}$ is the error term. In estimation, $\ln s$ and $\ln(n + g + \delta)$ are allowed to vary over time. s is proxied by the investment-to-GDP ratio while n is proxied by the (working-age) population growth rate (and $g + \delta = 0.05$ is assumed following Mankiw et al. (1992)).

In our model as presented in Equations 3.4 and 3.5 above, we decompose $x^s_{i,t}$ into its private and government components, and add government consumption to the equation as an additional explanatory variable.

C.2.4 Notions of convergence in the Solow model

The Solow model has spurned theoretical and empirical debates about the "convergence" of countries' output and growth. More specifically, there are two notions of convergence predicted by the Solow model, which can

be tested empirically (Islam, 1995). There should be **convergence in terms of levels of income**, according to which – if countries are similar as regards preferences and technology – steady-state income per capita levels across countries will be the same, and countries will converge to this steady state level as time passes. There should also be **convergence in terms of growth rates**: since the steady-state growth rate is determined by the rate of technological progress, then if technological progress is a "public good" and shared across countries, all countries should eventually converge to the same growth rate.

One way of investigating convergence empirically is to study the correlation between "initial income" and subsequent growth rates – due to the assumption of diminishing marginal returns to capital, countries with a low capital stock should have higher marginal returns to capital and should hence grow faster, given similar savings rates, which would imply a negative correlation between initial income and subsequent growth. Examining the presence – or otherwise – of this negative correlation empirically involves testing both convergence hypotheses mentioned above (Islam, 1995): it might be that poorer countries "catch up" with richer ones by growing faster initially (convergence in terms of levels of income), but that their growth rates then slow down as a result of decreasing returns to capital (convergence in terms of growth rates).

However, in response to the mixed empirical evidence as regards this negative correlation – for example, Romer (1989) (as quoted by Islam, 1995) finds it to be zero or even positive – the notion of **"conditional convergence"** was coined, according to which countries will converge to their respective steady states of per capita income once we control for differences in certain country characteristics. This means that – after controlling for these characteristics – the correlation between initial income and subsequent growth rates should again be negative. For example, Mankiw et al. (1992) control for some differences by including saving and population growth rates.

Appendix D

The data on government balance sheet and budget deficit components

D.1 Introduction

Many governments across the OECD have seen their net worth – that is, their total assets less their total liabilities, measured relative to GDP or national income – decline considerably in recent decades, as Atkinson (2015) and Piketty and Zucman (2014) have noted, and as mentioned in previous chapters of this thesis.

This observation – which has received relatively little attention in academia and policy discussions, especially those about government debt and deficits – is one central motivation for the focus of this thesis on government asset accumulation and its relevance for fiscal policy and the macroeconomy. The main objectives of this appendix are thus (i) to clarify the crucial concepts and issues involved in government accounting, including the measurement and valuation of government assets and government investment, and (ii) to motivate the concern of this thesis with government asset accumulation by discussing trends across countries in governments' assets and net worth.

In this appendix, we draw heavily on Piketty and Zucman's Data Appendix to their 2014 paper as well as on the documentation accompanying the

United Nations' 2008 System of National Accounts (2008 SNA) and its European equivalent, the European System of National and Regional Accounts 2010 (ESA 2010). The Manual on Government Deficit and Debt (2014), developed by Eurostat to complement the ESA 2010, is also used.

This appendix proceeds as follows. In Section D.2, we introduce general principles that are applied to the measurement and valuation of government accounts by the 2008 SNA and ESA 2010. In Section D.3, we outline specific issues relating to balance sheet components, and present trends in government balance sheets for a few key countries of interest. Section D.4 discusses their flow counterparts, that is, the components of the government budget deficit. Finally, Section D.5 contains graphs of government balance sheet series for the countries included in the sample in Chapter 2. Overall, the spirit of this appendix is summarised well by Griliches' statement below.

"*While it is useful to alert users to their various imperfections and pitfalls, the available economic statistics are our main window on economic behavior. In spite of the scratches and the persistent fogging, we cannot stop peering through it and trying to understand what is happening to us and to our environment, nor should we. The problematic quality of economic data presents a continuing challenge to econometricians. It should not cause us to despair, but we should not forget it either.*"

– Griliches (1986); quoted in Atkinson (2015)

D.2 General principles in government accounting

D.2.1 Scope of the government sector

"Government" refers, throughout this appendix and previous chapters of this thesis, to the general government sector, as per sector classification S.13 in the ESA 2010: this includes all government units and all non-market non-profit institutions that are controlled by government units. Government units in turn encompass those of central government (all units with a national sphere of competence), state government (all government units in a federal system that have a state or regional sphere

of competence) and local government (all government units with a local sphere of competence) and social security funds.[1] Note, in contrast, that the term "public sector" refers to all resident institutional units that are controlled by government. It thus includes general government as well as public corporations (2008 SNA: 1.35). Put another way, the "general government" sector excludes public corporations.

Classified as "government units" are those core government entities inside of central, state or local government whose revenues and expenditures are directly regulated and controlled by a ministry of finance or equivalents. Social security funds are generally included in general government, except those defined-contribution schemes or funds that do not involve a government guarantee of the level of pensions to be paid and where this level depends on market performance – these are classified as financial corporations.

When the principal function of a government-controlled institutional unit is the redistribution of wealth or financial intermediation, these are always classified as belonging to the general government or in the financial corporations sector, respectively (Eurostat, 2014).[2] Otherwise, whether and how units – corporations, in particular – are included in general government depends on two broad criteria: firstly, on the type of their activity – classified as either "market" or "non-market" – and, secondly, on their ownership structure, with government either owning a majority and hence controlling stake or a minority and hence non-controlling stake. Table 1 summarises the classification approach embodied in the 2008 SNA / ESA 2010, which is explained in more detail next.

The activity of government units is classified based on the "market/non-market test": an institutional unit counts as "market" if it is not a dedicated provider of ancillary services, is not the only supplier of goods and services to the government or has competition, and has an incentive to maximise profit or to adjust supply to do so. This final criterion is linked to whether the majority of the unit's production is offered at

[1] Sometimes, separate legal entities are established to provide specific functions, such as road construction – these are known as "extra-budgetary units", but are included in the general government sector.

[2] An "institutional unit" is organised separately from other activities of government units, holds assets and liabilities separately and engages in financial transactions on its own account.

Table D.1: Sector classification of public-sector units

	Activity type	
Government stake	**Market**	**Non-Market**
Minority	General government (financial assets)*	Non-profit institutions serving households
Majority	Public corporations	General government (non-financial assets)

*The stake held by government counts as a financial asset for government. Overall, the unit in question falls under "private corporations".

so-called "economically significant" prices or not. Prices are taken to be "economically significant" when the producer has an incentive to adjust supply to maximise profit or, at least, to cover variable cost with revenue from sales, and when consumers are free to choose on the basis of the prices charged (ESA 2010: 20:23). When the majority of the costs of a unit can be met by proceeds from sales, and given that the other criteria are met, the unit is classified as "market".

Thus, when government owns a controlling stake in the institutional unit in question, *market* public sector units are classified as public (financial or non-financial) corporations, which are not included in the general government sector (2008 SNA: 4.127). Public financial corporations notably include the central bank, whose balance sheet is hence not included in that of general government.[3] *Non-market* public sector units in which the government owns a controlling stake are included in government non-financial assets. In contrast, when government only owns a minority stake, *market* public sector units are classified as equity stakes in general government financial assets, while *non-market* public sector units are included in the "non-profit institutions serving households" (NPISH) sector.

Note that the inclusion of more complex institutional arrangements –

[3]Transactions between general government and the central bank are recorded – they include dividends based on the current activity of the central bank plus exceptional payments after the sale or revaluation of reserve assets.

for example, quasi-corporations, restructuring agencies, special purpose entities, joint ventures or market regulatory agencies – depends on the exact nature of their institutional set-up, activity type, control, lifespan and residency, among other things. These cases are discussed in detail in the 2008 SNA, paragraphs 22.44 and after.

Furthermore, as laid out in the Manual on Government Deficit and Debt (Eurostat, 2014) accompanying the ESA 2010, the inclusion and valuation of many types of government fixed assets, such as utilities, telecommunication networks, roads, airports, hospitals, schools or prisons, depends on the exact nature of the contract involved in financing, constructing, operating and maintaining the particular asset – these include "traditional" procurement contracts for capital assets or goods and services, but also equity stakes, leases or concessions. Generally, if the government is financing most of the cost involved, the asset is counted in the balance sheet of general government. If the (non-public) corporation involved in the contract, in contrast, receives the majority of the revenue from the asset, it is counted in the balance sheet of private corporations, at least for the contracted period. In case of public-private partnerships (PPPs), the allocation of the relevant asset – in particular, for the initial recording of the asset – as well as the resulting fixed capital formation to a particular sector depends on who is bearing the economic risks involved. Often, another classification decision needs to be made at the end of the contract. Detailed rules are laid out for accounting not only for PPPs, but also for transfers to and from the European Union, privatisations and nationalisations, debt restructuring and bailouts. In case of public hospitals, their classification depends on the degree of control of government, the presence of a situation of real competition with private hospitals and the absence of sustained financial losses of public hospitals (Eurostat, 2014).

