Essays on Sovereign Debt Crises

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1. Referentin: Prof. Dr. Almuth Scholl

2. Referent: Prof. Dr. Stefan Niemann

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Einleitung

Die vorliegende Dissertation wurde während meines Studiums im Doktorandenprogramm *Quantitative Economics and Finance* an der Universität Konstanz verfasst. Sie umfasst drei eigenständige Aufsätze, die sich mit den Auswirkungen von Fiskalpolitik, insbesondere von Austeritätspolitik, und den ökonomischen Dynamiken im Kontext von Staatsschuldenkrisen befassen. Im Folgenden werde ich die einzelnen Kapitel kurz vorstellen und die wichtigsten Ergebnisse und Schlussfolgerungen hervorheben.

Im ersten Kapitel analysiere ich die Wechselwirkungen zwischen lang andauernder Arbeitslosigkeit und fiskalpolitischen Entscheidungen anhand eines quantitativen Staatsschuldenmodells, in dem Arbeiter während Phasen von Arbeitslosigkeit Humankapital verlieren. Muss eine Regierung höhere Zinsen für Staatsschuldtitel zahlen, bleibt ihr nur die Möglichkeit, durch Sparpolitik einen Staatsausfall zu vermeiden. Sparpolitik kann jedoch eine Verringerung des Bruttoinlandsprodukts und steigende Arbeitslosigkeit zur Folge haben. Wenn Arbeiter während andauernder Arbeitslosigkeit Humankapital verlieren, führt dies zusätzlich zu einer Verringerung des zukünftigen Produktionspotentials. In diesem Fall bleiben der Regierung weniger Mittel, um ihre Schulden zu bedienen, sodass die Wahrscheinlichkeit eines Staatsausfalls weiter ansteigt. Die Regierung könnte daher in Betracht ziehen, die Kosten der Sparpolitik zu vermeiden und mit Ihren Gläubigern in Verhandlungen um einen Schuldenschnitt einzutreten.

In diesem Kapitel untersuche ich, wie sich der Verlust von Humankapital während Arbeitslosigkeit auf die optimale Fiskalpolitik mit dem Risiko eines Staatsausfalls auswirkt. Zudem betrachte ich die kurz- und langfristigen Folgen von Verhandlungen um einen Schuldenschnitt. Um diese Probleme zu analysieren, verwende ich ein dynamisches stochastisches Staatsschuldenmodell mit endogener Teilnahme an Neuverhandlungen von Schulden, endogen bestimmten Schuldenschnitten, Arbeitsmarktfriktionen und Humankapitalverlust während Arbeitslosigkeit. Das Modell kalibriere ich, sodass die Modellsimulationen statistische Werte von Portugal widerspiegeln. Das Modell impliziert, dass eine gestiegene Intensität des Verlusts von Humankapital während Arbeitslosigkeit die Schuldenaufnahme reduziert und die Prozyklizität der Fiskalpolitik verringert. Dieses Ergebnis entspricht der Beobachtung von Unterschieden in der Zyklizität der Fiskalpolitik zwischen Ländern mit niedrigem und hohem Pro-Kopf-Bruttoinlandsprodukt. Das Modell sagt Schuldenneuverhandlungen in Portugal im Jahre 2011 voraus. In diesem Jahr trat Portugal tatsächlich in ein Bailoutprogramm ein. Relativ zu einer Vergleichsökonomie, in der keine Möglichkeit in Schuldenneuverhandlungen einzutreten besteht, verringern Schuldenschnitte den Anstieg der Arbeitslosigkeit langfristig. Insgesamt zeigt das Kapitel, dass die langfristigen Effekte verzerrender Sparpolitik in bedeutendem Maß auf die Zyklizität der Fiskalpolitik und die Schuldenpolitik der Regierung einwirken. Das Kapitel ergänzt damit die Literatur, die sich mit Fiskalpolitik und Staatsschuldenkrisen befasst (z.B. Cuadra et al., 2010), die aber von den langfristigen negativen Auswirkungen von Sparpolitik auf Arbeitslosigkeit und Produktivität abstrahiert.

