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Fiscal Risk and Public Sector Balance Sheets

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Abstract

The sovereign debt crisis in the euro area has shown that sovereign default risk can be a serious issue also in advanced economies. We use a difference-in-difference approach to identify the factors that lead to the crisis in the euro area. We find that, the global financial crisis of 2008-09, which hit all euro-area countries, uncovered persistent weaknesses in some countries. In others, which started from a seemingly strong fiscal position, the crisis was triggered by a strong decline in revenues. Responding to the incipient recession with structural rather than cyclical measures also contributed to the emergence of a debt crisis. We then discuss the use of advanced statistical methods to evaluate fiscal sustainability. One approach is the estimation of fiscal limits and fiscal space, the other the construction of government balance sheets using a model-based approach to the valuation of government assets and liabilities. We show that the two approaches are closely related. We suggest that the use of such approaches can help governments to identify fiscal risks and improve fiscal transparency. In Europe, this could be a useful activity of the newly created fiscal councils.

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1. Introduction

The huge increase in public debts during the financial crisis in many developed countries has raised concerns about the sustainability of public finances, especially as it has come on top of the adverse public finance consequences of ageing societies. In the euro-area in particular, the sovereign debt crisis that started in 2010 shows that sovereign default risk can be a serious issue even in developed economies. A review of this crisis indicates that it came from three sources: persistent budgetary weaknesses, large negative revenue shocks combined with the absence of sufficiently flexible fiscal instruments to offset them, and the political expediency perceived by governments of making the public sector responsible for fraudulent behavior and excessive non-performing loans accumulated in the banking sector.[1] These problems are not confined to the crisis countries in the euro area; they contributed to the increase in public debt even in countries that did not face outright public debt crises like Germany or the US and they exist in many other countries. We take the euro-area sovereign debt crisis as the starting point and case study for this paper to fiscal risk can be identified and contained.

The euro-area sovereign debt crisis was not supposed to happen. Building on the "Excessive Deficit Procedure" (EDP) of the Maastricht Treaty and the "Stability and Growth Pact" (SGP) of the late 1990s, the member states of the euro area had vested themselves with an elaborate system of fiscal rules and processes based on a host of statistical indicators in the 15 years before the global financial crisis that started in 2007 and the *Great Recession* of 2008-2009. These rules and processes aimed at assuring a high degree of fiscal discipline and the sustainability of public finances in each member state. Within this framework, euro-area governments are required to comply with conditional and unconditional fiscal targets and to report publicly and annually on their fiscal strategies, intentions, policies, and outcomes. This machinery is watched over by the European Commission and Eurostat, which has developed a common accounting framework for the public sector in the member states. Because of its strong reliance on fiscal numerology, the approach has been dubbed "government by

[1] The literature commonly speaks of „contingent liabilities" in this context. This term is justified insofar as it relates to government-provided disaster insurance. When it is used for bailouts of private banks and enterprises, however, it is utterly inadequate because governments are not liable for private debts and the supposed contingency is nothing but a discretionary political decision to use public funds for the benefit of private individuals.

statistics."[2] The idea was that the commitment to common numerical rules would compensate for the lack of a strong fiscal authority coordinating the fiscal policies of the member states, an institutional deficiency that had been criticized especially by economists in the US long before the crisis.[3]

Since the global financial crisis of 2007-2009 and in response to the mounting problems with public debt sustainability, the EU has expanded the scope and the depth of "government by statistics" through the "Six Pack" and the "Two Pack." The "Six Pack," which entered into force on 13 December 2011, strengthens the enforcement of the EDP and the SGP, gives more weight to deviations from the 60% limit for the debt-GDP ratio, and adds new rules for government spending and a new "Macroeconomic Imbalance Procedure," which is similarly based on a range of statistical indicators.[4] The "Two Pack," which entered into force on 30 May 2013, further develops the processes for monitoring the member states' public finances and their efforts to correct deviations from the norms under the EDP and the SGP.[5] Yet, the crisis has shown that "government by statistics" has utterly failed, as it neither prevented the building up of large fiscal imbalances nor contributed much to identifying the risks in public finances that emerged with the financial crisis.

There are three main reasons for this failure. The first is that the fiscal indicators on which the European framework relies are backwards-looking rather than forward-looking. They measure the outcomes of past policies but they do not guide expectations about future developments.[6] Furthermore, they provide only a very limited look at the sources of mounting public debts. For example, Jaramillo et al (2016), in an analysis of a large, global sample of episodes during which governments built up large amounts of debt in relatively short time (which they call "public debt spikes"), show that cumulated budgetary flows contribute only a small part to the increase in public debt during such episodes, the largest part coming from stock-flow adjustments.

The second reason is that the indicators focus on nominal budgetary flows and stocks of explicit financial liabilities of the government, but they disregard the true economic value of

[2] Pisani-Ferry (2010, p.2)
[3] See Jonung and Drea (2009) for a summary of the debate in the US
[4] European Commission (2011)
[5] European Commission (2013)
[6] This shortcoming of traditional fiscal indicators has long been recognized in the context of evaluating the fiscal consequences of ageing societies, a topic I will not pursue in this paper. See e.g. Velculescu (2010).

these objects which must take into account the riskiness of government assets and liabilities. Furthermore, they neglect the existence of the political risk of governments desiring to provide bailouts to private institutions and the risk-based value of such implicit liabilities, which have proven highly relevant in the European sovereign debt crisis. Finally, they largely ignore the implications of budgetary operations for the net wealth of government. Milesi-Ferretti and Moriyama (2004), for example, use a balance-sheet approach to analyze the effects of fiscal adjustments in the euro-area countries on government net worth. They point out that, during the run-up to EMU, most European governments seem to have limited the growth of gross debt by reducing gross assets, reducing net wealth and making themselves more financially vulnerable as a result. If the goal of the operation is to make provisions for future spending needs, to reduce future taxation, or to improve the government's ability to react to unforeseen events, such adjustments are clearly counterproductive.

The third reason is the lack of a coherent and consistent conceptual framework within which the information from gleaned from the indicators is organized and aggregated and compliance with or deviations from the rules are analyzed. Even 20 years after the Maastricht Treaty, it remains largely unclear how adherence to the rules would assure the sustainability of public finances and how deviations from them would endanger it.[7] The economics underlying European Commission's evaluations of the public finances of the member states are often unclear and questionable and the conclusions often seem to be driven by political considerations. If anything, "government by statistics" has created a culture of problem denial, allowing policymakers to argue that everything is fine as long as the numbers comply with the rules.[8]

In this paper, we ask how modern macroeconomic methods can contribute to avoiding sovereign debt crises. We explore this question in two directions, the estimation of fiscal limits and fiscal space on the one hand, and the evaluation of public sector balance sheets on the other. Both emphasize the role of micro-founded models and forward-looking expectations in the analysis of fiscal risks. We point out how these two approaches are linked and how they can be used to address specific questions related to fiscal risks. explore

[7] Schubert (2013) reminds us that the core criteria for general government debt and deficits, 60% and 3% of GDP, were the outcome of a historical coincidence.

[8] An example is the budget debate in Portugal during October 2013, which features the argument that one of the budgetary risks for 2014 is the reclassification of state-owned enterprises as part of the general government sector. See Portuguese Ministry of Finance (2013) p 78.

the sources of fiscal risk. Section 2 begins with a brief review of recent heuristic tools developed by the IMF to evaluate fiscal risk. Section 3 takes the European debt crises as an empirical example and uses a difference-in-difference approach to identify the sources of fiscal risk it has brought to light. Section 4 discusses the estimation of fiscal limits and fiscal space first presented by Bi and Leeper (2013). Section 5 shows how this can be extended to an economic evaluation of government balance sheets. In section 6, we conclude with some considerations of political economy.

2. Fiscal Risk: Heuristic Approaches

Recent work at the IMF has proposed sets of heuristic indicators to evaluate the riskiness of a government's fiscal position and its vulnerability against macroeconomic and financial shocks. It addresses the need for a transparent and consistent framework of interpretation of fiscal indicators and statistics. Cotarelli (2011) develops a fiscal "risk octagon." Each segment of the octagon measures fiscal risk in one dimension, i.e., fiscal shocks, macro shocks, contingent liabilities, long-term fiscal trends, asset and liability management, basic fiscal variables, market sentiment, and non-fiscal vulnerabilities. The octagon allows the tracking of the development of a government's position in these dimensions over time and the comparison of the positions of different governments in these dimensions at the same point in time. As a relative scale, it can show whether a government's position has become more or less risky or is more or less risky than another government's position. Yet, how far away it is from a fiscal crisis is hard to judge from this approach.

Baldacci et al. (2011a) propose thirteen fiscal indicators to evaluate the risk of a government being unable to roll-over its debt, which is what they regard as the crisis event. The indicators are divided into three clusters, one each for basic fiscal variables relating to the consistency of current and medium-term policies with fiscal solvency, for long-term fiscal trends such as economics growth and demographics, and for asset and liability management with a view towards roll-over risk. Each indicator is transformed into a standardized score based on the comparison with the same indicator for a group of other countries (advanced versus emerging economies). These scores are then aggregated to a synthetic index of fiscal stress, which can be used to identify periods of fiscal stress or as an early warning signal of fiscal crises. Baldacci et al (2011b) evaluate the performance of this early warning signal

based on historical experience. Schaechter et al (2012) add a further set of indicators to this analysis.

The heuristic approach provides a useful framework to organize the data and its analysis and to guide policy. However, it lacks a firm grounding in economics. Furthermore, the relative importance of the individual indicators is not clear, nor is it obvious how they relate to each other. When different indicators move in different directions, the approach fails to provide a clear judgment of the situation.

3. Sources of Fiscal Risk in the European Debt Crisis

3.1. The European Sovereign Debt Crisis: A Brief Review

The global financial crisis that started in 2007 and fully hit the markets with the collapse of Lehman Brothers in September 2008 caused severe recessions and financial market turmoil in the euro area. As a result of the operation of automatic stabilizers, discretionary fiscal measures to counteract the recession and efforts to stabilize and rescue faltering financial institutions, public finances were severely weakened. This set the stage for the subsequent public debt crisis in the euro area.

Sovereign yield spreads between non-German and German government bonds began to widen in the euro area soon after the beginning of the financial crisis in 2007-08, indicating that investors demanded rising risk premiums on non-German public debt. Schuknecht et al. (2009) and Bernoth et al. (2012) among others, document that yield spreads responded to differences in fiscal performance between non-German euro-area members and Germany before that crisis already, but the impact of fiscal variables like deficit and debt ratios on yield spreads was quite weak. As the financial crisis evolved, yield spreads first rose in response to the increased degree of risk aversion in international financial markets and then became much more responsive to indicators of fiscal sustainability such as debt and deficit ratios (Schuknecht et al 2011, Mody and Sandri 2011, Gabriele et al. 2016). Bi (2012) show that such a change in the responsiveness of risk premiums to fiscal performance is compatible with rational, forward-looking investors. While Germany, for the first time since the beginning of the euro, clearly established itself in a regional safe-haven position, Southern European countries in particular saw the yields on their public debts rise and, with that, the main advantage they had expected from joining the euro disappear. Based on

historical data from US states, Bi and Traum (2016) indicate that investors pay little attention to fiscal variables in normal times, but a lot of attention during times of fiscal distress. Such a switch from rational inattention to attention to fiscal performance may have amplified the response of risk premiums to deficit and debt ratios in the euro area.

As a result of rising risk premiums on public debt in the euro area, countries with high and rising debt levels faced rapidly increasing costs of refinancing their public debts, which became a threat to the sustainability of their debts.

In October 2009, the Greek government announced that its deficit for that year would reach 12.6 percent of GDP instead of the previously posted 3.7 percent. Eventually, the 2009 deficit would be revised to 15.5 percent of GDP. This not only represented a breach of Greece's commitments under the SGP, it also fully exposed the weakness of the country's fiscal position as it came out of the financial crisis. In the weeks and months that followed, yields on Greek government bonds increased both in level and volatility, making the government's financial position increasingly unsustainable. On May 2, 2010, the EU together with the IMF decided to grant the country a € 110 billion, three-year support program to re-achieve sustainable public finances and improve its competitiveness. The program came with far-reaching conditionalities for reforms in the country's tax system and administration, reforms of the public sector, cuts in public sector employment, and privatization of government-owned assets. The financial conditions of this program were loosened in July 2011, when the EU and the IMF gave Greece (together with Portugal and Ireland) an extended repayment schedule and a lower interest rate. A second, € 130 billion support program was granted to Greece on 21 February 2012. In March 2012, privately held Greek public debt was restructured with a haircut amounting to 65 percent of GDP.

At the end of June 2015, Greece missed a payment according to the bailout program. The European Commission and the IMF immediately stopped its financial support, leaving Greece in an acute liquidity shortage. The Greek government imposed capital controls to prevent its citizens from taking their money out of the country, and bank holidays to stop runs on Greek banks. An acute political crisis followed, at the end of which the Greek government promised to continue playing by the rules of the bailout agreement. The EU and the IMF responded with a third bailout program worth USD 94 billion to be extended over the next three years.