D.2.2 Social security funds and pensions

Because, in principle, the general government sector includes social security funds, as mentioned above, the general government's balance sheet does include insurance and pension schemes. However, the exact manner in which pension schemes are included in the general government

balance sheet depends on the type of pension scheme and on which party assumes the financial risk involved.

As laid out by Eurostat (2004), specifically, unfunded (or "pay as you go") schemes – where one unit assumes the unconditional responsibility for and risk of paying pensions, and there is no accumulation of assets with the aim of using them as resources to pay benefits – are classified as social security schemes when they are managed by a government unit. In these schemes, there would not normally be an accumulation of assets. In funded schemes, assets are accumulated as resources for the payment of future benefits. Among funded schemes, in defined-benefit schemes, a certain level of benefits is paid out regardless of the value of accumulated assets, so that the managing unit bears the financial risk. When such a scheme is managed by a government unit, it is classified as a social security scheme. In (funded) defined-contribution schemes, the level of benefits that is paid out depends on the value of accumulated assets, so that recipients bear the financial risk. Even if a government unit manages such a scheme, so long as there is no government guarantee for the majority of payments in case of default, such a scheme is not to be classified as a social security scheme, but as a public financial corporation. Hence, it would not be included in our general government measures, but would be a in a broader set of public sector measures. Eurostat (2004) discusses intermediate cases in more detail.

Note that, in general, government guarantees for pension schemes are considered contingent liabilities, and are not recorded as liabilities in general government accounts (Eurostat, 2004). Following ESA 2010, pension obligations are recorded in a separate table to the core national accounts.

D.2.3 Valuation methodology

In general, the 2008 SNA / ESA 2010 consider and apply to both stock and flow measures: they aim to support the creation of a system of accounts that is complete and internally consistent, and hence specify that all changes in economic value between stock measures at two points in time must be captured in flows (2008 SNA: 3.3). Given that the 2008 SNA / ESA 2010 cover all sectors of the economy, the fundamental

accounting principle underlying the whole system of accounts is that of quadruple accounting: any given transaction gives rise to two entries for each party involved in the transaction. The principal unit of account is money, and all items included in the accounts are represented by their monetary value.

Note that assets do not include human capital (2008 SNA: 3.48, ESA 2010: 7.19) and that, correspondingly, spending on education and health services is treated as current spending rather than investment spending (Piketty and Zucman, 2014). Also, note that in case of the general government sector, consolidation between different levels of government is conducted for most items in both stock and flow accounts: current and capital transfers, interest and transactions in financial assets and liabilities are consolidated, but taxes and subsidies paid by one government unit to another and net acquisitions of non-financial assets are not. Consolidation does not affect balancing items such as the surplus (2008 SNA: 2.69).

Flows

Flow measures are measured over a period of time – commonly, a full year – and include transactions as well as other changes in value in assets and liabilities that do not result from transactions, such as the effects of price changes.

For flows, the principle of accrual recording is used, which means that they are recorded at the time that economic value is created, exchanged or extinguished – thus, a payment is recorded when the obligation to pay arises, rather than when the payment is actually made (ESA 2010: 20.123).

However, in the context of government accounting, this is easier said than done, since government records are, in many countries, operated on a cash basis – that is, flows are recorded when the cash is paid or received – rather than on an accrual basis. For example, accrual accounting means that government tax revenue should be recorded in accounts when the taxable event occurs (for example, when income is earned), although the ESA recognises that when accrued taxes are calculated based on taxes due, tax revenue might be overstated (ESA 2010: 20.172, 20.173).

Stocks

Stock measures are measured at a point in time and encompass, most fundamentally, the assets and liabilities sides of the balance sheet. Balance sheet items are recorded at current values at the time to which the balance sheet relates, which is, typically, the end of the calendar year (as at December 31st; 2008 SNA: 2.60).

The stated aim is to value balance sheet items of all sectors at market value (2008 SNA: 2.60). Exceptions include currency, deposits as well as loans and other accounts receivable or payable, which are valued at book value (ESA 2010: 20.149). If market value data exist, they are obtained through census-like methods – that is, units are asked directly about the current values of their assets and liabilities. When direct methods of measurement are not feasible, there are two main alternative valuation approaches: either, the "perpetual inventory method" (PIM) is used, which involves cumulating past flows, adjusting for price changes and depreciation (Piketty and Zucman, 2014). If the data required for PIM calculations is not available, then – as a "last resort" (ESA 2010: 1.95) – the "present discounted value" (PDV) of future expected returns of an asset is calculated.

Generally, census-like methods are used for all financial assets and liabilities, irrespective of sector, while PDV calculations are used to value natural resources and, in the context of government balance sheets, PIM is typically used to value government fixed assets such as transportation infrastructure.

As the OECD (2013) and Piketty and Zucman (2014) discuss, PIM is problematic for a number of reasons: calculations are highly sensitive to the quality and availability of underlying historical investment data, especially when depreciation is low, and to the precise assumptions made about depreciation (in particular, the asset service life, the asset retirement distribution and the functional form assumed for age-price profiles for different types of assets). In addition, price changes unrelated to depreciation likely take place during the valuation period, and the kind of price data that is necessary – for a range of different assets and vintages – to be able to estimate the market value rather than the book value of assets is often not available. There are also issues in valuing

assets that cannot be sold, or with items such as historical monuments – in this latter case, there are no hypothetical sales prices available, nor is there data on historical investment flows: as a result, many countries do not include monuments in their government assets. For example, France includes the land underlying the Louvre and the recently added pyramid in its assets, but not the Louvre itself (Piketty and Zucman, 2014).

D.3 Government balance sheet components

D.3.1 Balance sheet structure

Fundamentally and for all sectors, the 2008 SNA and ESA 2010 separate non-financial assets from financial assets and liabilities. For governments, the excess or shortfall of assets over liabilities is called "net worth" and can, somewhat tautologically, be included in a balance sheet representation of the type displayed in Table D.2.

Table D.2: Schematic government balance sheet

Assets		**Liabilities**
Financial assets (FA)		"Financial" liabilities (LI)
+		+
Non-financial assets (NFA)		*Net worth ("equity")**
$\sum$ Assets	=	$\sum$ Liabilities

*Net worth is just the difference between total assets and total liabilities

In the context of a firm or bank, so-called "net worth" would correspond to shareholder equity. A negative amount of equity would, for firms and banks but also individuals, usually be considered to spell trouble ahead. As mentioned above, for many governments, little attention has so far been paid to their net worth or "equity" position.

Government balance sheet definitions and measurement are discussed in the following. Developments in government balance sheet composition and net worth over the past decades are then presented and discussed for a set of countries of particular interest.

D.3.2 Definition and valuation

The definition and valuation – as per the 2008 SNA, the ESA 2010 and Piketty and Zucman (2014) – of the main government balance sheet items are summarised in Table D.3 and discussed one by one in the following. The focus is always on the "general government" sector as defined in Section D.2.1.

Non-financial assets

Non-financial assets can be thought of as including – in line with Piketty and Zucman (2014), who use a slightly different decomposition of non-financial assets than the 2008 SNA / ESA 2010 – (i) produced tangible capital such as roads, (ii) non-produced tangible capital such as natural resources, and (iii) intangible capital such as R&D. Category (i) corresponds to "produced non-financial assets" in the 2008 SNA / ESA 2010, while categories (ii) and (iii) jointly correspond to "non-produced non-financial assets" in the 2008 SNA / ESA 2010.

(i) Produced tangible capital consists of fixed assets, inventories and valuables. Fixed assets are formally defined as production assets that are used repeatedly or continuously in production for more than a year. They include buildings and structures, such as schools or roads, as well as machinery and equipment, and are valued using the perpetual inventory method. Inventories and valuables are estimated by combining census-like methods and cumulating past flows.

(ii) Most importantly in non-produced tangible capital, natural resources are valued at market value or by calculating the present value of future returns, but there is heterogeneity in classification practices across countries, for example as regards which sector subsoil assets such as coal, oil, natural gas or minerals are allocated to. Note that environmental assets over which there is no ownership or that cannot be exploited – such as air – are not included.

(iii) Intangible capital includes R&D, intellectual property products such as computer software and non-produced intangible

capital such as leases and licences as well as goodwill and marketing assets and is valued using the perpetual inventory method, but is still frequently excluded from national government balance sheet calculations and the data used here.

While the classification, measurement and valuation practices of government non-financial assets are presumed to be sufficiently similar across countries to insightfully use this data in empirical analysis, there is variation across countries in what is included in measures of government non-financial assets, for example, as regards weapon systems, intangible assets including R&D, inventories, valuables, contracts, leases and licences, goodwill and marketing assets, and natural resources. Tables A169 and A170 in Piketty and Zucman (2013) lay out in detail what is included for the countries included in their 2014 paper. For countries for which data was added – as an update to the 2014 paper – to the World Top Incomes Database (Denmark, Netherlands, Sweden), there is currently no documentation available that lists which types of non-financial assets are included.

Financial assets and liabilities

Financial asssets and liabilities are also estimated using census-like methods and are valued at market value, where available. Quoted equity is valued using the most recent quotation price, while unquoted equity is valued using ratios of book value to market value of similar companies. For valuing companies that do not issue shares, such as public corporations, measures of net assets (the difference between total assets and non-equity liabilities) are typically used (Piketty and Zucman, 2014). In some cases, valuation practices differ across countries, such as in valuing debt securities: debt securities are valued at market prices in most countries, but the United States record bonds at par value, and Piketty and Zucman do not correct for this in their data.