Das zweite Kapitel ist in Zusammenarbeit mit Almuth Scholl (Universität Konstanz) entstanden. In diesem Kapitel untersuchen wir den Einfluss von Bailoutprogrammen auf die Wahrscheinlichkeit eines Regierungswechsels sowie die Wahrscheinlichkeit eines Staatsausfalls. Um Zugang zu Krediten von internationalen Finanzinstitutionen zu bekommen, muss ein Land typischerweise Sparpolitik als Teil der Kreditbedingungen umsetzen. Empirische und annekdotische Evidenz deuten jedoch darauf hin, dass Sparpolitik die Wiederwahlwahrscheinlichkeit von Regierungen negativ beeinflusst und es mit erhöhter Wahrscheinlichkeit zu Regierungswechseln kommt. Politische Instabilität wiederum kann das Risiko eines Staatsausfalls erhöhen. Wir untersuchen den Einfluss von Bailouts auf die Wahrscheinlichkeit eines Regierungswechsels und die Wahrscheinlichkeit eines Staatsausfalls anhand eines dynamischen politökonomischen Staatsschuldenmodells mit endogenem Staatsausfallrisiko, endogener Entscheidung über die Teilnahme an einem Bailoutprogramm und endogenen Regierungswechseln. Im Modell konkurrieren zwei Parteien, die die Wohlfahrt der Bevölkerung maximieren möchten, sich aber im exogenen Nutzenverlust infolge eines Staatsausfalls unterscheiden. Regierungswechsel sind das Ergebnis individuellen Wahlverhaltens. Wir wenden das Modell auf Griechenland an. Das Modell impliziert, dass Bailouts die Wahrscheinlichkeit eines Regierungswechsels erhöhen, wodurch sich der Zinsaufschlag für Staatsanleihen wiederum erhöht. Während strengere Bedingungen in Form von zusätzlichen Sparmaßnahmen die Wahrscheinlichkeit eines Regierungswechsels und eines Staatsausfalls kurzfristig erhöhen, können beide Risiken durch zusätzliche Auflagen langfristig reduziert werden. Die Häufigkeit eines Regierungswechsels verläuft U-förmig zur Strenge der Sparauflagen.

Das dritte Kapitel stellt eine Gemeinschaftsarbeit mit Jan Mellert (TU Dortmund) dar. Wir untersuchen die makroökonomischen Auswirkungen von Bailouts mit unterschiedlichen vorgegebenen Zeitplänen für die Rückzahlung der Bailout-Kredite, z.B. unterschiedliche Laufzeiten und Zahlungsfristen. Insbesondere betrachten wir den Einfluss von Bailout-Krediten auf die Laufzeiten von Schulden gegenüber privaten Kreditgebern sowie die Wirkung der Laufzeit der Bailout-Kredite auf das Staatsrisiko.

Wir gehen in zwei Schritten vor. Zunächst betrachten wir empirisch, wie sich Programme des Internationalen Währungsfonds auf die Laufzeit von Bonds um den Zeitraum der Teilnahme an Bailoutprogrammen auswirken. Unsere Ergebnisse zeigen, dass die Laufzeit neu ausgegebener Bonds im Jahr des Eintritts in ein Bailoutprogramm zunimmt und auch in den Folgejahren höher als im Jahr unmittelbar vor dem Bailout bleibt.