Following a warning in early 2017 by the IMF that Greek public debt could again become unsustainable, the EU agreed to grant Greece more lenient conditions on that loan.

Greece's general government revenues fell from € 88.1 billion in 2009 to € 78.8 billion in 2013, but, as a percent of GDP, they increased from 37.9 to 44.3, indicating that nominal GDP fell even faster than tax revenues.[9] Primary expenditures, increased to 49 percent of GDP in response to the recession of 2008-09. Despite the adjustment measures taken by the government, they climbed to 58 percent in 2013 and came down afterwards, but never below pre-crisis ratios of GDP. Public debt stood at 129.1 percent of GDP in 2009 and, despite the restructuring that took place in early 2012, at 167.3 percent in 2013 and at 180.2 percent at the end of 2017.

Reflecting market concerns with the sustainability of Greek public debt, yields on 10-year Greek government bonds rose from 4.57 percent in October 2009 to 7.97 percent in May 2010, shortly after Greek government bonds had been given junk bond status in April 2010. They peaked at 29.12 percent in February 2012, that is, right before the restructuring of the privately held debt. Following the commitment of the ECB's president, Mario Draghi, to "do whatever it takes to preserve the euro" in a speech in London on July 26, 2012, and the ECB's announcement of its OMT policy on September 6, 2012, Greek bond yields gradually descended to around 10 percent in the Summer of 2013, still much higher than German Bund yields which then stood at around 1.5 percent.[10] Since 2010, Greek real GDP has fallen by 23.2 percent.

On 21 November 2010, Ireland became the second country to request financial support from the new European Financial Stability Fund. The agreement to support Ireland was reached on 28 November. After a long string of years with budget surpluses that had brought the debt ratio down to well under 30 percent, Ireland had realized budget deficits of 7.3 percent and 14.3 percent of GDP in 2008 and 2009 respectively. As a result of the financial crisis that started in 2007 and the collapse of a huge real estate bubble, the country faced a severe banking crisis.[11] At the end of September 2008, the government issued a

[9] Stylized facts characterizing fiscal crises presented in Gerling et al (2016) suggests that this pattern is typical at the beginning of such crises.

[10] For an empirical analysis of ECB decisions and announcements on sovereign yield spreads see Kilponen et al. (2012)

[11] See Fernandez-Villaverde et al. (2013), Honohan (2010), and Commission of Investigation (2011) for accounts of the Irish real estate bubble and financial crisis.

blanket guarantee on all bank deposits, thus turning bank deposits into the equivalent of government debt. The government's fiscal operations providing funds to the main Irish banks caused its deficit to rise to 30.9 percent of GDP in 2010, of which 20.2 percent was due to the expenditures for bank support. The fiscal cost of recapitalizing the Irish banks amounted to 46.3 billion euros or 30 percent of Irish GDP in 2009-10. Lane (2013) estimates the total cost of bank recapitalizations to the Irish government during 2009-2011 at 41 percent of 2011 GDP. In 2009, Ireland's government bonds lost their AAA rating and were downgraded to just above speculative grade. The country's debt ratio increased from 25 percent of GDP in 2006 and 2007 to 65.6 percent 2009 to 122 percent in 2013. Government revenues increased slightly in absolute numbers and as a ratio of GDP (slightly above 34 percent) in 2010 through 2013, while expenditures excluding bank support remained stable in absolute numbers and fell from 44.7 percent of GDP in 2010 to 41.9 percent in 2013. Yields on Irish government bonds had increased from 4.25 percent to 6.42 percent between January 2008 and October 2010, they peaked at 12.45 percent in July 2011 and then descended to 3.92 percent in August 2013. Nominal GDP fell from 161 billion euros in 2009 to 156.5 in 2010 and then turned around to reach 166.2 billion in 2013. Real GDP contracted by 0.8 percent in 2010 (following a 5.5 percent contraction in 2009) and grew by a total of 3.2 percent afterwards.

On 8 April 2011, the Portuguese government requested financial assistance from the EU and the IMF and on 17 May it signed an agreement for a support program. Portugal had incurred general government deficits of 10.1 percent and 9.1 percent of GDP in 2009 and 2010 respectively, up from 3.6 percent in 2008. The rise in the deficit was due mainly to an increase in total expenditures from 44.3 percent of GDP in 2007 to 51.5 percent in 2010, which in turn was mainly due to a rise in current expenditures by 4.7 percent of GDP and in capital expenditures by 3.3 percent. Total government revenues increased from 72 billion euros in 2010 to 76.9 billion in 2011, but fell to 67.8 billion in 2012; the projection is for an increase to 70.1 billion in 2013. Relative to GDP, total revenues went from 41.6 percent in 2010 to 45.0 percent in 2011 and 41.0 percent in 2012. Meanwhile, total expenditures rose from 83.8 billion in 2009 to 89.0 billion euros in 2010 and then fell to 84.5 billion in 2011 and 78.4 billion in 2012. As a ratio of GDP they peaked at 51.5 percent in 2010, up from 49.7 percent in 2009, and then descended to 47.4 percent in 2012. Portugal's debt ratio increased from 71.7 percent at the end of 2008 to 123.6 percent at the end of 2012. Government bond

yields stood at 4.31 percent in January 2008. In March 2011 they had reached 7.8 percent, to peak at 13.1 percent in March 2012. By August 2013, they had come down to 6.6 percent. Portugal's nominal GDP fell from 172.7 billion euros in 2010 to 166.9 billion euros in 2012. Its real GDP contracted by a total of 3.2 percent in the years 2010-2012.

Meanwhile, financial markets had also become increasingly worried about the sustainability of public finances in Spain and Italy. Italy had weathered the financial crisis of 2008-2009 quite well, with a sharp recession in 2009, a return to positive real growth already in 2010, and without major problems with financial institutions. Nevertheless, as markets began to ask higher yields for the sovereign debts of Greece, Ireland, and Portugal, they also gradually asked for higher yields on Italian public debt. Italian bond yields stood at 4.4 percent in January 2008 and peaked at 7.06 percent in November 2011. By the fall of 2013, they had returned to 4.4 percent. The government was able to maintain primary budget surpluses in most years since 2007, the exception being 2009 with a primary deficit of 0.8 percent of GDP. However, the increasing cost of funding combined with the high level of debt caused the overall deficit to rise from 1.6 percent of GDP in 2007 to 5.5 percent in 2009 and to come down only gradually to 3.0 percent in 2012. This, combined with low GDP growth rates, caused the debt ratio to embark on an increasing path from 103 percent of GDP – where it had remained stable for several years before – to a projected 131.4 percent in 2013.

Like Ireland, Spain had witnessed strong improvements in its fiscal balances and public debt ratio in the ten years before the financial crisis. As in Ireland, this was due to a large extent to strong economic growth. These, gains, however, were quickly more than wiped out by the fiscal developments following 2007. Government revenues declined from 41.7 percent of GDP in 2007 to 35.1 percent in 2009 and hovered around 36 percent in the following years. Total expenditures increased from 39.2 percent of GDP in 2007 to 46.3 percent in 2009 and then slightly further to 47.0 percent in 2012. The increase in expenditures was almost entirely due to rising current expenditures, from 33.8 percent of GDP in 2007 to 40.3 percent in 2009 and 41.0 percent in 2012, while government investment fell as a share in GDP. Spain's budget balance turned from a surplus of 1.9 percent in 2007 to a deficit of 11.2 percent in 2009, followed by deficits of 9.7 percent of GDP, 9.4 percent, 10.6 percent in 2010-2012, respectively. As a result, the debt ratio more than doubled from 36.3 percent of GDP in 2007 to 84.2 percent in 2012. Spanish government bond yields increased

from 4.18 percent in January 2008 to 6.79 percent in July 2012, and then declined to 4.5 percent in August 2013. Spain's real GDP has contracted by a total of 5.0 percent in the period 2009-2012.

Doubts about the sustainability of Spanish public finances were fueled by the crisis in the country's banking sector caused by the collapse of the housing boom in the wake of the financial crisis.[12] Large-scale fiscal operations to support troubled banks would have caused further increases in public debt, and, anticipating this, markets seemed increasingly reluctant to lend to the Spanish government. In June 2012, shortly after the collapse of *Bankia*, an institution with assets amounting to one third of Spanish GDP, Spain requested financial assistance through the EFSF to help with the resolution of the banking crisis. Agreement for a loan of up to € 100 billion loan was reached between Spain and the European Commission in July 2012; the agreement was later assumed and implemented by the European Stability Mechanism, an intergovernmental institution created in October 2012.

The last euro-area country to receive an official financial support program was Cyprus in May 2013. In 2008, the general government balance recorded a surplus of 0.9 percent of GDP, which turned into a deficit of 6.1 percent in 2009 due to a rise in expenditures by 4.1 percent (of which 2.5 percent current expenditures) and a decline in revenues by 3.0 percent. In the years thereafter, the government neither managed to increase revenues substantially as a share of GDP, nor to reduce expenditures. As a result, the debt ratio increased from 48.9 percent in 2008 to a projected 109.1 percent in 2013. Government bond yields peaked at 7.0 percent in July 2013. Nominal GDP is projected to decline from 17.9 billion euros in 2012 to 16.4 billion euros in 2013, while real GDP contracted by 2.4 percent in 2012 and is projected to decline by 8.7 percent in 2013. Cyprus had enjoyed sizeable capital inflows for a number of years before the crisis, but these inflows started to dry up in 2011, putting the Cypriot banking system under intense pressure. The government's request for financial assistance in July of 2012 thus came in the context of its efforts to prevent its banking system from collapsing. Cyprus was granted a financial program of € 9 billion from the ESM and € 1 billion from the IMF in March 2013. In contrast to the EFSF/ESM program with Spain, the program with Cyprus included conditionalities not only for recapitalizing and

[12] See Fernandez-Villaverde et al. (2013) for an account of the Spanish real estate boom and banking crisis.

restructuring the banking sector, but also for downsizing that sector, structural reforms of the economy, fiscal consolidations and privatization of government-owned assets.

3.2. What makes a sovereign debt crisis?

3.2.1. Asymmetric Shocks

A number of reasons have been suggested to explain the emergence of European sovereign debt crises. The first explanation is that these countries had been hit by negative asymmetric shocks which were exogenous to their economic policies. This, together with the idea that countries exposed to asymmetric shocks should benefit from some system of risk sharing through intergovernmental transfers, is the main argument used to justify the call for a fiscal union in Europe.

In fact, this view has little support by the data. Table 5 shows the average real GDP growth rates for 2002-2006 and the growth rates each year from 2007 to 2012 for the euro area as a whole and the six countries considered here. In the five years before the crisis, the euro area's average growth rate was 1.76 percent. Greece, Ireland, Spain and Cyprus had average growth rate well above the euro area, while Italy and Portugal grew considerable less than the group as a whole. During the years of the financial crisis, 2007-2009, euro-area real GDP growth fell from 3.00 percent to -4.39 percent. Ireland was the only country among the six that suffered a real growth rate of one cross-section standard deviation less than the euro area average, and this only in 2008, when Irish real GDP fell by 2.1 percent. Cyprus and Spain continued to grow faster than the euro area during the years of the financial crisis. Portugal and Greece did so in 2009, when they had milder recessions than the euro area. In 2008, these two countries had slightly lower growth rates than the euro area. Ireland and Greece grew faster than the euro area in 2007. Only Italy consistently had growth rates below the euro area in 2007-2009.

To sharpen the notion of an asymmetric shock, we calculate the difference in real GDP growth rates between 2009 and 2007. Table 5 shows that euro-area real GDP growth fell by 7.49 percent during that period. We then subtract this difference from the each country's difference growth rates between 2007 and 2009. This difference in difference is negative only for Ireland during 2007-2009, and even there is within one cross-section standard deviation from the euro-area average. For Greece, Spain, Italy, Cyprus, and Portugal, the result is positive, indicating that these economies experienced small but positive asymmetric

shocks during the period of the financial crisis. There is thus no strong indication that countries whose fiscal sustainability deteriorated after 2009 were hit by larger negative shocks than the euro area on average.[13]

A possible counter-argument to this is that the six crisis countries were indeed hit by larger negative shocks than the euro area on average, and that these shocks are not reflected in their real GDP growth rates because of the larger fiscal stabilization efforts the governments of these countries undertook. If so, one would expect that these countries had much larger cyclical deficits than the euro area had on average during 2007-2009. Table 3 shows that this is not the case. Only Ireland and Spain had cyclical deficits larger than the euro area, but the differences are marginal. Greece, Ireland and Spain had much larger cyclical deficits than the euro area in 2010 and 2011, but this must be attributed to the fiscal adjustments following the emergence of the public debt crisis. We conclude that the asymmetric-shock hypothesis does not do much to explain the debt crises in Europe.