Government financial assets comprise

(i) currency and deposits, including government deposits at both central banks and regular banks;

Table D.3: Elements of the government balance sheet

Category	**Example**	**Valuation**[1]	**Example magnitude**[2]	
			% of total	
Financial assets (FA) and liabilities (LI)			***FA***	***LI***
(i) Currency and deposits	Gov. deposits at the central bank	Book value	11%	1%
(ii) Debt securities	Securities held by a social security fund	Market value	2%	72%
(iii) Loans	A loan to a public corporation or student	Book value	45%	1%
(iv) Equity stakes	Minority stake in a corporation[3]	Market value	12%	0%
(v) Insurance and pension schemes	Public pension fund reserves	Market value	0%	15%
(vi)-(viii) Other fin. assets / liabilities[4]		Market value	30%	11%
Non-financial assets (NFA)			***NFA***	
(i) Produced tangible capital				
- Fixed assets	A road or school or bridge	PIM	85%	
- Inventories	Materials, uncompleted fixed assets	Census-like methods	15%	
- Valuables	Gold, paintings, sculptures	Census-like methods		
(ii) Non-produced tangible capital	Oil deposits	Market value or PDV		
(iii) Intangible capital	Software	PIM		

[1]Valuation as in the 2008 SNA, ESA 2010 and Piketty and Zucman (2014)

[2]Piketty and Zucman (2014) do not provide this level of granularity of data, so the "example" magnitudes are for Canada's general government and taken from Statistics Canada for financial assets and liabilities and the Canada's Department of Finance for non-financial assets (Table 385-0033)

[3] Equity stake liabilities not usually recorded for government units, but can appear if entities are classified as belonging to general government based on the market / non-market test (Table 1; ESA 2010: 20.145)

[4]Including monetary gold and SDRs, financial derivatives and other accounts receivable / payable (valued at book value)

(ii) debt securities, for example those held by social security or other reserve funds;

(iii) loans, including loans to other government units and foreign governments, public corporations and students;

(iv) equity stakes, for example in public corporations and investment fund shares;

(v) insurance and pension schemes;

(vi) monetary gold and special drawing rights (SDRs), if managed by the government rather than the central bank;

(vii) financial derivatives, which include guarantees given by government; and

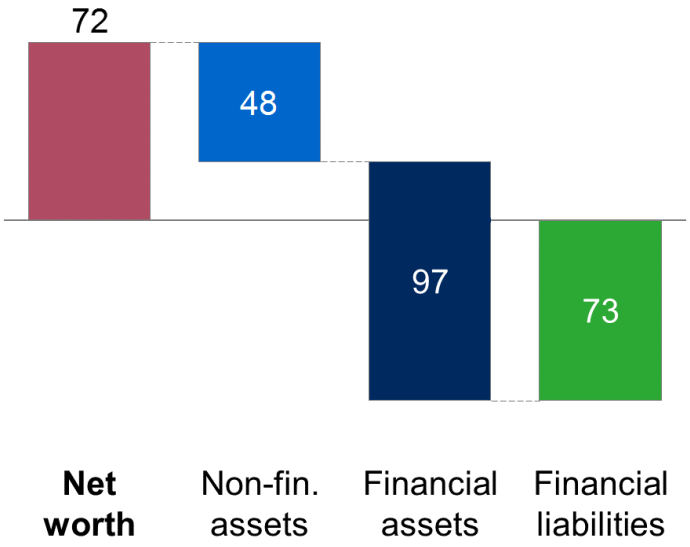
(viii) other accounts receivable.

Note that, according to Piketty and Zucman (2013), the distinction between government financial and non-financial assets is "fragile". This is the result of the difference in classification of public sector units resulting from their type of activity and ownership structure, as summarised in Table D.1: if a corporation meets a majority of its costs from selling its output at economically significant prices and hence is classified as a "market" producer, the share of it that is owned by the government is counted as a financial asset of the government. However, if a government-controlled corporation only meets a minority of its costs through sales at such prices and is hence classified as "non-market", it will be counted as a non-financial asset of the government.

Government (financial) liabilities are comprised of the same categories as government financial assets, with the exception of (viii), which in this case comprises other accounts payable. Figures D.1 and D.2 illustrate the relative magnitudes of government non-financial assets, financial assets and (financial) liabilities for Sweden and the UK.

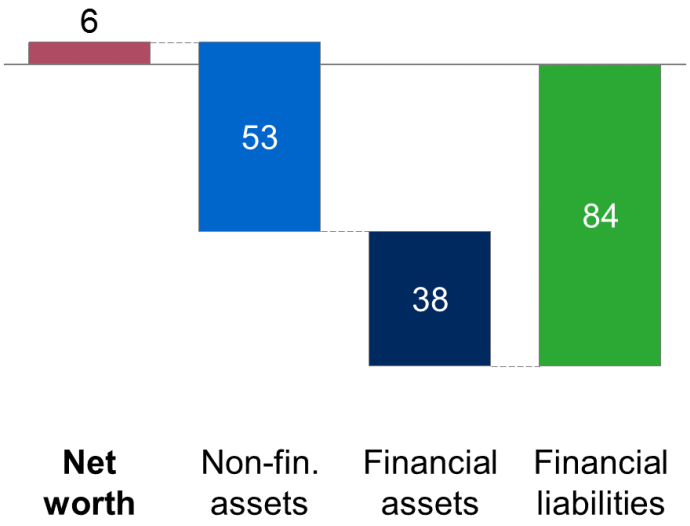
Among financial liabilities, almost all items are recorded at market value – with the exceptions of categories (i), (iii) and (viii), which are valued at book value, as explained in Section D.2.3 above – in accounts based on 2008 SNA / ESA 2010, which includes those assembled by Piketty and

Figure D.1: Government net worth decomposition, Sweden, 2014



In percent of national income
Source: Piketty and Zucman (2014)

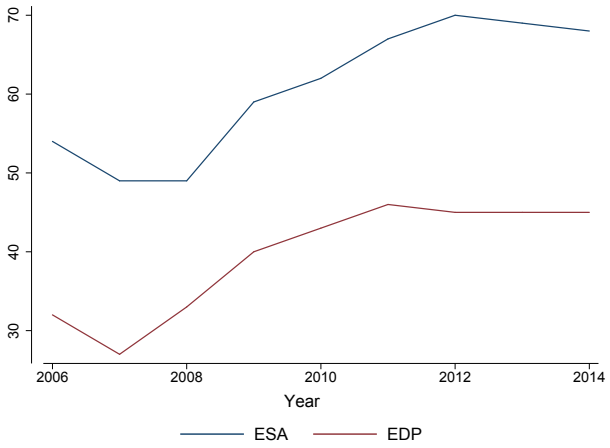
Figure D.2: Government net worth decomposition, UK, 2010



In percent of national income
Source: Piketty and Zucman (2014)

Zucman (2014). Recording at market value means recording a bond that has a face value of 1,000 but is trading at 900 on the 31st of December of the relevant year as 900 on the government balance sheet. In contrast, those measures of government liabilities that are relevant for the EU's Maastricht criteria and Excessive Deficit Procedure (EDP) only include categories (i), (ii) and (iii) and, additionally, are measured in face or par value terms (Eurostat 2014), which means that the amount of liabilities is reported as the contractually agreed amount that will have to be returned to the creditor upon maturity. In the example above, this means that the bond enters the government balance sheet with a value of 1,000. Figure D.3 below shows, using the example of Denmark, that, as a result, while tracing broadly similar trends, the two measures of government liabilities can differ substantially.

Figure D.3: Comparison of ESA and EDP debt measures



Both are measured in percent of GDP at current prices
Source: Piketty and Zucman (2014) for ESA measures,
Eurostat for EDP measures and GDP at current prices

Finally, note that in their original dataset, Piketty and Zucman (2014) use averages of end-of-year values of years t and $t-1$ of balance sheet measures for year t, but we use end-of-year-t values in baseline specifications for comparability with the literature.

D.3.3 Developments in governments' net worth, selected countries

As noted at multiple points throughout this thesis, many governments across the OECD have seen their net worth decline substantially in past decades (Atkinson, 2015; Piketty and Zucman, 2014). In the following, developments in governmental net worth over the past decades are discussed for a set of five countries of particular interest – Germany, Japan, Sweden, the United Kingdom and the United States – for all of which government net worth has recently changed considerably. Figures of government net worth, assets and liabilities for all countries that are included in the sample for econometric analysis in Chapter 2 can be found in Section D.5.

Germany

The net worth of the German general government has declined from 65% of national income in 1991 to less than 9% of national income in 2013, based on data from Piketty and Zucman (2014) and as displayed in Figure D.16 in Section D.5.[4] Figure D.17 additionally shows Germany's general government's total assets and total liabilities, the difference of which equals net worth. Clearly, the substantial decline in net worth, relative to national income, in Germany is driven, most fundamentally, by an increase in government liabilities that are not used to finance investment or, equivalently, that are not matched by a corresponding increase in government assets. In total, government liabilities more than doubled relative to national income over this period, increasing from 43% of national income to 98% in 2013.