In einem zweiten Schritt entwickeln wir ein dynamisches stochastisches Staatsschuldenmodell mit endogenem Staatsausfallrisiko, endogener Teilnahme an Bailoutprogrammen, endogener Bestimmung der Laufzeit von Staatsschulden gegenüber privaten Kreditgebern, sowie Bailoutkrediten mit längeren Laufzeiten. Wir wenden das Modell auf Kolumbien an. Das Modell impliziert, dass Bailouteintritte nach Jahren mit hoher Produktion, ansteigender Verschuldung, ansteigendem Staatsausfallrisiko und abnehmenden Kreditlaufzeiten erfolgen. Im Jahr des Eintritts in ein Hilfsprogramm ersetzt die Regierung einen großen Anteil ihrer Schuldenverpflichtungen durch Hilfskredite. In den Jahren nach dem Bailout kommt es zu einer signifikanten Anzahl an Eintritten in weitere Bailoutprogramme. Die Staatsverschuldung sinkt verglichen mit den Jahren vor dem Bailouteintritt und die gewählte Laufzeit von Staatsschulden steigt an. Im Gleichgewicht nutzt die Regierung Hilfskredite anstelle von langfristigen Schulden um sich gegen zukünftige Einkommensrisiken abzusichern. In der Folge ist die Laufzeit von Schulden gegenüber privaten Kreditgebern geringer als in einem alternativen Modell ohne die Möglichkeit in ein Bailoutprogramm einzutreten. Längere Laufzeiten und Zahlungsfristen für Hilfskredite führen zu häufigerem Eintritt in Bailoutprogramme und höherer Verschuldung. Die Laufzeit von Schulden gegenüber privaten Kreditgebern fällt. Das Kapitel ergänzt die theoretische Literatur über Bailouts, die den Einfluss von Bailouts und Schulden mit sicherer Rückzahlung in einem Modell mit einperiodigen Schulden betrachtet, z.B. Fink und Scholl (2016); Hatchondo et al. (2017); Juessen und Schabert (2013); Roch und Uhlig (2018). Insbesondere erweitern wir die Literatur, die sich mit der Entscheidung über die Laufzeit von Staatsschuldtiteln befasst, aber von der Möglichkeit der Inanspruchnahme von Hilfskrediten abstrahiert (Arellano und Ramanarayanan, 2012; Sánchez et al., 2018; Dvorkin et al., forthcoming).

Summary

This dissertation has been written during my studies in the doctoral program *Quantitative Economics and Finance* at the University of Konstanz. It comprises three independent chapters which focus on the effects of fiscal policy, in particular austerity policies, and the economic dynamics in the context of sovereign debt crises. In the following, I provide a brief outline of each chapter and discuss the main findings and conclusions.

In Chapter 1, I introduce skill loss during unemployment in a quantitative sovereign debt model to study the interactions between persistent unemployment and fiscal policy decisions. A government that faces rising bond interest rates has to implement austerity policies to avoid a default. Austerity, however, may reduce GDP and increase unemployment. If workers lose human capital during unemployment spells, the country's future production potential may be reduced. In such a case, the government has less resources to serve its debt obligations, which may elevate the probability of a default. The government may thus consider debt renegotiations as an alternative to austerity policies.

In this chapter, I study how skill loss during unemployment spells affects optimal fiscal policy in the presence of default risk and the consequences of debt renegotiations in the short run and the long run. I analyze these questions using a dynamic stochastic model of sovereign debt with endogenous participation in debt renegotiations, endogenous recovery rates, matching frictions, and skill loss during unemployment. I calibrate the model to Portugal and find that a higher intensity of human capital depreciation reduces the issuance of debt and weakens the pro-cyclicality of fiscal policy. This finding is in line with differences in fiscal policy cyclicality between countries with low and high gross domestic product (GDP) per capita. The model predicts debt renegotiations in Portugal in 2011, which is the year of the Portuguese bailout program. In comparison with a counterfactual economy in which the possibility to enter debt renegotiations is absent, haircuts mitigate the rise in unemployment persistently. Overall, the chapter shows that the long-term effects of distortionary austerity have a major impact on the cyclicality of fiscal policy and the government's borrowing policy. It thus contributes to the literature on fiscal policy and sovereign debt crises (e.g. Cuadra et al., 2010), which abstracts from the long-term negative effects of austerity on employment and

productivity.