Between 2009 and 2011, the euro area returned to a real GDP growth rate of 1.44 percent. It is in this period, that several of the crisis countries experienced negative asymmetric growth. As shown in Table 5, Greece had a very strong negative deviation from euro-area growth. In Portugal and Cyprus, the deviation was sizable, though less than one standard deviation away from the euro-area growth rate. Ireland and Italy, in contrast, had stronger improvements in real growth than the euro area. Yet, in view of the strong fiscal contractions in Greece, Portugal, Cyprus, and Spain during that period, one can hardly argue that their negative growth performance can be attributed to exogenous developments. It would be difficult to use this evidence to argue for a fiscal union providing governments with insurance against asymmetric policies.

As noted above, Greece, Ireland, and Portugal experienced sharp turnarounds of their financial account balances in the wake of the financial crisis. Still, they were not the only countries facing such turnarounds, and their sudden stops of capital inflows were not the most severe in the euro area, either. Between 2008 and 2009, Estonia and Lativia suffered

[13] I do not argue here that business cycles in the euro-area were symmetric. The countries that were hit by significant asymmetric shocks according to this definition in 2007-2009 were Estonia, Slovenia, Slovakia, and Finland. In his discussion of this paper, Christian Durand argued that a similar difference-indifference analysis based on unemployment rates would lead to the conclusion that Spain and Ireland were indeed hit by negative asymmetric shocks, while the other countries were not. However, the rise in unemployment in both countries came only at the end of the period marked by the Great Recession.

sudden stops of capital inflows resulting in an increase in their financial account balances by 17.5 and 16.7 percent of GDP, respectively. Considering private portfolio investment, the Netherlands and Austria experienced turnarounds of 13.1 and 11.8 percent of GDP between 2008 and 2009, respectively, Belgium and Malta had turnarounds of 14.1 and 11.8 percent of GDP between 2009 and 2010, respectively. Thus, even with regard to sudden stops the countries suffering from public debt crises subsequently are no gross exceptions in the euro area.

3.2.2. Sudden Stops

Greece, Ireland, Portugal, and Spain experienced very sizeable capital inflows in the years preceding the financial crisis and the debt crisis and were exposed to sudden stops of capital inflows during the crisis (see Table 5).[14] Portfolio capital inflows already dried up Spain in 2007-2008 and turned into moderate net outflows in 2011 and 2012. Ireland's financial balance turned from (-19.1) percent of GDP in 2007 to 0.7 percent of GDP in 2009. Greece and Portugal followed with a strong turnaround of portfolio inflows from (-12.4) to 9.6 percent of GDP in Greece and from (-9.0) percent of GDP to 5.6 percent in Portugal between 2009 and 2010. For both countries, these sharp turnarounds were offset by "other investments", presumably the building up of large negative balances within the European TARGET2 system, mostly vis-à-vis Germany.[15] In Cyprus, capital inflows fell by one half as a percentage of GDP between 2010 and 2011, but the country was still able to attract net inflows. Italy, finally, experienced a more moderate reversal of portfolio inflows by 4.7 percent of GDP between 2010 and 2011, which again was offset partially, at least, by "other investment" inflows. These experiences of sudden stops indicate that private investors became increasingly weary of financing the current account deficits of these countries, and can be regarded as the quantitative aspect of the rising risk premiums in government bond yields the governments faced.

The sudden stop in capital inflows was a main contributing factor to the sharp decline in house prices experienced by Ireland already in 2007-2009 and by Spain, Portugal and Cyprus in 2010-2012. As shown in Figure 1, house prices dropped by a little over 30% in 2007-2009, and by another almost 30 percent in 2010-2012. In Spain, there was only a moderate decline

[14] See Merler and Pisani-Ferry (2012) for a detailed account of the European sudden stops.
[15] See Sinn and Wolmershäuser (2012)

during the financial crisis, but a strong decline after 2009. Portugal and Cyprus witnessed less dramatic yet significant drops in house prices after the beginning of the debt crisis.

Still, Greece, Ireland, Portugal, and Spain were not the only countries facing such turnarounds, and their sudden stops of capital inflows were not the most severe in the euro area, either. Between 2008 and 2009, Estonia and Latvia suffered sudden stops of capital inflows resulting in an increase in their financial account balances by 17.5 and 16.7 percent of GDP, respectively. Considering private portfolio investment, the Netherlands and Austria experienced turnarounds of 13.1 and 11.8 percent of GDP between 2008 and 2009, respectively, Belgium and Malta had turnarounds of 14.1 and 11.8 percent of GDP between 2009 and 2010, respectively. Thus, even with regard to sudden stops the countries suffering from public debt crises subsequently are no gross exceptions in the euro area.

3.2.3. The Sovereign-Bank Nexus

As the crisis progressed, euro-area banks' holdings of domestic government bonds recorded a significant increase (Paolo, Grande, & Panetta, 2014). Many worried that the resulting bank-sovereign nexus would generate a negative feedback loop between sovereign and the banks. Increased sovereign default probability increases doubt on bank solvency, because sovereigns are the ultimate insurer of their banks and banks' capital would be largely reduced in the event of a default. This in turns was reflected in an increase the stress on the local firms, who relied heavily on domestic banks for financing. As the economy weakens and tax revenues decline, further worsening the economic downturn.[16] Bank of International Settlement (2011) documented that since 2010, as worries about sovereign defaults in peripheral regions - Greece, Ireland, Spain and Italy - intensified, risk premia on their sovereign bonds increased dramatically. At the same time, there was significant financial stress on banks that had invested in them and an increase in bank lending rate to private sector. This further led to negative effects on economic activities (Neri & Ropele, 2015).

3.2.4. Asymmetric Policies

Turning to fiscal positions, Table 3 reports the average structural and cyclical deficits for the euro area and the six countries considered here on average for 2003-2006 and each year

[16] There is a growing literature that studies the sovereign-bank nexus. See for example (De Bruyckere, Gerhardt, Schepens, & Vennet, 2013), (Acharya, Drechsler, & Schnabl, 2014), (Gennaioli, Martin, & Rossi, 2014).

after 2006. The table shows that Ireland and Spain had very strong fiscal positions marked by considerable structural surpluses in the years before the financial crisis. In contrast, Greece, Italy, Portugal, and Cyprus all had sizeable structural deficits exceeding three percent of GDP during that period. These countries thus approached the global financial crisis with relatively weak fiscal balances. In 2007 and 2008, the euro area on average and all subsequent crisis countries except Italy still showed comfortable cyclical budget surpluses.

Table 4 considers the patterns of adjustment in fiscal aggregates during the financial crisis and during the European debt crisis. We compute the changes in the ratios of general government revenues, general government expenditures, various expenditure categories and primary deficits to GDP. Again, we compare the euro area average with the six crisis countries. Thus, Table 4 is based on a difference-in-difference analysis of fiscal adjustments. Boldface numbers highlight country-specific differences in excess of one cross-section standard deviation among the euro area countries other than the crisis countries. We compute the cross-section standard deviation for the non-crisis countries in order not to bias our threshold for significant differences against identifying outliers. We summarize the information in Table 4 in the following table. Here, a red cell indicates that the fiscal indicator under consideration deviates from the average of the non-crisis euro-area by at least one standard deviation for the country under consideration during 2007-2009.

The table reveals some interesting points. First, there are some clear differences between Italy and Portugal on the one hand and Greece, Ireland, Spain, and Cyprus on the other. The first two countries do not show fiscal adjustments significantly different from the average of the euro area other than their increase in the gross debt ratio. The four other countries do show significantly different fiscal adjustments. First, the decline in general government revenues was much stronger than on average in the euro area and so was the increase in the primary deficits. In contrast, differences on the spending side of the budget are much less clear. For Greece and Spain, the increase in total spending was not significantly different from the euro-area average in 2007-2009, for Ireland it was and this is due to the government's efforts to bail out the main banks.

Patterns of Fiscal Adjustments, 2007-2009

	Greece	Ireland	Italy	Portugal	Spain	Cyprus
Decline total revenues						
Increase total spending						
Social benefits						
Final consumption						
Personnel						
Interest						
Primary deficit						
Gross debt						
Share structural deficit						

Source: Table 4. Colored cells indicate changes in the respective fiscal indicator larger than the euro-area average by at least one cross-section standard deviation. Lighter colors for Cyprus indicate significant differences in 2010-2011.

Furthermore, Greece, Ireland, Spain, and Cyprus all show significantly stronger increases in social benefits, government final consumption, and compensation of employees than the euro-area average. One may suggest that these spending categories are generally difficult to reverse and, therefore, translate into longer-lasting budgetary effects than what one would wish to fend-off a temporary albeit strong recession. This suggestion is supported by the evidence given in the last row of the table. There, we show the share of the change in a country's structural deficit between 2007 and 2009 in the country's change in the overall deficit. A large share would indicate that most of the fiscal adjustment to counteract the recession following the financial crisis was undertaken by structural rather than cyclical measures. While the average share of the structural deficit adjustment in the euro area was 42.5 percent, all crisis countries except Italy had shares above two-thirds, Greece, Portugal, Spain and Cyprus even had shares of 75 percent and above. Finally, Greece, Ireland, Spain and Cyprus also experienced a significantly stronger increase in interest expenditures compared to the euro-zone average.

Thus, what marks a crisis country in the European debt crisis are strongly asymmetric fiscal adjustments relative to the euro-area average. Crisis countries seem to have used relatively more sticky and structural fiscal policy tools than the rest of the group. The exception to this is Italy which, apart from a stronger increase in its debt ratio behaved in a not significantly different way compared to the average of the euro-area.

This review suggests a distinction between three different cases of sovereign debt crises in the euro area. The first, exemplified by Italy and Portugal, is a generally weak fiscal situation, one that seems sustainable in normal times but turns out to be unsustainable (Portugal) or at least more critical than previously perceived (Italy) when the economy is hit by a negative shock. The second, exemplified by Greece, Spain, and Cyprus, is that of a significant decline in government revenues due to an adverse macroeconomic shock combined with a lack of sufficiently flexible tools on the expenditure side of the budget to counteract the underlying macroeconomic shock. The third, exemplified by Ireland and, again, Spain is the exposure to large contingent liabilities arising from a banking crisis and the government's perception of a need to come forward with large amounts of public funds to stabilize the banking sector.

While the first two cases are similar in their focus on the flow budget, the third case is different in that it focuses on assets and liabilities and, therefore, the governments' balance sheets. This points to different sources of risk in the public sector that deserve to be treated in different ways. In the next section, we discuss two approaches how these can be addressed by statistical models and methods.

4. Fiscal Risk: Statistical Approaches

Consider a government with total revenues, R_t,, total primary expenditures, G_t, seignorage revenue μ_t, and a stock of (net) government debt, B_{t-1}, outstanding, paying an interest rate of i_{t-1} on its debt. The government's flow budget constraint is[17]

(1) $$B_t = (1 + i_{t-1})B_{t-1} - (R_t - G_t) - \mu_t.$$

The conventional notion of sustainable public finances is that the government is within its intertemporal budget constraint,

(2) $$B_{t-1} \leq E_t \sum_{\tau=0}^{\infty} D_{\tau|t}(R_{t+\tau} - G_{t+\tau} + \mu_{t+\tau}),$$

(3) $$D_{\tau|t} = \prod_{j=0}^{\tau} \frac{1}{1+i_{t-1+\tau}}.$$

[17] Gabriele et al (2017) and Consiglio and Zenios (2017) focus their analysis on the government's gross financing need (GFN) instead of the flow budget constraint. GFN is defined as the flow budget constraint including any scheduled debt repayment during the period on the expenditure side and excluding seignorage as a potential revenue.

where D_t is the discount factor and E_t denotes a conditional expectation based on information available at time t. This would mean that there is a maximum sustainable debt stock defined by the equality sign in (2) and government debt is unsustainable, if the stock of debt outstanding exceeds that maximum.

It has long been recognized that this definition of sustainability is pretty meaningless for practical policy purposes, if we assume that the government can always credibly promise to adjust its revenues and primary expenditures in future periods with no costs or constraints. In practice, governments operate under constraints which limit the amount of revenues they can raise each period and the extent to which expenditures can be adjusted. Among these constraints are

- Economic constraints. These arise from the structure of the economy and from macroeconomic shocks. Structural constraints are based on the concept of the *Laffer curve,* which holds that there is a critical tax rate that generates a maximum of revenues from a given tax base. Raising the tax rate beyond this critical value will lead to a shrinking tax base due to negative incentive effects, increasing tax evasion, and other distortions and revenues will fall. Furthermore, for a given tax rate, the size of the tax base and, hence, tax revenues will change with macroeconomic developments. Thus, the maximum amount of revenues that can be extracted from a tax base is a stochastic variable.[18]
- Political constraints. These arise from political opposition against cuts in transfer programs such as pensions, welfare payments, and or reductions in public wages and employment. In democratic societies, transfer programs and the level of public employment result from compromises between different groups of voters and their representatives (Persson and Svensson, 1989, von Hagen, 2006). Such opposition generates persistence in government expenditures, as shown in public-finance applications of models of wars of attrition (Alesina and Drazen, 1991). Bi and Traum (2012) model tighter political opposition against tax increases as a reduction in in the government's time preference.