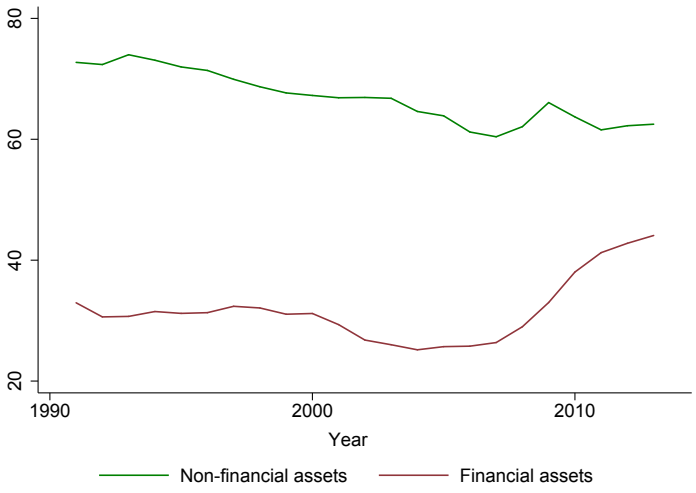
Government assets had been declining somewhat prior to the recent financial crisis, but have grown significantly since. This is due to a substantial increase in government financial assets, which grow from

[4]Note that the data that Piketty and Zucman present refers to the relevant geographical boundaries of the German state during the year in question. So data before 1991 refers to West Germany only, including Saarland and West Berlin, while data for 1991 and after refers to reunified Germany. This creates the potential for a discontinuity, but de facto any discontinuity present appears to be small: Piketty and Zucman find that the wealth-income ratio for the whole West German economy was about 290% in 1990, while that of reunified Germany was 284% in 1991.

around 26% of national income in 2007 to 44% by 2013, while non-financial assets fluctuate between 60% and 66% in the years preceding and following the crisis, as can be seen in Figure D.4.

The increase in financial assets, in turn, is due to the creation of the then so-called Financial Market Stabilisation Fund (SoFFin) and, with it, the creation of bad banks ("Abwicklungsanstalt"), which sit on the government's balance sheet (Handelsblatt (December 14th, 2009); Focus (May 31st, 2012), Bundesbank). Two struggling banks (HRE and WestLB) offloaded risky assets into such bad banks, which explains the increase in securities held by general government between 2008 and 2010. Figure D.4 also shows that in the decades preceding the crisis, both financial and non-financial assets of general government had been gradually declining relative to national income.

Figure D.4: Government fin. and non-fin. assets, Germany, 1990-2013



In percent of national income
Source: Piketty and Zucman (2014)

Japan

While Japan has witnessed an even more dramatic decline in government net worth over the past decades – from 103% of national income in 1990 to -5% in 2013, as can be seen in Figure D.20 in Section D.5 – the story behind this decline is different to that of Germany. Assets grew from 183%

of national income to 285%, while liabilities grew from 80% of national income to 290% between 1990 and 2013 (Figure D.21): this means that about half of the increase in liabilities, relative to national income, over this period was matched by an increase in assets. Hence, in spite of the dramatic increase in assets owned by the government, the government's net worth has still been falling and entered negative territory in 2012.

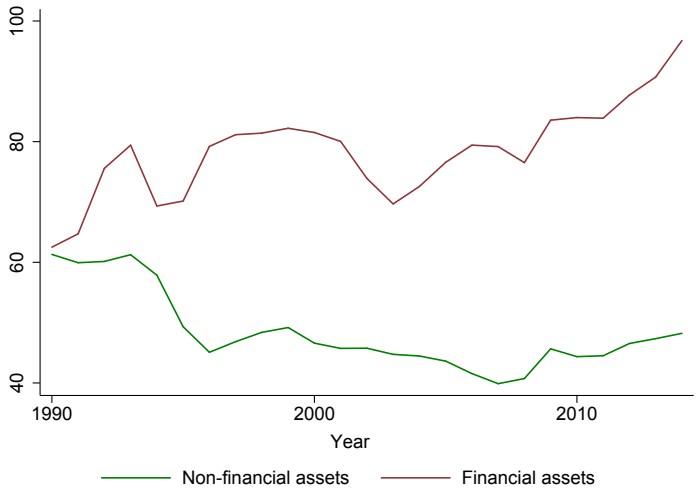
It is also interesting to note that the 1990s banking crisis in Japan is visible in an increase in the growth rate of liabilities after 1991 and, in particular, the late 1990s. Furthermore, the recent financial crisis is apparent in larger-than-average year-on-year absolute jumps in assets and liabilities of 17% and 37% relative to national income, respectively, from 2008 to 2009, in case of liabilities reflecting a particularly large primary budget deficit that year. It is also remarkable to note that both assets and liabilities are much larger, relative to national income, in Japan than in most other mature countries, with both – based on Piketty and Zucman (2014) – approaching 300% of national income. In contrast, both government assets and government liabilities tend to fluctuate somewhere around 100% of national income in Germany, Sweden, the United Kingdom and the United States. As Piketty and Zucman discuss in the Data Appendix (2013) to their paper, one factor that is behind the particularly large balance sheet of the Japanese government is the fact that foreign exchange reserves are included on the government's balance sheet instead of the central bank's. Another part of the story is that the government finances a substantial fund that lends to SMEs and public corporations. Finally, social security funds in Japan are heavily invested in Japanese government bonds and the Japanese general government holds a large amount of shares in Japanese public corporations (Piketty and Zucman, 2014).

Sweden

Although Sweden's government net worth declined substantially in the 1990s, when it stood at around 15% of national income, this trend has been in reversal since the late 1990s, with net worth recovering to 72% in 2014, as Figure D.24 in Section D.5 shows. This recovery is due to, initially, a reduction in debt load relative to national income after a deep recession and banking crisis in the early 1990s, as can be seen in Figure D.25 in

Section D.5. This reduction coincides with the 1998 governance reform of the Swedish National Debt Office[5], which stipulates that each year, parliament must authorise the government to raise additional debt (IMF and the World Bank, 2003). More recently, net worth has been on the rise due to a faster increase in asset accumulation than in debt, which is due in particular to an increase in financial assets in the late 2000s (see Figure D.5), in turn possibly reflecting increased state equity in banks and loans to troubled European countries.

Figure D.5: Government fin. and non-fin. assets, Sweden, 1990-2014



In percent of national income
Source: Piketty and Zucman (2014)

United Kingdom

The net worth of the government of the United Kingdom has declined from 66% of national income in 1990 to 6% in 2010, as Figure D.26 in Section D.5 illustrates. Although data from Piketty and Zucman (2014) is not available for the United Kingdom's general government sector after 2010, national sources suggest that government net worth entered negative territory in 2011 and has stayed there since (ONS, 2016).

Behind this decline is a combination of shrinking assets and growing liabilities, as can be seen in Figure D.27 in Section D.5: assets decreased

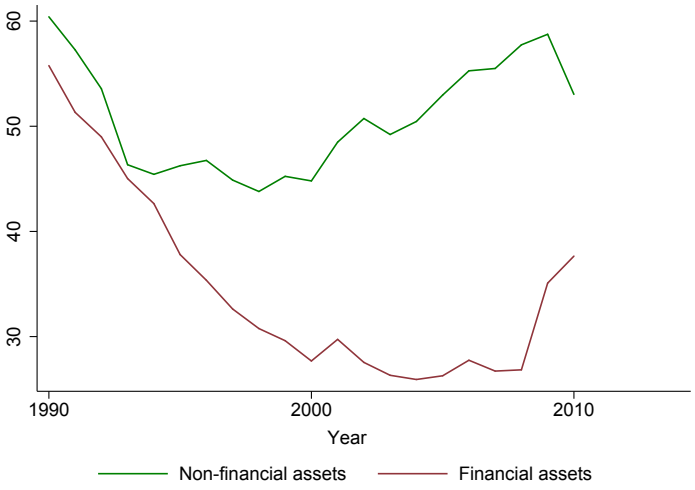
[5]The SNDO manages central government debt, not general government debt.

from almost 120% of national income in 1990 to around 75% in the 2000s, yet recovered to more than 90% by 2010. Liabilities stood at 50% of national income in 1990 but increased again after, reaching 84% in 2010. The low levels of liabilities in the early 1990s were the result of substantial debt repayment, the first "reverse auction" held and declining gilt prices (Bank of England, 1989) during the 1980s. On the asset side of the balance sheet, non-financial assets were trending downwards until the 2000s due to privatisations reducing dwellings, land and machinery owned by government (Bova et al., 2013). The recent financial crisis is also clearly visible in the United Kingdom's government's balance sheet and net worth: government liabilities as a share of national income show the impact of the recession as well as of fiscal stimulus and bailouts of banks in response to the crisis, with liabilities increasing from 55% of national income prior to the crisis (in 2007) to 84% by 2010 (Chote et al., 2010). Government financial assets, shown in Figure D.6, increase from 27% of national income in 2007 to 38% by 2010, reflecting capital injections into banks by government (equity stakes in Lloyds / Lloyds Banking Group, Northern Rock and the Royal Bank of Scotland), loans extended to banks by government (Northern Rock) and the creation of defeasance structures by government (Bradford & Bingley, Northern Rock Asset Management) over the course of the financial crisis (ONS, 2015).[6] This increase in assets means that government net worth decreases by less than the increase in liabilities in the crisis years 2009 and 2010.