Chapter 2 is joint work with Almuth Scholl (University of Konstanz) and focuses on the impact of bailouts on political turnover and sovereign default risk. Austerity policies are typically part of the conditionality that countries have to fulfill to receive official financial assistance. However, empirical and anecdotal evidence suggests that austerity policies have a negative impact on the reelection probability of a government and increase the probability of a political turnover. Political instability, in turn, may increase the probability of a default. We analyze the impact of bailouts on political turnover and sovereign default risk in a dynamic politico-economic model of sovereign debt with endogenous default risk, endogenous bailout participation and endogenous political turnover. The model features two parties which both care about the population's welfare, but differ in an exogenous utility cost of default. Political turnover is the outcome of the individual voting behavior. We apply the model to Greece and find that bailouts amplify political turnover risk, which, in turn, elevates sovereign interest spreads. While conditionality fosters the probability of political turnover and sovereign default in the short run, it may mitigate political turnover and default risk in the long run. We find that the frequency of political turnover is U-shaped in the strength of conditionality.

Chapter 3 is joint work with Jan Mellert (TU Dortmund). We study the impact of bailouts with different predetermined repayment schedules for official debt, i.e. different maturities and grace periods, on macroeconomic outcomes. In particular, we consider the effect of institutional debt on the maturity of public debt owed to private creditors and how the maturity of institutional debt affects default risk.

We proceed in two steps. First, we consider empirically the impact of programs by the International Monetary Fund (IMF) on bond maturity around episodes of participation in bailout programs. Our results imply that the maturity of new bond issuances increases in the year of bailout entry and remains higher than in the pre-bailout period.

In a second step, we develop a dynamic stochastic model of sovereign debt with endogenous default risk, endogenous bailout participation, endogenous maturity choice on privately held bonds and bailout credits with long maturities. We apply the model to Colombia and find that bailouts are preceded by high output, increasing indebtedness, increasing default risk, and decreasing portfolio maturity. At bailout entry, the government replaces a high share of its debt obligations by official loans. Bailouts are followed by a significant number of follow-up programs, lower debt levels compared to pre-bailout periods and increasing portfolio maturity. In equilibrium, the government uses official debt instead of long-term debt to hedge against future income risk such that the maturity of debt owed to private creditors is lower than in the model in which the option to enter a bailout is absent. Longer maturities and grace periods for official loans increase the bailout frequency and indebtedness. The maturity of privately held debt drops. The chapter contributes to the theoretical literature on bailouts which studies the impact of bailouts and non-defaultable debt on sovereign default risk in a set-up with one period debt, see e.g. Fink and Scholl (2016); Hatchondo et al. (2017); Juessen and Schabert (2013); Roch and Uhlig (2018). Importantly, we extend the literature on the maturity choice of sovereign debt, which abstracts from official financial assistance (Arellano and Ramanarayanan, 2012; Sánchez et al., 2018; Dvorkin et al., forthcoming).

CHAPTER 1

Persistent Unemployment, Sovereign Debt Crises, and the Impact of Haircuts

1.1 Introduction

During the Great Recession, the Southern European countries experienced a strong and persistent increase in unemployment. At the same time, rising spreads on sovereign bonds necessitated the implementation of austerity measures. However, procyclical fiscal policy may have adverse effects on employment, production, and tax revenues and thus elevate debt problems.

Beside the short-run costs from unemployment in form of lower production and higher expenditures on unemployment transfers, long-run effects on the countries' production potential may occur. Empirical evidence suggests that workers' human capital may depreciate during spells of unemployment (e.g. Schmieder et al., 2016), such that an economy with increasing long-term unemployment becomes less productive. Debt renegotiations are an option to avoid the costs of fiscal consolidation.