Such constraints impose structure on the intertemporal budget constraint and give rise to the notion of a *fiscal limit,* which has been defined as the level of debt from which on debt

[18] For a methodological exposition of dynamic Laffer curves related to taxes on labor or capital incomes, see D'Erasmo et al. (2016)

rises forever as the largest primary surplus which the government can achieve is not sufficient to offset the growing debt service (Ostry et al., 2010, p. 7), or as the maximum level of debt that the government is able to pay back (Bi and Leeper, 2013 p. 7). A government's *fiscal space* then is the difference between the fiscal limit and the current level of debt. The notions of fiscal limit and fiscal space provide a meaningful link between the stock of debt and the budgetary flows.[19]

A sovereign debt crisis is a situation in which a government hits its fiscal limit. When this happens, the government has three options. The first is to use seignorage and inflate away its debt. Obviously, this option is only available if the government borrowed in its own currency and the country is not part of a monetary union. The second option is to (partially) default on the debt. Default requires agreements with its debtors on rescheduling the debt and commonly leads a loss of access to credit financing including for private borrowers. The resulting collapse of credit causes severe economic contractions and hardship.[20] The third option is to ask its international partners for financial assistance. As the recent European examples have shown, such assistance will come only with the condition that the government undertakes fiscal adjustments it would not implement on its own initiative because of their high economic and political costs. Either way, therefore, hitting the fiscal limit is a painful event and governments have an interest in avoiding it. Estimating fiscal limits and fiscal space help them do that. Similarly, private investors have an interest in knowing how large the fiscal limit is in order to avoid losing wealth in a sovereign debt crisis.

Estimating fiscal limits requires modeling government revenues and expenditures under the constraints mentioned above as well as the behavior of interest rates (Ostry et al. 2010) or bond prices as in Bi and Leeper (2013), Bi and Traum (2013), and Bi et al. (2016). Ostry et al. estimate reduced-form reaction functions for the general government primary budget balance as a function of the level of general government debt (both relative to GDP). An important feature of their estimates is that the reaction function is non-linear. At low levels of debt, the primary balance falls with increasing debt; with debt levels between 50 and 150 percent of GDP, the primary balance increases with rising debt, with very high debt levels, it again falls. Furthermore, they estimate risk premiums in sovereign bond yields that rise as

[19] The necessity of such a link and its lack in conventional debt sustainability analysis is emphasized by Gabriele et al (2017) and Consiglio and Zenios (2017)

[20] See the empirical evidence in Gerling et al (2017)-

governments approach the fiscal limit. Based on this model, they estimate fiscal limits for 23 advanced economies. The average fiscal limit is almost 180 percent of GDP, individual limits rage from 157 percent (Iceland and Ireland) to 220 percent (Korea).

Bi and her co-authors present a structural approach based on a DSGE model to estimate fiscal limits. They assume one-period bonds and abstract from seignorage, which makes the flow constraint equal to the government's gross financing need.[21] The model has the following building blocks:

- A macroeconomic production function with stochastic and persistent productivity shocks, P_t, and embedding a Laffer curve for income taxes,
- A fiscal policy block consisting of a stationary stochastic process of government purchases, g_t, a process of stochastic government transfers to households, z_t, stochastically switching between a stationary and a non-stationary regime, rs_t, a reaction function of the income tax rate as a function of the level of debt which gives rise to a tax revenue function T_t, and a default rule specifying the rate of default if the government hits the fiscal limit,
- A forward-looking bond pricing equation which depends on the households' perception of the probability of default next period and implies that bond prices fall and yields rise as the perceived probability of default increases.

To estimate the distribution of the fiscal limit, Bi and her coauthors derive the infinite sum of discounted future primary government surpluses, where tax revenues are evaluated at the peak of the Laffer curve, T^{max}, and the discount factor is based on the marginal rate of substitution between current and future consumption when the tax rate is set accordingly, $d^*_{\tau+1} = \beta u^*_{c,\tau+1}/u^*_{c,\tau}$, where u^*_c is the marginal utility of consumption evaluated at the tax rate that maximizes tax revenues. Implicitly, this assumes that governments can always quickly move to the peak of the Laffer curve to move the fiscal limit out as much as possible given the current state of the economy and of fiscal policy. The fiscal limit is a conditional distribution depending on the parameters of the shock processes, the tax reaction function and the fiscal transfer regime and on the current state of the economy:

(4) $$\Omega_t \sim \sum_{\tau=1}^{\infty} d^*_{t+\tau} \left[T^{max}_{t+\tau}(P_{t+\tau}, g_{t+\tau}) - g_{t+\tau} - z_{t+\tau}(rs_{t+\tau})\right].$$

[21] Abstracting from seignorage amounts to the assumption that all seignorage revenue is distributed to the households in lump-sum transfers.

This distribution is determined by the probability distributions of the productivity shock, the fiscal shocks to government spending and transfers, and the process driving the regime switching. Comparing (4) and (1) reveals the nature of the fiscal limit as an intertemporal budget constraint with tax revenues assumed to be maximized and where the stochastic discount factor, d^*_t, acknowledges the condition that households must be willing to hold the existing stock of government debt and to buy any new debt the government wishes to issue.

From (4), the expected fiscal limit can be derived as the conditional expectation, $E_t(\Omega_t)$. Larger non-stationary transfers make the expected fiscal limit smaller ceteris paribus; the longer transfers are expected to stay in that regime, the smaller will be the expected fiscal limit. Furthermore, the expected fiscal limit will shrink when taxes become more distortionary. This implies that fiscal adjustments that reinforce adverse incentive effects may pull the fiscal limit closer even if they generate more revenues on impact. Fiscal adjustment programs for governments that find themselves close to their expected fiscal limits must, therefore, pay particular attention to the incentive effects they have on employment and investment. Rising political costs of or mounting political opposition against tax hikes reduce the fiscal limit.

Equation (4) can also be used to formulate sustainability constraints on fiscal policy. Rather than restricting the deficit-to-GDP ratio, which is a backwards-looking indicator, as the euro-area fiscal rules currently do, such constraints could take the forward-looking form of keeping a minimum probability, $\pi>0$, that the fiscal limit be hit over the next m periods,

(5) $$prob(B^*_{t+1} > \Omega_{t+1}, \dots, B^*_{t+m} > \Omega_{t+m}) \leq \pi.$$

Compared to a simple debt or deficit limit, the advantage of such a constraint is that it leaves governments with many more choices over fiscal policies. The sequence B^*_{t+1}, …, B^*_{t+m} applies the well-known concept of *conditional-value-at-risk* used in bank management to the management of public debt. It is similar in spirit to the conditional-value-at-risk for public debt proposed by Consiglio and Zenios (2017) on the basis of a stochastic model for the government's gross financing need.

Bi and Leeper (2013) calibrate their model to Greek and Swedish data to evaluate the behavior of the fiscal limit distribution and the risk premium in the bond yield under a variety of assumptions concerning the state of the macro economy and the transfer regime. Both exhibit strong nonlinearities. Bond yields in particular do not budge with a rising debt

ratio until the latter reaches values close to 100 percent and then increase very steeply. This gives support to the empirical results for sovereign risk premiums e.g., in Bernoth et al (2012) and Schuknecht et al. (2011). Similarly, the probability distribution of the fiscal limit is very flat and low for small and moderate debt ratios but increases steeply once a threshold has been crossed. Both the risk premium and the fiscal limit distribution turn out to be very sensitive to changes in the persistence of the fiscal transfer regime. Increasing the persistence of fiscal transfers even slightly results in a significant increase in the risk premium and pulls the fiscal limit closer to the current debt ratio.

This last point is particularly interesting in light of our discussion in the previous section. There, we saw that the crisis countries are characterized by much larger shares of structural deficit changes in total deficit changes during the financial crisis of 2007-2009. By definition, structural changes are expected to be more permanent.[22] This observation therefore translates into the proposition that crisis countries used more permanent spending increases to combat the crisis than other countries. The Bi et al. model suggests that doing so pushed these countries much closer to their fiscal limits and perhaps even beyond and explains why sovereign risk premiums shot up after 2009. The same argument implies that fiscal adjustment programs aiming at enlarging a government's fiscal space should focus primarily on structural measures and structural rather than headline balances.

The Bi et al. models provide a useful way organizing our thinking about the macroeconomics of sovereign risk. Developing models of this kind further can be useful to identify sources of risk in the public sector. This would require a number of extensions.

First, a more elaborate economic structure. With the exception of Bi, Shen, and Yang (2016), Bi and her coauthors use a closed-economy models with no capital in production to describe the macro economy. Introducing investment would open up an important channel of transmission of fiscal policy in this context. Empirical experience from the current euro-area crisis and econometric evidence for emerging economies[23] suggest that risk premiums paid by private enterprises are correlated with sovereign risk premiums, both because a fiscal retrenchment weakens future profit expectations making potential lenders more reluctant to lend and because a partial government default would weaken the balance sheets financial

[22] Milesi-Ferretti and Moriyama (2004, p. 8) implicitly define structural fiscal measures as measures which changes the need for future taxation.

[23] Arteta and Hale (2008), Das et al. (2010) find that private access to credit and capital markets deteriorates significantly during periods of sovereign debt crises.

institutions and lead to a cutback in credit supply. An increase in sovereign risk premiums would, therefore drive up the interest rate private enterprises pay to finance capital investment and this would push down aggregate investment. This, in turn, would aggravate the budget deficit as tax revenues fall and make it harder for the government to prevent government debt from increasing further.

Furthermore, domestic banks' holding of domestic government bonds increases the spillover risk of sovereign stress to banks and thus result in a negative feedback loop when sovereign risk is elevated. However, the effect of sovereign-bank nexus on public debt sustainability is multifaceted. Gennaioli, Martin, & Rossi (2014) and Thaler (2017) point out that when domestic banks hold domestic government bonds, this reduces the government's incentive to default. As a result, banks' exposure to domestic government bonds can reduce the cost of borrowing. Asonuma, Bakhache, & Hesse (2015) find empirical evidence that higher bank home bias is associated with higher debt levels, however with less responsive fiscal policy. Introducing banking sector would furthermore allow the model to capture the interlinkage between public debt and the domestic financial sector.

Finally, the euro-area experience suggests that external linkages through capital flows can be important factors in the development of a public debt crisis. This suggests the use of an open-economy model with international capital flows.

Second, Bi et al. consider a single debt instrument in their model simulations to estimate the fiscal limit, i.e., a one-period bond indexed to the price level. Practical application of their method requires a comprehensive measure of all financial obligations of the general government sector, including deposits and financial obligations issued by government-owned financial institutions and contingent liabilities such as government guarantees on bank deposits evaluated at the current probability of them turning into actual liabilities. While contingent liabilities are reported, if at all, as additional information, they are not included in common measures of public debt. In a case like the Irish, where the government decided to give a blanket guarantee on all deposits and some other debts of the Irish banking system at the end of September 2008, even a mild probability of realization would have strongly increased the debt measure, showing that this decision pushed the country

critically close to the fiscal limit already at the end of 2008, i.e., two years before the Irish government asked for financial assistance from its European partners.[24]

Although both the EU and the IMF include high-powered money in gross public debt,[25] that seems inadequate for countries issuing fiat monies which are, by definition, claims on nothing. In view of equation (2), accounts payable and future pension liabilities should not be included in the stock of gross debt, as these are contained in the discounted future streams of expenditures.[26]

Practical applications would also require a comprehensive measure of government net debt,[27] taking into account financial and real assets owned by the government. As noted by the literature, pricing such assets is not trivial as markets often do not exist for them and reliable data do not exist for all countries.[28] In the context of estimating fiscal limits and fiscal space, pricing government assets would have to give emphasis to their liquidity: As the government approaches the fiscal limit, it may have to sell off assets quickly to overcome a financing gap.

Third, Bi et al only consider an aggregate tax revenue function and aggregate spending and transfer schedules for the government. Disaggregating taxes and transfers would allow evaluating their different risk profiles more clearly. For example, Kanda (2010) shows that asset-related taxes in Ireland had risk profiles very different from other taxes and exposed the government very strongly to the real estate bust in 2007/2008. Disaggregation would give more precise estimates of the fiscal limit distribution.

Furthermore, in Bi et al there is only one income tax and one aggregate Laffer curve. In practice, some taxes will have different Laffer curves than others and some may not exhibit a Laffer curve at all.[29] Similarly, some government transfer programs may be easier to reverse

[24] In August 2008, total deposits at Irish banks stood at 166.4 percent of Irish 2nd-quarter annualized GDP. Since the reason for the guarantee was the perception of an imminent risk of collapse of the banking sector, the probability of the guarantee becoming real cannot have been negligible. Nevertheless, the Irish debt ratio shows only a relatively small increase for 2008.