Measures of financial assets and liabilities for the United Kingdom that cover the public sector as a whole, that is, which include public non-financial and financial corporations in addition to general government, show the impact of the bank bail-outs even more dramatically – data from the Office for National Statistics suggests that net debt (government liabilities less government financial assets, measured as a share of GDP) more than tripled from 2008 to 2009 (ONS, 2014).

[6]Banks that were wholly nationalised or majority-owned by government do not show up here – they are classified as public (financial) corporations, and hence are part of the public sector, but not of general government.

Figure D.6: Government fin. and non-fin. assets, UK, 1990-2010



In percent of national income
Source: Piketty and Zucman (2014)

United States

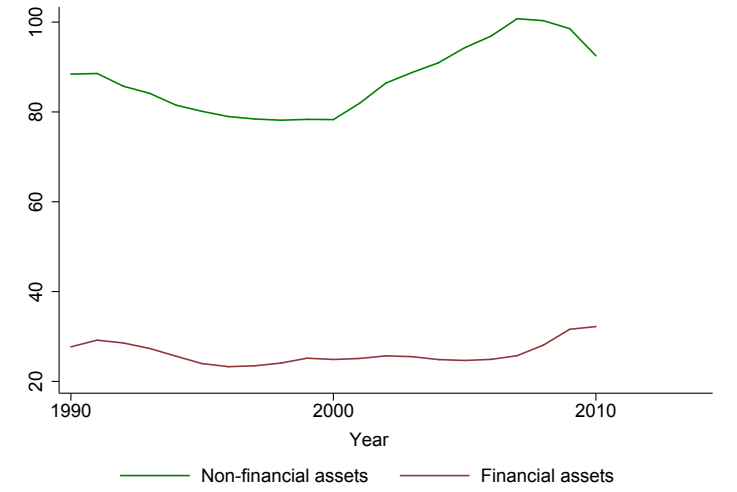
After having peaked at 79% of national income in 1981, the net worth of the United States' government declined to 20% by 1994, recovered to 54% in 2007, but declined to 21% in 2010 and has entered negative territory since, based on the most recent available data.[7] Behind these developments are fluctuations in both government assets and government liabilities, the latter of which stood at 78% of national income in 1990 and increased to 104% by 2010. These developments are shown in Figure D.29 in Section D.5. Figures D.30 and D.31 in Section D.5 display the longer-term series available for the United States from 1870.

As can be seen in Figure D.7, financial assets have tended to range around 25-30% of national income, while non-financial assets have fluctuated between around 80% and around 100% of national income in recent decades. An increase in the value of non-financial assets between 2000 and 2007 is at least in part driven by the house price boom increasing the

[7]Most recent available data comes from the US Federal Reserve (2017), while the data used for the analysis here comes from Piketty and Zucman (2014) in the interest of consistency across countries and reaches only until 2010. There is also updated data available from Piketty and Zucman (2014) that reflects this negative turn, yet this does not reach as far back as the original release.

value of buildings and structures owned by different levels of government (Bova et al., 2013).

Figure D.7: Government fin. and non-fin. assets, US, 1990-2010



In percent of national income
Source: Piketty and Zucman (2014)

Liabilities as a share of national income had been trending downwards since the end of World War II until the early 1980s (see Figure D.31 in Section D.5), as a result of a growing economy, unanticipated inflation and relatively small deficits at least until the 1970s (The White House, 2016). The subsequent growth in debt came to a halt and reversed in the mid-1990s, due to budget agreements that were enacted and that served to reduce deficits (The White House, 2016). Since the bursting of the 2001 stock market bubble and the accompanying recession, liabilities have been on the rise again relative to national income. The recent financial crisis is also clearly visible, with liabilities jumping from 73% of national income in 2007 to 104% in 2010. This increase is mirrored by large primary deficits during the crisis years and reflects the impact of the recession, bank bailouts and stimulus programmes.

D.4 Government budget deficit components

Government flow measures – most fundamentally, general government revenue and expenditure – are generally classified as such based on sources and uses of cash.

D.4.1 Sources of cash

General government total revenue is a source of cash and consists, most importantly, of

(i) taxes on production and imports ("indirect taxes") as well as on income and wealth ("direct taxes");

(ii) social contributions levied by government;

(iii) sales of goods and services, for example, in canteens set up by government units for their employees, or R&D contracts between public universities[8] and corporations (ESA 2010: 20.81); and

(iv) other current and capital revenue.

For the set of OECD countries considered in Chapter 1, based on data from the Annual Macroeconomic Database of the European Commission's DG ECFIN (AMECO), total revenue typically ranges between 30% and 60% of GDP, depending on "the role of the welfare state" in the country in question – for example, it amounted to 58% of GDP in Denmark, 55% of GDP in Finland and 54% of GDP in France in 2014, but only 34% of GDP in Switzerland and 33% of GDP in the United States in 2014.

D.4.2 Uses of cash

General government total expenditure is a use of cash and, most generally, the sum of

[8]Universities are classified as non-profit institutions, but counted among the general government sector if government is in control of them, which is determined based on a list of indicators about, for example, the process for appointing staff (SNA 2008: 4.88).

(i) capital expenditure; and

(ii) current expenditure.

Like total revenue and for analogous reasons, total expenditure tends to range between 30% and 60% of GDP for OECD countries – for example, total government expenditure amounted to about 58% of GDP in Finland and France and to 57% of GDP in Denmark in 2014, but to only 34% in Switzerland and 38% in the United States in 2014, based on AMECO data.

Government capital expenditure includes gross capital formation – which is gross *fixed* capital formation plus other capital expenditure, namely changes in inventories and net acquisitions of valuables and net acquisitions of non-produced non-financial assets – and capital transfers, including investment grants and other capital transfers. Gross fixed capital formation is, in Chapters 1 and 3, used as a proxy for productive investment by government, because inventories are used up in production as intermediate consumption and valuables are mostly held as stores of value (ESA 2010: 7.23), so that neither typically amounts to new productive investment.

Government gross fixed capital formation consists of net acquisitions of fixed assets as well as additions to the value of non-produced assets by producers, over the course of the year in question. In parallel to the types of assets included in fixed assets, gross fixed capital formation covers net acquisitions in, most importantly, dwellings, other buildings and structures, machinery and equipment such as ships or computers, weapons systems, cultivated biological resources such as trees, costs of ownership transfer on non-produced assets and R&D (ESA 2010: 3.127). It explicitly includes both improvements to existing fixed assets that go beyond ordinary maintenance or repairs and disposal costs, such as decommissioning costs of nuclear power stations. It excludes catastrophic losses of fixed assets, such as from flooding, for example. Gross fixed capital formation usually amounts to between 2% and 5% of GDP, with trend levels varying between countries: average public investment is about 2.4% in Germany, but around 4% in the United States and above 4% in Sweden based on AMECO data. Many countries have reduced their capital expenditure in recent years, especially those embroiled in the

sovereign debt crisis in Europe such as Portugal, but so did Japan, for example. Figure 1.1 above illustrates these facts.

Government current expenditure includes, most importantly, so-called production-related expenses such as the compensation of employees (wage payments), social benefits in cash and social transfers in kind, including health care or retirement benefits. Finally, it includes interest payable on loans, bills, notes, bonds and deposits (which though is excluded in our measure of current expenditure used in the analysis of Chapter 1). It tends to amount to between 30% and 50% of GDP based on AMECO data.

Government consumption is, roughly speaking, a subset of government current expenditure, excluding – relative to current expenditure – social benefits paid in cash, subsidies and other current expenditure. Table D.4 provides a detailed breakdown of these two measures (ESA 2010; Pulpánová, 2013). Social benefits other than social transfers in kind (D.62) include social security benefits and assistance (such as a children's allowance) paid in cash. Social transfers in kind via market producers (D.632) include goods and services financed by government but provided by market producers, such as healthcare or goods and services provided by pharmacists (ESA 2010: 20.97).

D.4.3 Balancing items

What is known as the government budget surplus or deficit, or, correspondingly, as net lending or net borrowing is the difference between total government revenue and total government expenditure: it is the amount the government has available to lend or has to borrow to finance its non-financial operations (ESA 2010: 20.112). To arrive at the "primary" surplus or deficit – a measure frequently invoked in policy decisions and used heavily in the analysis in Chapter 1 above – expenditure on interest is added back.

Finally, then, Figures D.8 and D.9 illustrate the components of the primary deficit and their relative magnitudes for Sweden in 2014 and the United Kingdom in 2010. Note that current expenditure here (as in Chapter 1 above) is adjusted to exclude interest payments.