The experiences of the Southern European countries during the Great Recession give rise to three important questions. How does skill loss during unemployment spells affect optimal fiscal policy in the presence of default risk and what is the impact of such fiscal policy on macroeconomic outcomes? What are the consequences of debt renegotiations on unemployment in the short and long run? Do creditors suffer smaller losses if they agree on haircuts at the beginning of a crisis, enabling the sovereign to avoid the loss of production potential through austerity? To study these questions, this paper develops a dynamic stochastic model of sovereign debt with endogenous haircuts, long-term debt, matching frictions, and skill loss during unemployment.

The model features a small open economy populated by infinitely-lived households and a continuum of identical profit-maximizing firms. Households consist of workers. Employed workers face an exogenous job separation risk. Following Sterk (2016), workers are either high-skilled or low-skilled. If a high-skilled worker does not find a new job in the period of job separation, her human capital depreciates. Low-skilled unemployed workers regain their skills after one period of employment. In each period, firms decide on posting vacancies taking into account the realization of a productivity shock, the job separation rate, the average skills of job seekers, and a tax rate on sales. Matching follows a Cobb-Douglas function and depends on the number of job searchers and the number of vacancies posted.

The government finances public consumption and unemployment transfers by raising sales taxes and issuing external debt. Following Chatterjee and Eyigungor (2012), external debt is long-term and matures probabilistically. Risk-neutral private foreign investors borrow at the risk-free interest rate and provide credit. They have complete information about the current state of the economy and demand a premium which reflects the endogenous risk of renegotiations. The government cannot commit to repay its debt and has the option to enter debt renegotiations, in which case it suffers a one-time utility cost as in Bianchi et al. (2018). In the period of renegotiations, the government is excluded from international financial markets and bargains with the foreign creditors on the total surplus of an agreement. In the following period, the government regains access to foreign credits with reduced debt obligations.

In a quantitative exercise, I apply the model to Portugal. The policy functions imply that the government enters debt renegotiations when employment and exogenous productivity are low and the debt level is high. With lower employment, the share of low-skilled workers increases and the expected lower productivity of job seekers reduces the willingness of firms to hire. It follows that, if debt is low and unemployment increases, the government issues debt and reduces taxes to increase the firms' benefit from hiring. Thus, there is a positive feedback between employment and expansionary fiscal policy. At high debt levels, the government is borrowing constrained and prefers to enter debt renegotiations to avoid the negative impact of austerity on employment.

From an ex ante perspective, a higher intensity of the skill loss during unemployment reduces public debt issuance and the pro-cyclicality of fiscal policy. Instead of entering renegotiations more frequently to reduce taxes, the government finds it optimal to issue less debt such that debt-to-GDP declines. This result is due to a general equilibrium effect. For a given debt and employment level, the probability of renegotiations increases in the intensity of the skill loss. Higher interest spreads would require larger tax hikes to service debt amplifying the procyclicality of fiscal policy. In general equilibrium, however, since interest rates are higher, the government is more borrowing constrained and issues less debt. Lower debt service obligations reduce taxes and dampen tax hikes during economic downturns. Thus, taxes become less procyclical. With increasing skill loss, firms increase job creation and the employment level is generally higher. There are two opposing forces at work. On the one hand, with a higher intensity of the skill loss, the productivity of job seekers is lower and newly hired workers are less productive such that the benefits from hiring decline. On the other hand, firms benefit from preventing skill depreciation of newly displaced workers by posting costly vacancies. The second effect dominates. Related to the model implication of less procyclical taxation in the presence of a higher intensity of the skill loss, cross-country evidence for OECD countries suggests that fiscal policy in economies with higher GDP per capita is less procyclical (c.p. Vegh and Vuletin, 2015).

To study the model dynamics, I run a series of simulations. I find that renegotiations are preceded by periods of increasing unemployment rates and rising debt-to-GDP ratios. Unmployment decreases after a haircut despite high shares of low-skilled job seekers, bad exogenous productivity realizations and high separation rates because the government has more fiscal space to reduce taxes and to improve the firms' benefit from hiring. Due to low tax rates, the government starts accumulating debt again, such that the strong expansionary fiscal policy is short-lived and unemployment temporarily increases again.