[25] See debt concept D2 in Dippelsman et al. (2012)

[26] See Dippelsman et al. (2012)

[27] The Bi et al. papers use general government gross debt for their debt variable in the empirical applications of the model.

[28] E.g. Milesi-Ferretti (2004), Dippelsman et al. (2012). Bova et al. (2013)

[29] As the Greek experience in particular suggests, this depends on the exact definition of the Laffer curve. In Bi et al, the eventual negative effect of higher tax rates on tax collections stems entirely from disincentive effects to work. In a more general interpretation, tax evasion and low-quality tax administration may lead to Laffer-curves, too.

than others. A more refined analysis of the fiscal sector and the policy instruments governments have available would allow a sharper picture of the fault lines in the public sector and provide governments with clearer guidance for how to push out the fiscal limit distribution and create more fiscal space.[30]

At the same time, when modeling government spending and revenue, one may need to take into account the property of public debt cycles. Poghosyan (2015) find that the longer the public debt expansion or contraction has lasted, the more likely it is going to end in the next period. He also finds that financial cycles have asymmetrical effects on public debt cycles and that government expand deficit (debt-to-GDP ratio) after a credit bust to cushion recessions, but fails to make use of good economic time to rebuild fiscal buffer – empirical evidence that supports the ''deficit bias'' hypothesis.

Modeling aspects of the fiscal sector seem logically inconsistent at a first glance, if it is the government itself that provides the model. Would a government not tend to always make benign assumptions about, e.g., the persistence of its transfer programs? As far as tax revenues are concerned, Bi et al. avoid that question by evaluating the fiscal limit distribution at the peak of the Laffer curve. The distribution they derive thus assumes that governments can move to that peak instantaneously and with no cost. In a world with multiple taxes which have different distributional consequences, however, it would seem that the choice of tax parameters is the outcome of a political equilibrium which might be as difficult to change the equilibrium transfer policy. Within the highly aggregated models these authors present, one may argue that the distributional consequences of tax policies away from the Laffer curve are included in the governments' transfer policies. Juessen et al (2011) present a similar analysis of a government's repayment ability assuming that tax rates can never be changed even if the fiscal limit is approaching. This seems to go too far in the opposite direction.

How potential future defaults are expected to be resolved can also affect the fiscal limit. Asonuma, Chamon, Erce, & Sasahara (2017) find that the effect of sovereign debt restructuring on output depends much on the type of restructuring. If future debt

[30] As Christian Durant rightly pointed out in his discussion of this paper, the properties of a Laffer curve based on income taxes depend critically on the labor supply elasticity, which is among the most difficult parameters to estimate empirically and, therefore, among the most contentious features of empirical models. I take this as saying that practical applications should treat this point with particular care. At the same time, other taxes may have "Laffer curves" as well due to increasing tax evasion and shadow economic activities when tax rates rise.

restructuring can take place preemptively, the associated output costs –both regarding magnitude and persistence – is much smaller than the case when restructuring only happens after a default. Hence, the constraints that countries face on the choices of how to restructure their debt, or the institutional setup for debt restructuring can affect expected future tax revenue and thus influence fiscal limit.

More generally, the key to this question is that what matters in the model is not so much fiscal policy as intended by the government itself but rather future fiscal policy as perceived by the private sector. Independent statistical information about the credibility of future fiscal reforms would increase the usefulness of this approach for policy purposes.

5. Fiscal Risk and Government Balance Sheets

5.1. Principles

The purpose of a balance sheet is to characterize the financial position of an organization by summarizing its claims on and its liabilities to other organizations. One important aspect of this is transparency. A balance sheet should give a complete picture of the organization's financial position and show where its financial risks and weaknesses are. Importantly, although the balance sheet is only a snapshot made at a certain point in time, it should convey information that reflects expectations about the future viability of the organization.

A government balance sheet offers an alternative way of identifying sources of risk in the public sector and assessing the sustainability of public debt. Conceptually, we can construct a balance sheet by rewriting the sustainability condition (2).

(6) $$E_t \sum_{\tau=0}^{\infty} D_{\tau|t}(R_{t+\tau} + \mu_{t+\tau}) = B_{t-1} + E_t \sum_{\tau=0}^{\infty} D_{\tau|t} G_{t+\tau} + W_t,$$

where W is government net worth. The sustainability condition thus is $W_t > 0$.[31]

Note that B is to be interpreted as an appropriate measure of net debt as discussed above. For balance-sheet purposes, we can interpret the left hand side of (6) as the government's total assets and the right hand side as its total liabilities plus its net worth. To write out the balance sheet in more familiar terms, we rewrite some of the expected discounted streams of revenues and expenditures more explicitly as public assets and liabilities. Let K be the stock of physical public capital and nonfinancial tangible assets, A the stock of intangible

[31] The European Commission's (2012) Fiscal Sustainability Report provides an evaluation of this condition based on the discounted sum of all future primary balances based on current policies and net debt.

public assets, F financial assets, N nonfinancial liabilities such as pensions claims, C contingent financial liabilities such as government guarantees for bank deposits, and W government net worth. Underlying the government's balance sheet is the following broad list of assets and liabilities:

ASSETS		LIABILITIES	
Physical public capital and other nonfinancial tangible assets	K	C	Contingent liabilities
Intangible assets	A	N	Nonfinancial liabilities
Financial assets	F	B	Financial liabilities
		W	Net worth

This yields the following balance sheet equation:

(7) $K_t + A_t + F_t = B_{t-1} + N_t + p_{Ct}C_t + W_t.$

The condition for sustainable public finances then is

(8) $W_t \geq 0.$

To evaluate that condition requires a proper valuation of the various assets and liabilities. Bova et al. (2013, pp. 35sq) discuss some of the accounting issues related to nonfinancial assets. In the current context of looking at government balance sheets to assess the risk of sovereign debt crises, the valuation of government assets and liabilities should be guided by the question how much expected revenue the government can generate from its assets and what is the expected expenditure that cannot be avoided given its liabilities. For physical assets, for example, this would call for a valuation according to the prospective revenue from selling or leasing the asset.

As in the analysis of fiscal limits and fiscal space, valuing government assets and liabilities must be forward-looking, mimicking how a private investor would look at them. Since the government's right to tax is generally considered to be its main intangible asset, it is interesting so ask what this means for the value of taxation.

For a given tax, the value of the asset, $A_{i,t}$, is the discounted sum of expected future revenues, which depend on the tax rate, ϕ_i, the tax base, $\Phi_i(\phi_i,\ldots)$, and the stochastic discount factor, $d_{\tau|t} = \beta^{\tau}u_{c,t+\tau+1}/u_{c,t+\tau}$, where $u_{c,t+\tau}$ is the marginal utility of consumption in

period t+τ. As in the analysis of fiscal limits, this is the discount factor consistent with the private sector's willingness to hold the government's bonds. Thus,

(9) $$A_{i,t} = E_t \sum_{\tau=0}^{\infty} d_{\tau|t}\phi_{i,t+\tau}\Phi_i(\phi_{i,\tau+\tau}, \dots) = \sum_{\tau=0}^{\infty} \phi_{i,t+\tau}(E_t d_{\tau|t} E_t \Phi_{i,t+\tau} + cov_t\big(d_{\tau|t}\Phi_{i,t+\tau}\big)).$$

Since the marginal utility of consumption may depend on the marginal tax rate, the sequence of discount factors depends on the sequence of marginal tax rates expected in the future. This implies that changes in the time profile of marginal taxes can change the value of the asset even is the total amount of expected tax revenues does not change. As before, we are interested in the maximum amount of revenue the government can extract from a particular tax and, therefore, use the revenue-maximizing tax rate $\varphi_{it} = \varphi_{it}^{*}$, which is the rate corresponding to the peak of the Laffer curve for this tax.. Thus, we have

(10) $$A_{i,t}^{*} = \sum_{\tau=0}^{\infty} \varphi_{i,t+\tau}^{*}(E_t d_{\tau|t}^{*} E_t \phi_{i,t+\tau}^{*} + cov_t\big(d_{\tau|t}^{*}\phi_{i,t+\tau}^{*}\big)),$$

where d^{*} is the discount rate evaluated at the revenue-maximizing marginal tax rate, ϕ^{*} is the tax base evaluated at the peak of the Laffer curve, and $\varphi^{*}\phi^{*}$ is the corresponding revenue. [32]

Nonfinancial liabilities are future expenditure streams which the government has already committed to and cannot avoid except at very high economic and political costs. Examples are pension claims and other welfare benefits and public sector wages. The balance sheet value of a given government liability, $N_{i,t}$, is the discounted sum of the future payments, s_{it}, arising from that liability,

(11) $$N_{i,t} = \sum_{\tau=0}^{\infty}(E_t d_{\tau|t}^{*} E_t s_{i,t+\tau} + cov_t\big[d_{\tau|t}^{*} s_{i,t+\tau}\big]).$$

Here, again, the discount factor and the future payment streams are evaluated assuming that all tax rates are set at their revenue-maximizing levels. It then becomes clear that, conceptually, the government's net worth corresponds to taking expectations over the conditional fiscal limit distribution (4). As in the analysis of fiscal limits and fiscal space, evaluating government balance sheets to assess fiscal risks requires proper modeling of the tax base and its dependence on the tax rate.

[32] Gray et al. (2008) propose the use of stochastic methods of contingent claim valuation for similar purposes. Their analysis assumes that government assets and liabilities are driven by Brownian motion so that continuous-time finance models can be applied. Increasing volatility of asset returns would cause governments to move closer to "fiscal distress", which is similar in spirit to governments losing net worth on their balance sheets.

Finally, the balance sheet value of a given conditional liability, $C_{i,t}$, leading to future expenditure streams e_{it} if the contingency arises is

(12) $$C_{it} = \sum_{\tau=0}^{\infty}(E_t d^*_{\tau|t} E_t e_{i,t+\tau} + cov_t\left[d^*_{\tau|t} e_{i,t+\tau}\right]).$$

The covariance terms in equations (10), (11), and (12) indicate that the balance sheet values of all taxes and future expenditures depend on their risk profiles in addition to their expected future streams of revenues and expenditures. Specifically, the balance sheet value of a certain stream of revenues or expenditures is higher if its covariance with the discount factor is positive. Thus, to protect the government's net worth, taxes should have positive and expenditure streams negative covariance with the discount factor. For conventional utility functions such as logarithmic utility, the discount factor is positively related to the marginal utility of current consumption and negatively to the marginal utility of future consumption. Taxes on current consumption would fulfill that condition better than taxes on future consumption. If current wealth is more strongly correlated with future consumption than with current consumption, this is consistent with the analysis of Kanda (2010), which suggests that the balance sheet value of asset-related taxes should be regarded as lower than the balance sheet value of income taxes of the same total expected revenue stream, because the revenue from such taxes is high in times of boom and disappears in times of bust. Furthermore, highly cyclical taxes, which generate low revenues during macroeconomic slumps, when the marginal utility of consumption is high, should be attributed lower balance sheet values than noncyclical taxes of the same expected total revenue stream. This implies that a government can increase its balance sheet net worth and improve sustainability by moving from more to less volatile taxes and from more to less cyclical taxes for the same expected revenue stream. The latter point may generate a tension between the goals of macroeconomic stabilization and maintaining sustainable public finances.

5.2. Implications for Balance Sheet Management

To analyze these points further, we assume a logarithmic utility function $u(c_t)=\ln(c_t)$, such that the stochastic discount factor is

(13) $$d^*_{\tau|t} = \beta^{\tau}\frac{c^*_t}{c^*_{t+\tau}}, where\ \ln(c^*_t) - \ln(c^*) = \gamma(\ln(c^*_t) - \ln(c^*)) + \eta_t,$$

where $c^* > 0$, $0 < \gamma < 1$. Note that $d_{\tau|t}^*$ is large, when current consumption is large relative to expected future consumption, and small, when current consumption is small relative to expected future consumption. Thus, η_t is a shock to current relative to future consumption. Consider a government liability N_{it} with

(14) $\ln(s_{i,t}) - \ln(s) = \alpha_i(\ln(s_{i,t}) - \ln(s)) + \varepsilon_{it}$,

where $s > 0$, $0 < \alpha < 1$, and ε_t is i.i.d. with $E\varepsilon_t = 0$. The following equations assume that the economy is in steady state in t-1, and that, to a first-order approximation, a variable without time index is at its steady.state level.

Let $E(\varepsilon_{i,t}\eta_t)=\sigma_{\varepsilon i\eta}$ be the covariance between contemporaneous expenditure shocks and consumption shocks, and $E(\varepsilon_{i,t}\eta_{t-j})=0$ for all $j\neq 0$. The covariance between the stochastic discount factor $d^*_{\tau|t}$ and an expenditure shock in period t is

(15) $cov_t(d^*_{\tau|t}, s_{i,t+\tau}) = -\frac{c_t^*}{c^*} s\beta^\tau \sum_{n=0}^{\tau-1}(\gamma\alpha_i)^n \sigma_{\varepsilon i\eta}$,

while the expected value of future expenditure streams is

(16) $E_t(s_{i,t+\tau}) = s(1 + \alpha_i^\tau \varepsilon_{i,t})$.