Table D.4: Distinguishing current and consumption expenditure

	Inclusion in	
Expenditure category (ESA reference)	***total current expenditure excl. interest***	***final consumption expenditure***
Intermediate consumption (P.2)	yes	yes
Compensation of employees (D.1)	yes	yes
Interest (D.41)	no	no
Social benefits other than social transfers in kind (D.62)	yes	no
Social transfers in kind via market producers (D.632)	yes	yes
Subsidies (D.3)	yes	no[2]
Other current expenditure (D.29+D.4-D.41+D.5+D.7+D.8)	yes	no[2]
Capital expenditure (P.5+D.92+D.99+NP)	no[1]	no
LESS adjustment term[3]	no	yes

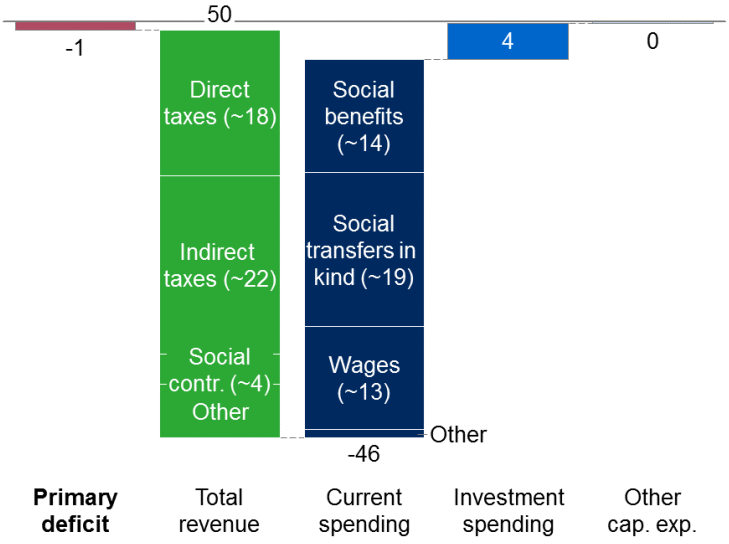
1 In our modified definition of current expenditure used for analysis in Chapter 1, we include "other capital expenditure", which includes capital transfers in the form of investment grants (D.92), other capital transfers (D.99), and acquisitions less disposals of non-produced non-financial assets (NP) but not gross capital formation (P.5), since the former categories do not amount to new productive investment. See Section 1.3.1 for details.

2 Parts of these categories are included in the adjustment term.

3 Adjustment term = consumption of fixed capital + other taxes (D.29 payable; 2) - other subsidies (D.39 receivable; 1) + net operating surplus - market output (P.11) - output for final use (P.12) - payments for other non-market output (P.131).

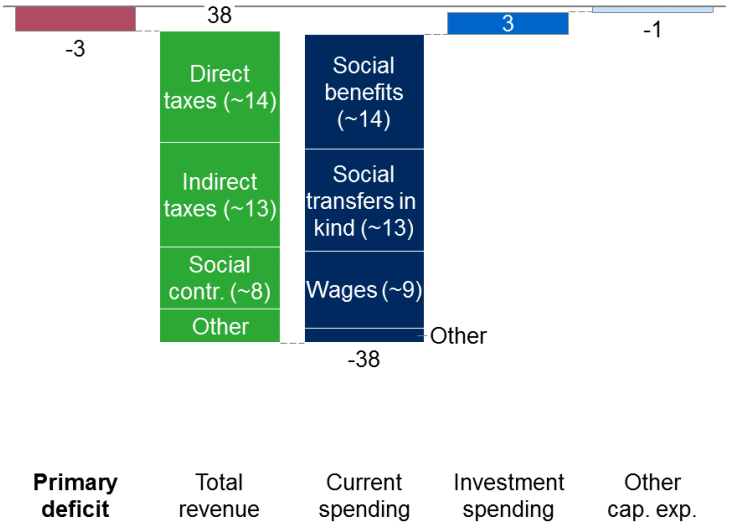
Source: ESA 2010

Figure D.8: Government budget deficit components, Sweden, 2014



As a percentage of GDP
Source: AMECO

Figure D.9: Government budget deficit components, UK, 2010

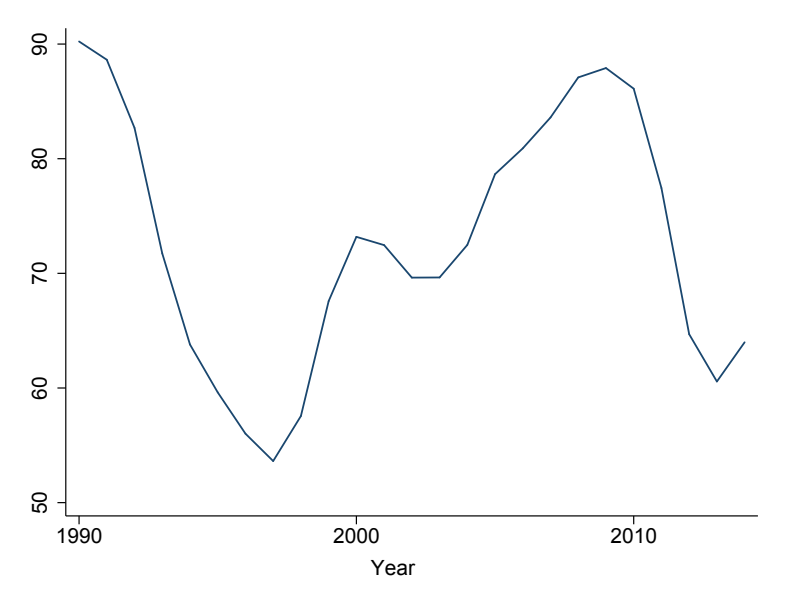


As a percentage of GDP
Source: AMECO

D.5 Graphs of balance sheet components

D.5.1 Australia

Figure D.10: Government net worth, Australia, 1990-2014



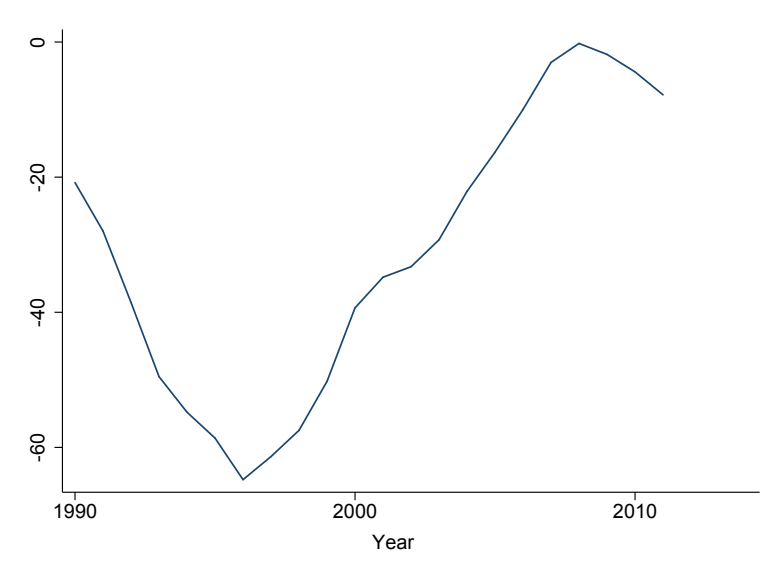
In percent of national income
Source: Piketty and Zucman (2014)

Figure D.11: Government assets and liabilities, Australia, 1990-2014

In percent of national income
Source: Piketty and Zucman (2014)

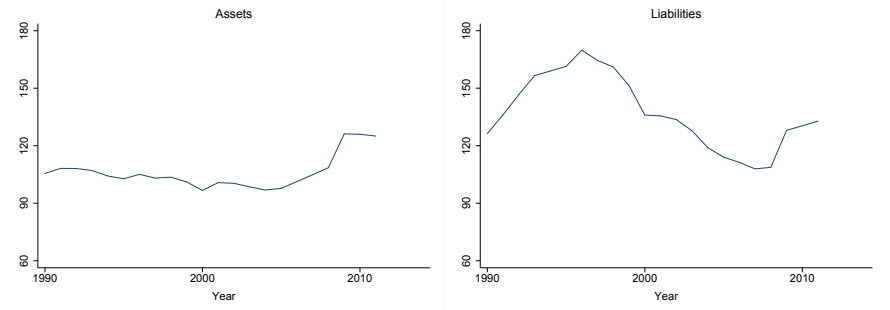
D.5.2 Canada

Figure D.12: Government net worth, Canada, 1990-2011



In percent of national income
Source: Piketty and Zucman (2014)

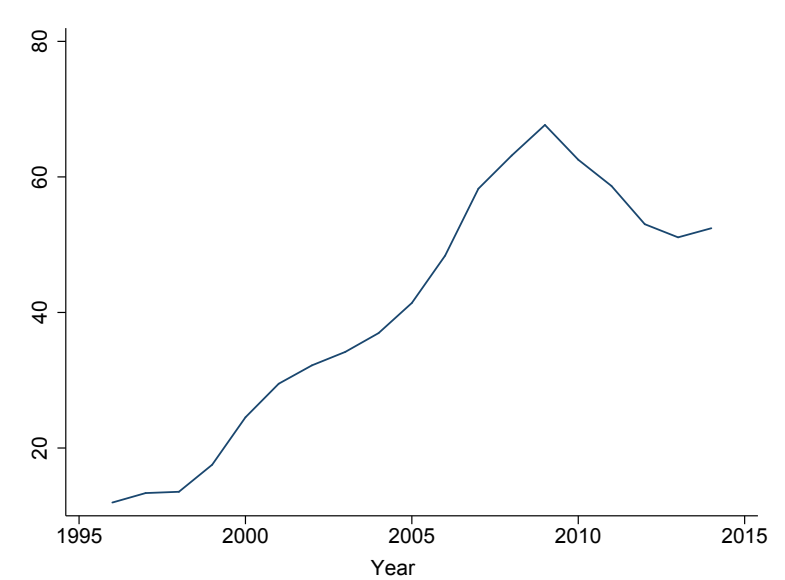
Figure D.13: Government assets and liabilities, Canada, 1990-2011