Combining (14) to (16), the unconditional expectation of the balance sheet value of this liability is

(17) $E(N_{it}) = \frac{s}{1-\beta} - s\sigma_{\varepsilon i\eta} \sum_{\tau=0}^{\infty}\beta^\tau \sum_{n=0}^{\tau-1}(\gamma\alpha_i)^n$.

This shows that the balance sheet value depends critically on the persistence of the expenditure process, α, and on its covariance with consumption shocks. First, for a positive expenditure shock, it is the larger, the greater the persistence of the process. Second, it decreases with the covariance between this shock and the consumption shock. Thus, pro-cyclical government expenditure has a smaller conditional mean net present value. This is because borrowing is cheaper in times when the economy is in boom. This weakens the justification for strong automatic stabilizers, if the government borrows primarily in its own domestic market.

Consider now a severe economic recession causing the government to increase its current expenditures. Thus, there is a positive expenditure shock ε_t. This will raise the balance-sheet value of the future liabilities to the expected value

(18) $N_{i,t} = \frac{c_t}{c} E(N_{i,t}) + \frac{c_t s}{c}\left[\frac{\varepsilon_{i,t}}{1-\beta\alpha_i} - \frac{\eta_t}{1-\beta\gamma} - \frac{\varepsilon_{i,t}\eta_t}{1-\beta\gamma\alpha_i}\right]$.

The balance-sheet implications of this increase and, therefore, the implications for the government's net worth and debt sustainability depend on the design of the expenditure program used to fight off the recession. The larger the persistence of expenditures under that program, the more the government's balance sheet is compromised and the greater the adverse effect on debt sustainability. This is consistent with our empirical findings above. Governments counteracting the incipient Great Recession of 2008-2009 by increasing expenditures that are difficult to reverse were more likely to find themselves in a debt crisis subsequently. Furthermore, expenditure programs that are appropriate for countercyclical fiscal policies are those that have little persistence. That is, they are reversed quickly and they fall when the economy recovers.

Next, consider the balance sheet value of different types of taxes. In an economic slump like the Great Recession, governments experience negative tax revenue shocks, the balance-sheet implications of which are again larger when the revenue process is highly persistent. Thus, again, low persistence is desirable from this perspective. At the same time, the lower the covariance of tax revenue and consumption shocks, the better government's net wealth and debt sustainability are protected.

5.3. The Role of Seignorage

One important case in this context is the value of the government's inflation tax. Seignorage revenues are commonly regarded as small especially for advanced economies as inflation rates are small. From a sustainability perspective, however, this is misleading, since inflation is an important instrument to deal with excessive public debt. Facing the risk of default, a government whose debt is in its own currency can resort to the money-printing press and pay off its creditors at the cost of higher inflation rates. This implies that seignorage revenues can be very high in exceptional, low-probability states when revenues from other taxes are too low to service public debt.

Bolton and Huang (2017, 2018) recognize that possibility, but they treat money as part of a nation's equity. This seems odd, because the stock of money outstanding in an economy says very little about what that stock could be in times of crisis. Instead, it seems more logical to treat the government's right to issue money as an intangible asset.

A proper balance sheet valuation of that right should account for that high value of seignorage in times of fiscal distress. This implies that entering a monetary union can have a significant negative effect of government net worth especially for countries with high public debt to begin with, a point that was probably overlooked by many euro-area governments at the time when they adopted the euro and gave up control over seignorage.

5.4. Empirical Examples

To illustrate our discussion empirically, we simulate in a simple exercise the distribution of net present values (NPV) for different revenue and expenditure categories for the Greek government. This is then compared to a simulation for the Netherlands. By examining the whole distribution, we will be able to evaluate not only each category's contribution to the expected government net worth but also its role in driving the dispersion of the net worth distribution.

Analogous to Bi and Leeper (2013), the conditional distribution of the NPV of a financial category i is defined as

(19) $$\Lambda_{i,t}(S_t) \sim \sum_{\tau=t}^{\infty} d_{\tau|t} \Upsilon_{i,\tau},$$

S_t is the vector of state variables at time t, $d_{\tau|t}$ the discount factor. $\Upsilon_{i,\tau}$ denotes the cash flow from category i at time τ: $\Upsilon_{i,\tau} > 0$ if it is an income and $\Upsilon_{i,\tau} < 0$ if it is an expenditure. The government net worth is thus distributed as

(20) $$\mathrm{W}_t(S_t) \sim \sum_i \sum_{\tau=t}^{\infty} d_{\tau|t} \Upsilon_{i,\tau} - B_{t-1}$$

For the simple simulation, we assume log-output to be an AR(1) exogenous process with mean output level normalized to one

(21) $$\ln(\mathrm{Y}_t) = \rho_y \ln(\mathrm{Y}_{t-1}) + \varepsilon_{y,t}, \quad \rho_y \in (0,1), \quad \varepsilon_{y,t} \sim^{iid} N(0, \sigma_y).$$

Furthermore, for all revenue/expenditure categories except taxes, the cash flow $\Upsilon_{i,\tau}$ evolves analogous to (14). The modeling of the stochastic factor is an adapted version of (13). As the majority of both Greek and Dutch government bonds were held externally, assuming log-

utility function, the relevant discount rate is a function of international investors' consumption c and the real exchange rate e.[33]

(22) $$d_{\tau|t} = \beta^{\tau} \frac{c_t}{c_{t+\tau}} \frac{1}{e_{t+\tau}}.$$

It is assumed that foreign consumption, expressed in domestic prices, follows an AR(1) process

(23) $$\ln(c_t e_t) - \ln(ce) = \gamma[\ln(c_{t-1} e_{t-1}) - \ln(ce)] + \eta_t, \quad \gamma \in (0,1), \quad \eta_t \sim^{iid} N(0, \sigma_\eta).$$

Under these assumptions, the state vector at time t is $S_t = \left\{ Y_{t-1}, \{Y_{i,t-1}\}_i, \varepsilon_{y,t}, \eta_t, \{\varepsilon_{i,t}\}_i \right\}$.

Concerning the tax revenues, the NPV of future tax incomes should be evaluated at tax rates associated with the maximum total tax revenue. While the tax rates at the peak of the Laffer curve should be jointly derived for all tax categories, here for simplification, we draw the maximum tax-income-to-GDP ratio from the truncated empirical distribution above the third quartile.[34]

The conditional distribution of each expenditure position is simulated with the initial condition set to reflect the data in 2007. For each simulation, revenues and expenditures are calculated using a random draw of a 1000-year sequence of the exogenous variables. The NPV is derived for each financial position based on the simulated cash flows. The simulation is repeated 5000 times to arrive at the distributions of NPVs.[35]

The calibration is based on estimated parameters for Greece as well as the Netherlands. Table 7 summarizes the calibration. Within Greece, there is considerable heterogeneity regarding the persistence and volatility of different revenue and expenditure categories, as well as their correlations with the consumption shock. Furthermore, these profiles seem to be country specific with a sizable disparity between Greece and the Netherlands. Before we examine how this different structure of revenues and expenditures matter for each government's net worth, we will first illustrate how the characteristics of a cash flow stream

[33] Here the exchange rate is written in quantity notation, i.e., foreign currency per domestic currency. See Bi et al. (2016) for the derivation of the discount rate for a small open economy's external borrowing.

[34] This approach is similar to Bi et al. (2016), who draw the maximum tax rate from a truncated empirical tax distribution above medium. The empirical tax distribution is derived for the sample 1988-2017. This covers the euro debt crisis period, during which higher tax-income-to-GDP ratios are observed.

[35] In particular, the shock sequences $\left\{ \varepsilon_{y,t+l}, \{\varepsilon_{i,t+l}\}_i, \eta_{t+l} \right\}_{l=1}^{200}$ are drawn from the joint-normal-distribution for 200 periods. We repeat the simulations for 5000 times and distributions are estimated based on kernel density estimation using the Epanechnikov function.

affect its own NPV distribution, using the expenditure category "social transfers and benefits" as an example.

As we discussed before, the NPV distribution of an income streams depends on its persistence, volatility, and correlation with the discount factor. Figure 2 compares the simulated NPV distribution of the expenditure category "social transfers and benefits" to three counterfactual simulations, changing a single parameter in each case: (1) innovation persistence is increased to 0.9; (2) the volatility of innovation is quadrupled; (3) its correlation with the stochastic discount rate is decreased from -0.24 to -0.95. The expected NPVs are shown in brackets. Increases in persistence, volatility or a decrease in correlation with the consumption shock all raise the expected NPV of future social transfers and benefits and also the variance. This reduces the expected government net worth and, given the distribution of other financial categories, lead to the fattening of the tail distribution of government net worth, and further increase the probability of a negative government net worth. Quantitatively, changes of correlation have the most limited effect on the expected NPV.[36]

Figure 3 shows the simulated NPV distributions for all revenue and expenditure categories, as well as the government net worth of Greece (solid black line) and the Netherland (dashed red line). The government net worth is the sum of all NPVs minus the government debt level. In 2007, the Greek government debt-to-GDP ratio amounts to about 100%, while in the Netherlands, the ratio was around 43%. Conditional on the initial states of 2007, the net worth of Greece has a slightly smaller mass below zero than the Netherlands. The simulated probability of negative net worth amounts to merely 3.8% per year for Greece, and 5.1% per year for the Netherlands.[37].

Figure 3 also illustrates how the mix of fiscal policy may have contributed to a worsening of Greece's fiscal risk. As we have shown before, the increase in total government spending in Greece was not significantly different than that of the euro-area average. The fiscal instruments used, however, were more persistent and structural. In simulations, we examine the effect of expansionary fiscal policy on the government net worth by using two expenditure categories with different level of persistence. More specifically, we increase the

[36] If instead, the correlation is increased to +0.95, the expected NPV would only be decreased by 0.003.

[37] The empirical tax rate distribution for the Netherlands potentially understates its maximum tax revenues. Since it has not experienced a sovereign crisis as in Greece, the Netherlands had not the necessity to increase its tax revenue-to-GDP ratio as it was the case in Greece.

initial level of government employee compensation or that of intermediate government consumption each by 5 percentage points of GDP.[38] These changes in government spending have the same initial impact on the deficit, but a very different effect on the distribution of government net worth. If the more persistence instrument – employee compensation -- is used, the net worth distribution is moved further left and lead to a probability of a negative government net worth of 21% per year. There would be a mere 3.6 percentage point increase in the same probability compared to the baseline, if instead intermediate consumption were expanded.

Of course, these simulations are too crude for policy analysis. The analysis uses empirical distributions of tax-income-to-GDP ratios and not the tax rates at the peak of Laffer curve, potentially underestimating the NPV of the revenue side. The reaction functions of tax rates and various government expenditures are in reality more complex than the simple exogenous process assumed here. The simulation ignores the feedback effect of public spending on output. Finally, the simple stationary setup also does not take into account output growth, contingent liabilities or seignorage and non-financial government assets, which are also important determinants of public debt sustainability.

To address these shortcomings, a more elaborate model is required. However, the simulations do illustrate the heterogeneity of different revenues or expenditures' contribution to the government net worth, as well as the disparity across countries. It also demonstrates that expansionary fiscal policy of the same initial magnitude can have very different effect on fiscal risk.

5.5. Value-at-Risk Calculations

The conditional value-at-risk (CVaR) of an asset or a liability is its conditional expectation in the risky tail of its probability distribution. For example, the five-percentile CVaR ($CVaR_{0.05}$) of an asset its conditional expectation for all realizations smaller than the five-percentile value of the asset. If this is very small compared to the unconditional expectation, it means that the value of the asset can deteriorate dramatically in bad times and, therefore, tail-risk is very important. In contrast, if the $CVaR_{0.05}$ is not very different from the unconditional

[38] The magnitude is comparable to the increase in the total government expenditure-to-GDP ratio in Greece between 2007 and 2009 of 6.5 percentage points.

expectation, tail-risk is less significant. Similarly, the 95-percentile CVaR of a liability, $CVaR_{0.95}$, is its conditional expectation for all realizations greater than the 95 percentile and it indicates the significance of tail-risk in times when the liability is unusually great. Barnhill and Kopits (2004) and Consiglio and Zenios (2017) have proposed using CVaR analysis to assess the riskiness of government debt.

We use CVaR computations to evaluate the tail-risk of various government expenditures and revenues in our simulations for Greece. The results are reported in Table 8. Consider the unconditional distribution first. Here, we compute the overall expected value (mean NPV) and the CVaR for our various fiscal categories. The second and third rows of Table 8 show that the overall expected value of indirect taxes is 3.74, while the $CVaR_{0.05}$ of indirect taxes is 3.55, or five percent less, while for social contributions, the $CVaR_{0.05}$ is seven percent lower than the overall expected value. This suggests that tail-risk associated with social contributions is larger than that associated with indirect taxes. On the expenditure side, the simulations indicated that the tail-risk associated with "other expenditures" is larger than that of the other categories. While these differences seem small, the overall effect on government net worth is large. While the mean NPV of the Greek government net worth is possible, its $CVaR_{0.05}$ is negative, showing that the government's fiscal sustainability is quite vulnerable.

Since the NPVS in our simulations are affected by output fluctuations, we also compute the CVaRs of the various categories assuming that there is a large recession in the initial period of the simulations. A large recession is defined as a negative output shock smaller than the five- percentile of the output shock distribution. The mean NPVs in the fourth row of Table 8 illustrate how sensitive average balance sheet values are with respect to output fluctuations. While a large recession decreases the mean NPV and the CVaR of all revenues streams and increases them for most of the expenditure categories, the magnitude of the changes is small for the individual categories. This is because, due to the forward-looking nature of NPVs, the NPV distribution is mainly driven by longer-term fluctuations. Nevertheless, the combined effect on government net worth is again quite large. The initial condition of a large recession reduces mean expected government net worth by about 25 percent and makes the $CVaR_{0.05}$ of government net worth almost three times as negative, indicating a substantial risk of government default under this condition.

Furthermore, the small shifts in the individual NPVs caused by the initial recessions can lead to sizable changes in the fiscal risk. The last column captures the effect of large recessions on tail-risk. It shows the probability of a realization worse than the unconditional 5th percentile of revenue NPV distributions or the 95th percentile of expenditure NPV distributions, when the economy starts in a large recession. Compared to the unconditional probability of five percent of such events, the increases are notable and comparable for most categories. As a result, if hit by a large recession, the government net worth has more than double the chances of being lower than the its unconditional 5th percentile, signaling a potentially large increase in the fiscal risk.

6. Evaluating Government Balance Sheets: A Task for Independent Fiscal Councils

Identifying risks and fault lines in the public sector would greatly improve fiscal transparency. Unfortunately, many governments shun transparency because they wish to avoid being held accountable for their policies and they hope to improve their standing in financial markets by hiding information. While fiscal transparency has improved greatly in recent years as a result of the IMF's push in that direction which started after the financial crises of the late 1990s, data for government assets and liabilities are still far from being comprehensive and, even where they exists, they are often not easy to obtain.

Wealth of data alone does not produce transparency. The European experience with the EDP and the SGP is a case in point. While reporting requirements have grown over time, there is no clear conceptual framework within which the host of indicators is synthesized and evaluated. As a result, the European Commission's analysis of the individual countries' fiscal positions often seems quite arbitrary.[39] What is needed in addition to the necessary data is the development of analytical methods to derive conclusions regarding the sustainability of public finances.

In the previous section, we have discussed two approaches to using such data in a model-based framework to evaluate the risks associated with a government's fiscal position.

[39] Consider for example the European Commission's (2012) Sustainability Report which comes to the surprising result (p. 43) that Italy is the only country with positive intertemporal net worth in the euro area. As it turns out, this is based on the assumption, already falsified in 2012, that the Italian government in power at the time of writing the Report would successfully implement all announced reforms.

Compared to the traditional analysis of debt sustainability, which is based on a multitude of indicators, these approaches have the advantage of aggregating and summarizing the information in a consistent and transparent framework. Compared to the synthetic indicators proposed by Baldacci et al (2011a,b), they emphasize the forward-looking nature of expectations and asset values, the role of uncertainty and volatility and the importance of economic constraints and linkages between the various indicators and the macro economy, which can only be taken into account by using econometric models. The analysis of fiscal limits focuses on the dynamic evolution of fiscal aggregates and the link between low-frequency events such as fiscal reforms or demographic trends and high-frequency data such as fiscal aggregates and bond prices. The balance sheet approach provides a snapshot in time of these processes which may be easier to interpret and more useful for practical asset and liability management. Both should be seen as complements rather than alternatives.

Implementation of both approaches would seem highly desirable especially for governments with little control over the inflation rate, which, as the sovereign debt crisis in Europe has shown, can find themselves in fiscal crises more easily than previously thought. Obviously, publishing such an evaluation and the assumptions and models it uses would greatly improve fiscal transparency.

For that reason alone, governments are unlikely to engage in such analysis. Central banks could do it, but at the risk of having to criticize their governments' fiscal policies which is not the domain of their policies and expertise. The IMF could do it, but Washington is often too far away to have an impact on fiscal policy especially when there is no crisis yet. In the European context, governments have now committed to the creation of independent fiscal councils. These councils have the task of evaluating the sustainability of public finances and to publish their assessments. In doing so, they should develop practical applications of these methods. Publishing consistent information about the government's net worth, how far away the government likely is from the fiscal limit and how fast it is approaching it would add substance to the public debate and help the public and the market hold the government accountable for its policies. In some cases at least, this may require more resources than the councils currently have available, but such constraints could be overcome by engaging the academic world in the development of the necessary tools.

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Table 1: General Government Revenues and Net Lending

	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus
		Total Government Revenues (% of GDP)						Net Lending (% of GDP)						
2002-06	44.8	39.2	34.9	44.0*	39.2	40.7*	38.8	-2.5	-5.9	1.2	-3.8	0.6	-5.0	-3.8
2007	45.3	40.7	36.9	46.0	41.1	41.1	44.8	-0.9	-6.5	0.1	-1.6	1.9	-3.1	3.5
2008	45.0	40.7	35.7	45.9	37.0	41.1	43.1	-2.4	-9.8	-7.4	-2.7	-4.5	-3.5	0.9
2009	44.9	38.3	34.7	46.5	35.1	39.6	40.1	-6.9	-15.6	-13.9	-5.5	-11.2	-10.2	-6.1
2010	44.8	40.6	35.2	46.1	36.6	41.6	40.9	-6.5	-10-7	-30.8	-4.5	-9.7	-9.8	-5.3
2011	45.3	42.4	34.9	46.2	35.7	45.0	39.7	-4.4	-9.5	-13.4	-3.8	-9.4	-4.4	-6.3
2012	46.2	44.7	34.6	47.7	36.4	41.0	40.0	-4.0	-10.0	-7.6	-3.0	-10.6	-6.4	-6.3
2013	46.8	43.5	34.8	48.2	36.8	43.1	40.6	-3.4	-3.8	-7.5	-2.9	-6.5	-5.5	-6.3

Source: European Commission, AMECO

Table 2: General Government Total Expenditures and Social Transfers

		Greece	Ireland	Italy	Spain	Portugal	Cyprus	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus
	Total Expenditures (% of GDP)							Social Transfers other than in kind (% of GDP)						
2002-06	47.4	45.1	33.7	48.0	38.6	45.7	42.5	16.3	15.2	9.1	16.9	11.6	11.9	11.8
2007	46.0	47.2	36.8	47.7	39.2	44.3	41.3	15.6	15.3	10.3	17.0	11.6	14.6	11.5
2008	47.1	50.1	43.1	48.6	41.5	44.7	42.1	15.9	16.7	12.3	17.6	12.5	15.1	12.1
2009	51.2	54.0	48.6	52.0	46.3	49.7	46.2	17.6	18.1	15.2	19.2	14.7	17.0	13.3
2010	51.0	51.3	66.1	50.5	46.3	51.5	46.2	17.5	18.1	15.5	19.2	15.4	17.1	14.2
2011	49.5	51.9	48.2	50.0	45.1	49.4	46.0	17.3	19.4	15.7	19.3	15.4	17.3	14.6
2012	49.9	54.7	42.2	50.7	47.0	47.4	46.3	17.6	20.0	15.0	19.9	16.1	18.0	15.0
2013	49.7	47.3	42.3	51.1	43.3	48.6	47.1	17.8	18.6	14.4	20.4	16.4**	19.4	15.7

*2004-06, **social transfers in kind also increased by 2 percent of GDP 2007-2009

Source: European Commission, AMECO

Table 3: General Government Structural and Cyclical Deficits

	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus
	Structural Deficit (% of GDP)							Cyclical component of deficit (% of GDP)						
2003-06	2,80	6,31	-1,48	5,15	-0,46	5,33	4,34	-0,13	-0,07	0,17	-0,60	-0,53	0,43	0,17
2007	2,13	7,62	1,81	3,51	-0,93	3,73	-2,44	-1,41	-1,37	-1,89	1,72	-1,00	-0,47	-1,06
2008	2,95	9,62	7,57	3,84	4,46	4,49	0,79	-0,88	-0,70	-0,21	0,93	-0,21	-0,06	-1,72
2009	4,51	14,77	9,82	4,19	8,55	8,69	6,45	1,82	0,63	2,05	-1,97	2,05	1,21	-0,33
2010	4,46	8,83	9,11	3,70	7,41	8,81	5,70	1,06	2,31	2,25	-0,97	2,25	0,35	-0,41
2011	3,55	5,36	7,65	3,61	7,25	6,56	6,59	0,63	4,43	1,49	-0,87	1,49	0,85	-0,52
2012	2,14	0,96	7,41	1,43	5,46	4,17	6,72	1,12	5,80	0,65	-1,71	0,65	1,60	-0,01
2013	1,39	2,04	6,92	0,49	4,36	3,65	5,39	1,53	6,26	0,14	-2,21	0,14	2,09	2,70

Source: European Commission, AMECO

Table 4: Changes in Selected Budgetary Aggregates (percent of GDP), 2007-2009 and 2009-2011

	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus	Euro	Greece	Ireland	Italy	Spain	Portugal	Cyprus
	2007-2009							2009-2011						
Total Revenues	-0.4	**-2.4**	**-2.2**	0.5	**-6.0**	-1.5	**-4.7**	0.4	**4.1**	0.2	-0.3	0.6	**5.4**	-0.4
Total Expenditures	5.2	6.8	**11.4**	4.3	7.1	5.4	4.9	-1.8	-2.0	-0.5	-2.0	-1.1	**-0.4**	**-0.3**
Social Benefits other than in kind	2.0	**2.9**	**4.9**	2.2	**3.1**	2.4	1.8	-0.3	**1.3**	0.5	0.1	**0.7**	0.3	**1.3**
Gen. Govt. Fin. Cons.	2.3	**3.1**	**3.3**	1.9	**3.0**	2.2	2.7	-0.7	**-3.1**	**-1.9**	-1.0	-0.4	**-2.1**	-0.1
Compensation of Employees	1.0	**2.0**	**2.3**	0.7	**1.8**	0.6	**1.6**	-0.5	**-1.1**	**-0.9**	-0.6	-0.4	**-1.4**	**-0.2**
Interest	-0.1	**0.4**	**1.0**	-0.3	**0.2**	-0.3	-0.4	0.2	**1.9**	**1.2**	0.2	**0.7**	**1.2**	-0.2
Primary deficit	5.8	**8.5**	**12.9**	4.2	**12.9**	7.1	**10.1**	-2.4	**-8.1**	-1.8	-2.0	2.4	**-7.0**	**0.4**
Share of structural def.	42.5	**78.1**	**67.0**	15.6	**76.1**	**74.6**	**92.5**	45.6	**167.9**	**79.4**	35.7	**97.9**	**85.5**	**-264.5**
Gross debt	13.6	**22.5**	**39.8**	**13.1**	**17.6**	**15.3**	-0.3	8.0	**40.6**	**41.6**	**15.3**	4.4	**24.6**	**12.5**

Note: Bold figures denote deviations from euro-area average in excess of one cross-section standard deviation among the non-crisis countries.
Source: European Commission, AMECO

Table 5: Real and Nominal GDP Growth

	Real GDP Growth							Change in Real GDP Growth	
	2002-06 Average	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2007-2009**	**2009-2011**
Cyprus	1,49	2,09	3,21	2,53	-0,68	-0,90	**-1,82**	0.44	-3.43
Greece	2,55	0,54	-0,59	1,25	**-6,93**	**-8,54**	**-5,77**	0.71	-9.79
Ireland	3,28	2,45	**-2,48**	-1,07	**-2,76**	0,00	1,55	-3.52	1.07
Italy	-0,71	-1,32	-1,53	-1,11	-0,27	-1,06	**-1,76**	0.21	0.05
Portugal	-1,03	-0,63	-0,38	1,48	-0,05	**-2,99**	**-2,56**	2.11	-4.47
Spain	1,58	0,48	0,52	0,64	**-2,31**	-1,02	-0,81	0.16	-1.66
Euro Area	1,76	3,00	0,38	-4,39	1,99	1,44	-0,61	-7.39	5.82
Std.Dev.	2.00	2,40	2,50	3,30	1,00	2,00	1,40	4.9	5.0

Note: Individual country data are growth rate differentials relative to the euro area. Std.Dev. is the cross-section standard deviation for the 11 non-crisis euro-area countries. Boldface entries indicate growth rates which are at least one standard deviation below the euro-area average

Source: European Commission, AMECO

Table 6: Financial Account Balances (%of GDP)

	2006	2007	2008	2009	2010	2011	2012
Balance on Financial Account (Net borrowing -)							
Cyprus	-6.8	-11.5	-16.5	-10.9	-9.5	-4.3	-4.3
Greece	-9.8	-12.3	-12.9	-10.6	-9.4	-8.6	-2.1
Ireland	-2.7	-19.1	-9.1	0.7	-4.6	-3.8	1.3
Italy	-1.7	-1.7	-2.0	-2.5	-5.6	-4.6	-0.5
Portugal	-9.5	-8.5	-11.2	-10.4	-9.0	-5.7	1.1
Spain	-8.6	-9.6	-9.2	-5.0	-4.1	-2.7	0.1
Net Portfolio Inflows							
Cyprus	-8.0	-4.9	-23.4	6.0	-8.3	-4.8	-0.3
Greece	-3.5	-8.0	-7.2	-12.4	9.6	9.1	51.1
Ireland	-11.9	-11.3	-21.3	-1.4	-2.3	3.7	3.2
Italy	-3.0	-1.2	-4.8	-1.8	-2.5	2.2	-1.9
Portugal	-2.4	-5.9	-9.0	-9.0	5.6	2.7	12.7
Spain	-18.9	-8.5	0.1	-4.8	-3.4	3.0	4.0

Note: Source: IMF and European Commission DG ECFIN. For Ireland and Cyprus, net portfolio flows include “other investments” since the individual series are implausibly large and volatile. For Greece 2012 net portfolio investment is offset by “other investments” of 52.5 percent of GDP, reflecting the effect of the bond restructuring.