In percent of national income
Source: Piketty and Zucman (2014)

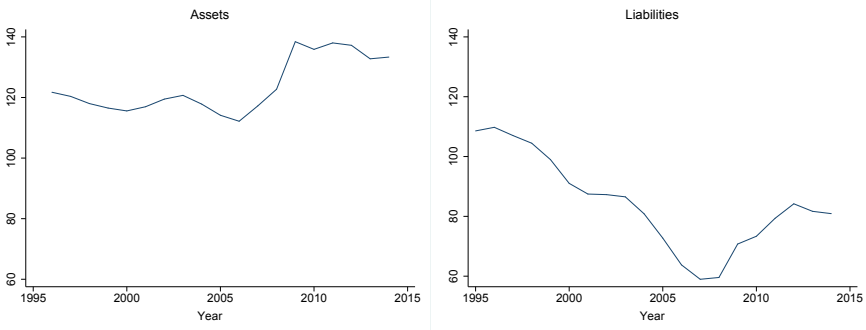
D.5.3 Denmark

Figure D.14: Government net worth, Denmark, 1996-2014



In percent of national income
Source: Piketty and Zucman (2014)

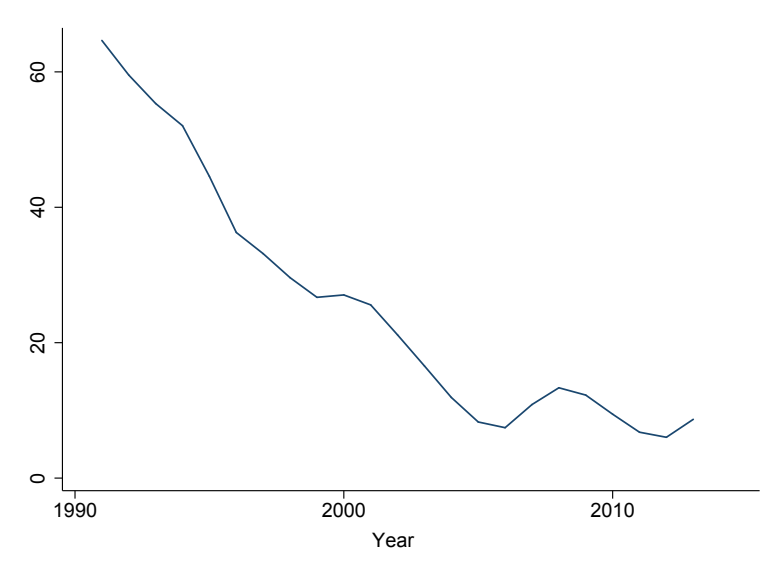
Figure D.15: Government assets and liabilities, Denmark, 1996-2014



In percent of national income
Source: Piketty and Zucman (2014)

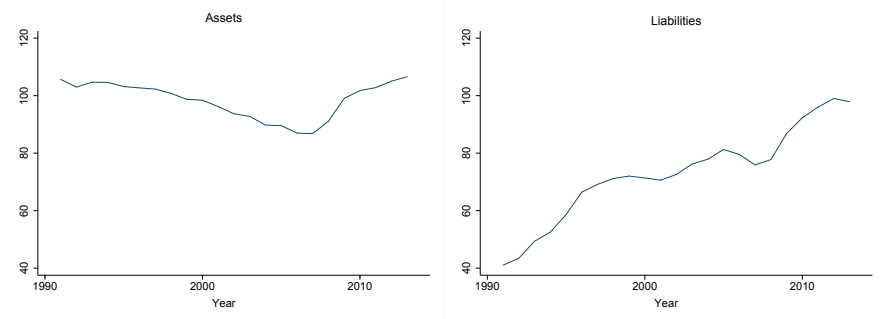
D.5.4 Germany

Figure D.16: Government net worth, Germany, 1990-2013



In percent of national income
Source: Piketty and Zucman (2014)

Figure D.17: Government assets and liabilities, Germany, 1990-2013



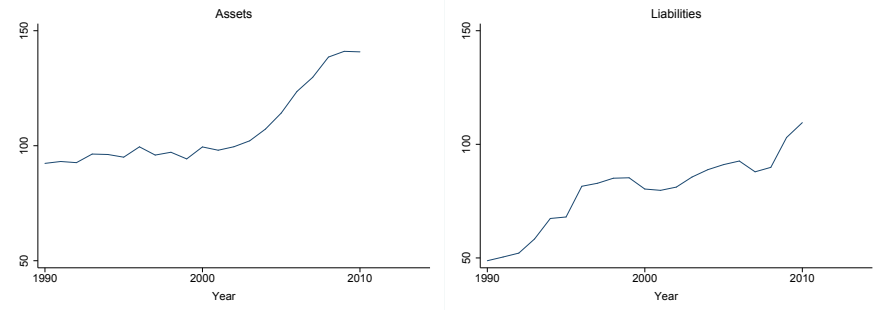
In percent of national income
Source: Piketty and Zucman (2014)

D.5.5 France

Figure D.18: Government net worth, France, 1990-2010

In percent of national income
Source: Piketty and Zucman (2014)

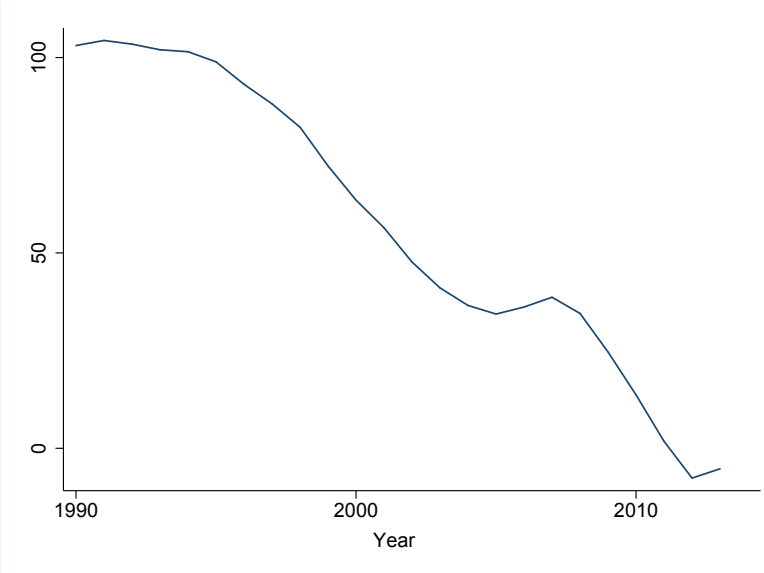
Figure D.19: Government assets and liabilities, France, 1990-2010



In percent of national income
Source: Piketty and Zucman (2014)

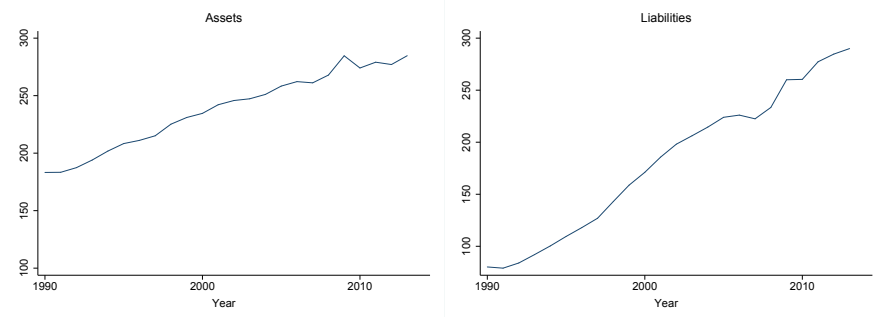
D.5.6 Japan

Figure D.20: Government net worth, Japan, 1990-2013



In percent of national income
Source: Piketty and Zucman (2014)

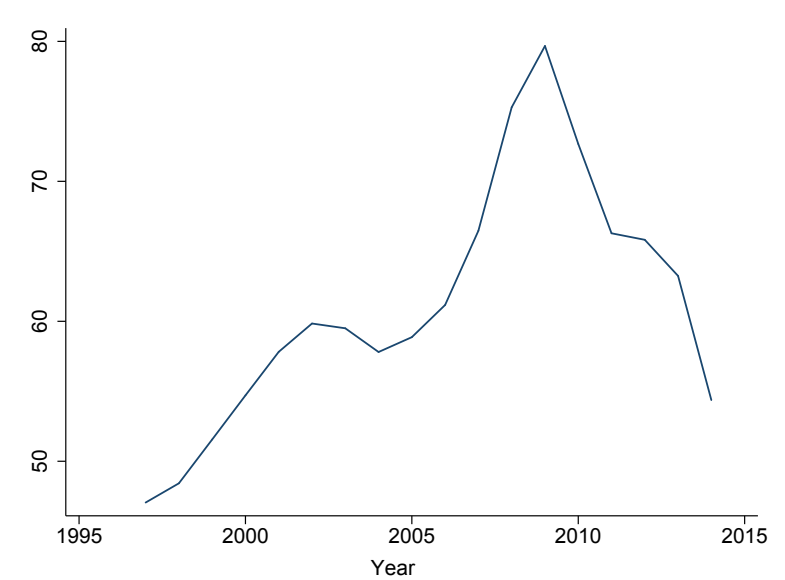
Figure D.21: Government assets and liabilities, Japan, 1990-2013