Table 7 Calibration

	Greece					**Netherlands**				
	average (% of GDP)	Persis-tence	StDev	Corr. output	Corr. Consumption	average (% of GDP)	Persis-tence	StDev	Corr. output	Corr. Consumption
GDP		0.81	0.02				0.83	0.02		
Stochastic discount factor component z_t		0.82	0.02	-0.13			0.81	0.01	-0.30	
Social contribution	10.98	0.84	0.04	0.70	-0.31	15.58	0.77	0.05	0.65	-0.43
Other revenues	6.38	0.63	0.12	0.55	-0.19	7.27	0.89	0.05	0.31	-0.28
Social transfers and benefits	13.84	0.63	0.03	-0.12	-0.24	20.26	0.84	0.03	-0.49	0.16
Government employee compensation	10.66	0.80	0.04	-0.07	0.10	10.86	0.86	0.02	-0.59	0.50
Government intermediate consumption	5.17	0.32	0.08	0.46	-0.12	5.11	0.87	0.02	-0.30	0.50
Other expenditures	7.89	0.59	0.13	0.38	-0.45	8.44	0.63	0.13	-0.15	0.57

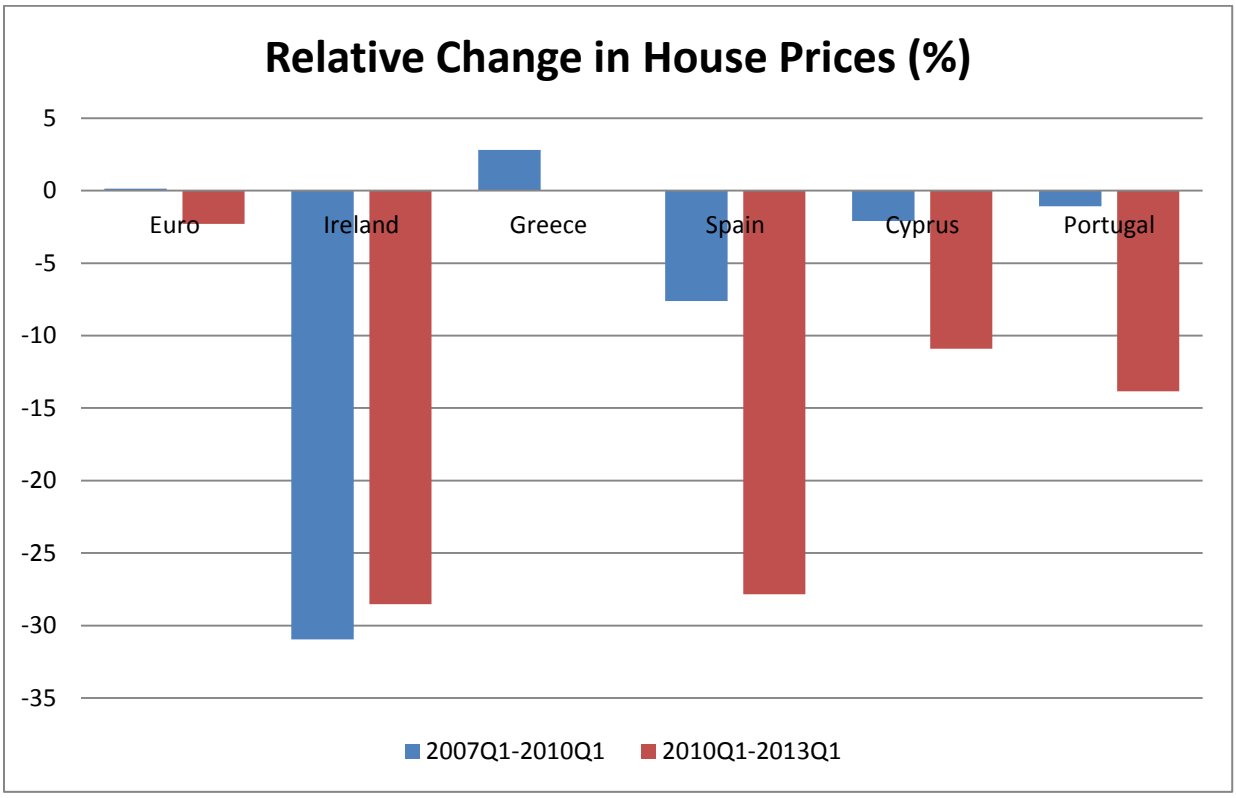
Data source: AMECO spring 2017 and spring 2011 releases; eurostat.

Note: StDev: standard deviation, corr: correlation coefficient with. Other revenues: other current revenue inducing sales and capital transfers received. Other expenditures: subsidies, other current expenditure, gross fixed capital formation, and other capital expenditure including capital transfers. All parameters are estimated using yearly, log-linear detrended, GDP deflator deflated, per capita time series. Sample period for government revenues and expenditures in Greece starts in 1988 due to data availability. It ends in 2009, just before the first bailout. Analogously, the sample for government revenues and expenditures in the Netherlands covers 1968-2009. The stochastic discount factor is calculated using the euro area (12 countries) consumption and the country-specific real effective exchange rate with respect to other euro-area member states. Due to data availability, the sample for stochastic discount factor covers 1995-2009. The standard deviations and correlations are based on the estimated covariance matrix of $\varepsilon_{y,t}$, $\eta_t, \{\varepsilon_{i,t}\}_i$ for each country. The log-linear trend is calculated based on the within sample periods that cover full business cycles (peak-to-peak): Greece 1990-2008; the Netherlands 1970-2008.

Table 8: Output Fluctuations and NPV Distributions: Greece

	unconditional distribution		**distribution conditional on large recessions**		
	mean NPV	$CVaR$	mean NPV	$CVaR\|$ recession	Prob. of a realization worse than the unconditional 5^{th} or 95^{th} percentile
Indirect taxes	3.74	3.55	3.73	3.54	7.2%
Direct taxes	2.47	2.34	2.45	2.33	7.2%
Social contribution	2.64	2.45	2.62	2.43	7.0%
Other revenues	1.55	1.40	1.53	1.39	7.6%
Social transfers and benefits	3.33	3.48	3.34	3.49	7.3%
Government employee compensation	2.56	2.72	2.58	2.73	7.2%
Government intermediate consumption	1.25	1.31	1.25	1.31	4.8%
Other expenditures	1.92	2.12	1.91	2.10	4.4%
Net worth	0.35	-0.05	0.26	-0.14	11.1%

Figure 1



Source: Eurostat

Figure 2: Social Transfers and Benefits

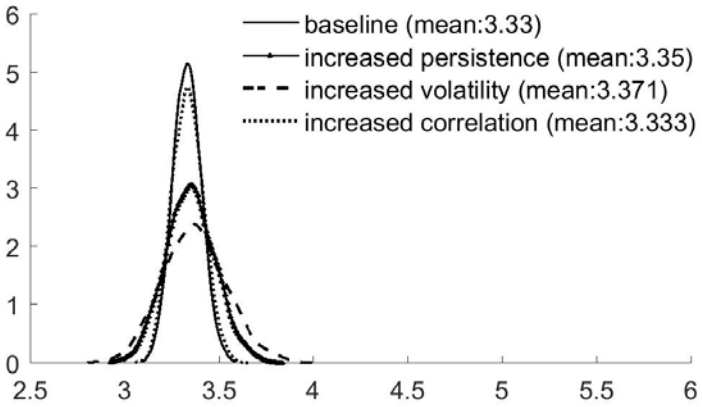
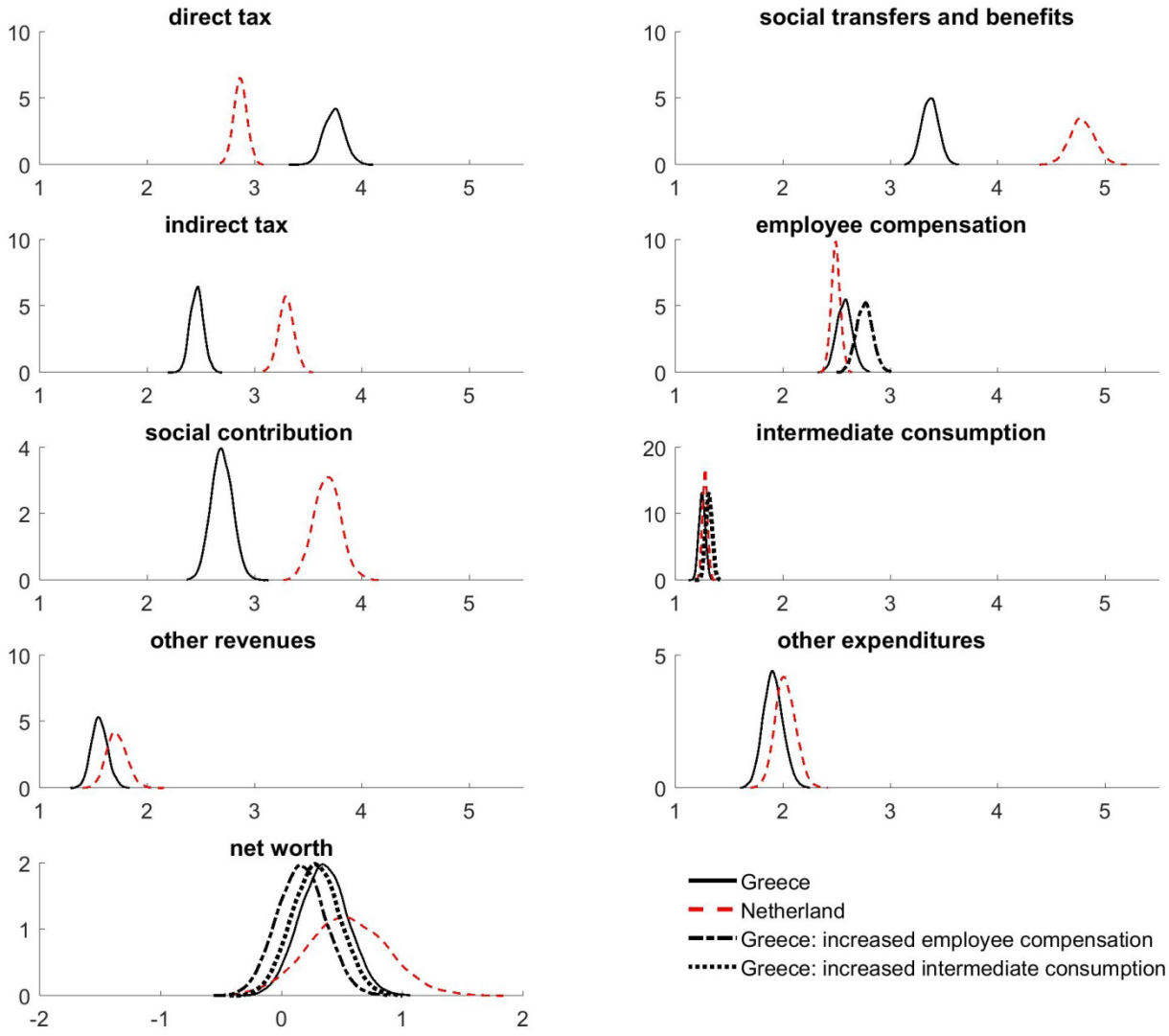


Figure 3: Government Balance Sheet Simulation



Notes: Annual output is normalized to one. Direct tax: taxes on income and wealth. Indirect tax: taxes linked to imports and production. Other revenues: other current revenue inducing sales and capital transfers received. Other expenditures: subsidies, other current expenditure, gross fixed capital formation, and other capital expenditure including capital transfers.