In percent of national income
Source: Piketty and Zucman (2014)

D.5.7 Netherlands

Figure D.22: Government net worth, Netherlands, 1997-2014



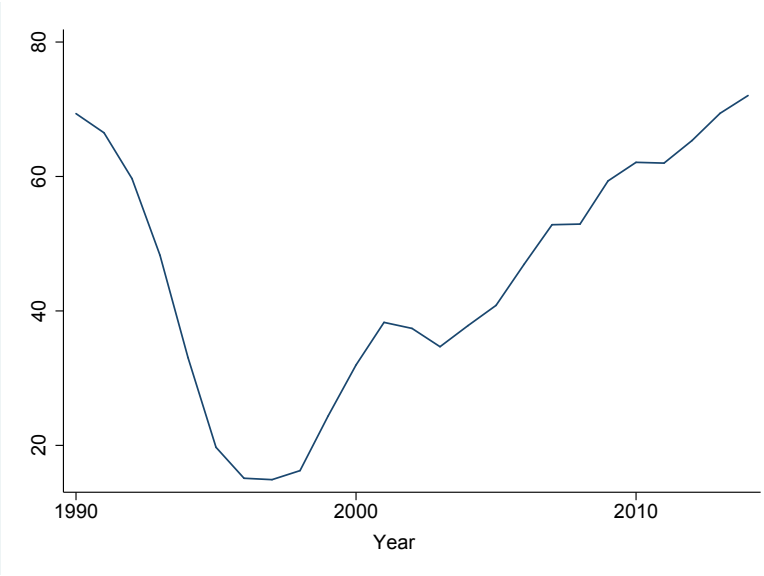
In percent of national income
Source: Piketty and Zucman (2014)

Figure D.23: Government assets and liabilities, Netherlands, 1997-2014

In percent of national income
Source: Piketty and Zucman (2014)

D.5.8 Sweden

Figure D.24: Government net worth, Sweden, 1990-2014



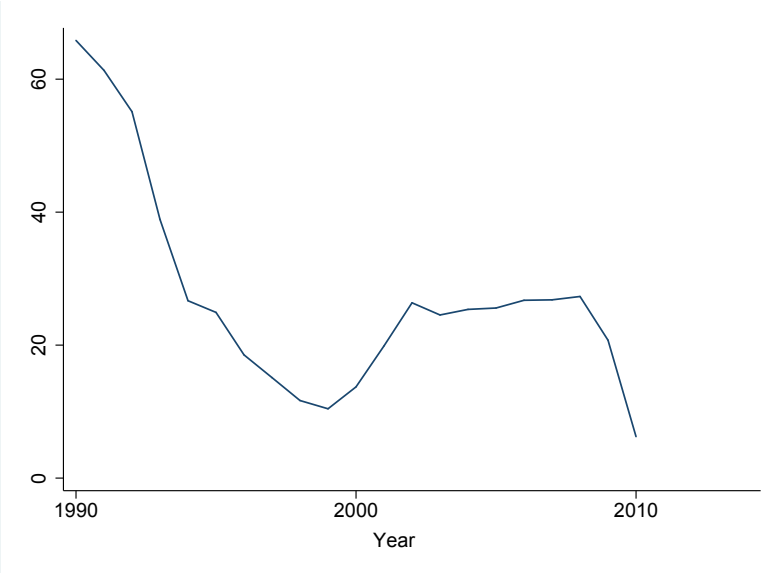
In percent of national income
Source: Piketty and Zucman (2014)

Figure D.25: Government assets and liabilities, Sweden, 1990-2014

In percent of national income
Source: Piketty and Zucman (2014)

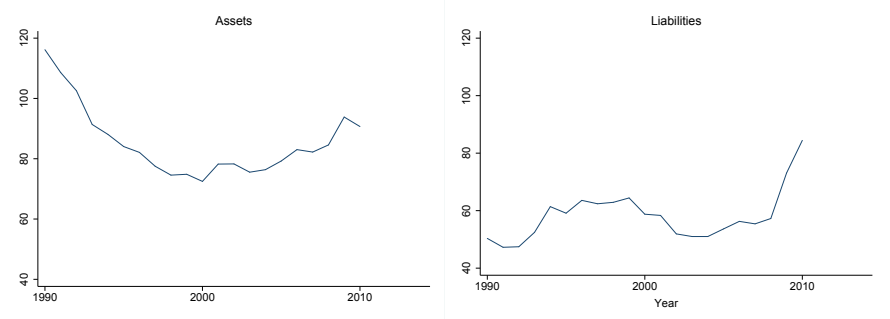
D.5.9 United Kingdom

Figure D.26: Government net worth, UK, 1990-2010



In percent of national income
Source: Piketty and Zucman (2014)

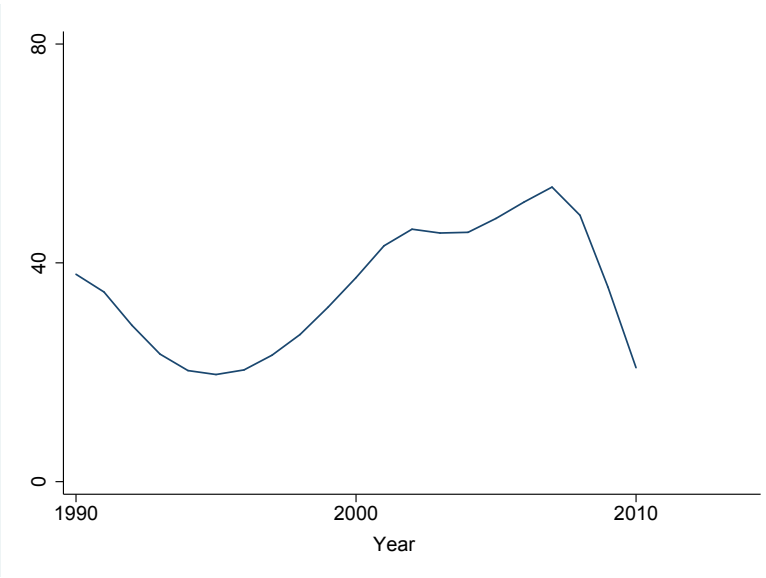
Figure D.27: Government assets and liabilities, UK, 1990-2010



In percent of national income
Source: Piketty and Zucman (2014)

D.5.10 United States

Figure D.28: Government net worth, US, 1990-2010

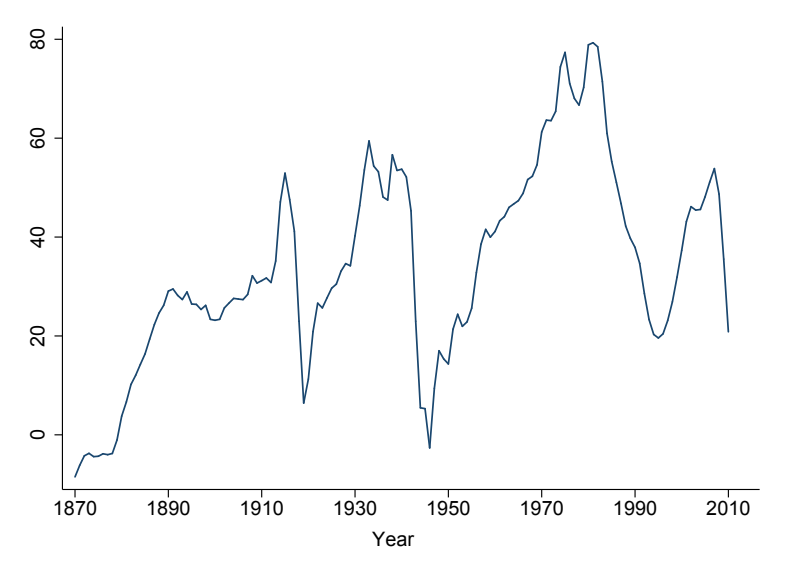


In percent of national income
Source: Piketty and Zucman (2014)

Figure D.29: Government assets and liabilities, US, 1990-2010

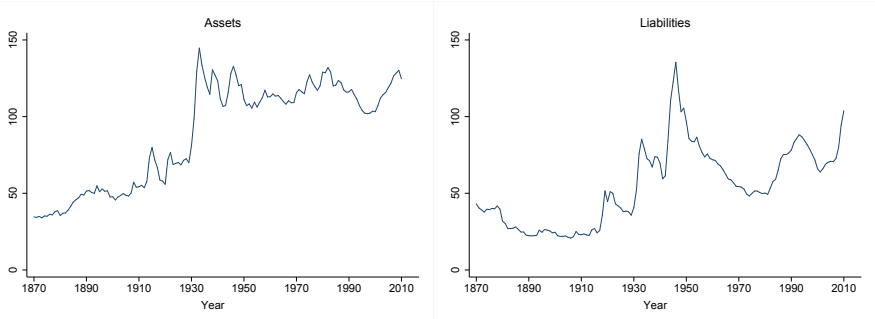
In percent of national income
Source: Piketty and Zucman (2014)

Figure D.30: Government net worth, US, 1870-2010



In percent of national income
Source: Piketty and Zucman (2014)

Figure D.31: Government assets and liabilities, US, 1870-2010



In percent of national income
Source: Piketty and Zucman (2014)