I use my model to evaluate what would have been the optimal debt rescheduling decision for Portugal. First, I employ a counterfactual analysis in which I choose a series of productivity shocks such that the unemployment rate from 1996 to 2017 is matched. For this series, I suppose that the government does not reschedule its debt obligations, which I technically implement by assuming high utility costs. Then, I control whether renegotiations would have been optimal under my benchmark specification with lower utility costs. The model predicts that debt renegotiations would have been optimal in 2011 with an immediate unemployment reduction of 0.79 percentage points and a medium-run reduction of up to 3.5 percentage points. If, instead, debt is rescheduled one year later in 2012, unemployment is lowered by 1.11 percentage points immediately, but shows a weaker medium-run decline of up to 3.1 percentage points. However, foreign creditors benefit from later haircuts because the reduction of the remaining debt obligations at the time of renegotiations. The recovery rate increases from 24.97% in 2011 to 26.11% if debt is rescheduled in 2012. Debt renegotiations in 2013 imply an even larger recovery rate of 28.85%.

In a robustness analysis, I consider variations of the sovereign's bargaining power to assess the impact of the outcome of debt renegotiations. A higher bargaining power and thus larger haircuts make the government less reluctant to enter debt renegotiations at low debt levels. Due to the higher probability of debt renegotiations, the government faces higher bonds spreads and therefore accumulates less debt. The long-term average of the unemployment rates decreases in the borrower's bargaining power. On the one hand, lower debt accumulation implies a declining debt service and lower tax rates. On the other hand, more fiscal space allows for stronger tax reductions with a persistent, positive impact on employment. The first effect dominates. Because of the strong effect on the borrowing ability, welfare is higher when the borrower's bargaining power and thus the size of the haircut is low.

Related Literature. The paper builds on three strands of the literature. First, this paper is related to the literature on fiscal policy and sovereign debt crises. Cuadra et al. (2010) rationalize pro-cyclical fiscal policy in a model with endogenous default risk and endogenous fiscal policy. Arellano et al. (2019), de Ferra (2018), and Kaas et al. (2020) study the impact of fiscal policy on firms' access to credits during sovereign debt crises. Bianchi et al. (2019) study the trade-off between unemployment reduction through expansionary fiscal policy and increasing borrowing costs in a two-sector economy with downward-rigid nominal wages and fixed exchange rates. Na et al. (2018) consider the impact of devaluations on unemployment around sovereign defaults. Anzoategui (2017) quantifies the difference in the macroeconomic outcome of Spain during the European sovereign debt crisis when fiscal policy follows estimated pre-crisis rules instead of fiscal consolidation. Balke and Ravn (2016) integrate matching frictions in a sovereign debt model and conclude that procyclical fiscal policy is optimal in normal times, but austerity is optimal during crisis times.[1] All these papers abstract from persistence of unemployment and the transmission of the impact of distortionary fiscal policy to future periods, which is my focus here.[2] Balke (2017) studies the impact of sovereign risk on unemployment via financial intermediaries. She finds that a default is accompanied by peaking unemployment rates since banks cannot provide the financial assistance required by firms to pay wages and vacancies. While her emphasis is on persistent unemployment as a cost of default in the absence of distortionary fiscal policy, unemployment in my model is amplified by fiscal consolidation. Additionally, I provide an endogenous mechanism to explain variations in fiscal policy cyclicality by incorporating skill loss during unemployment.[3]

Second, the paper is related to the literature on skill loss during unemployment. Pissarides (1992) employs an overlapping generations model to show that unemployment can become persistent if unemployed workers lose a part of their human capital. The reason is a reduction in vacancy posting as firms' incentives to hire decrease with the skill level. The lower number of jobs implies an extended unemployment duration.[4] Sterk (2016) uses a quantitative version of the model of Pissarides (1992) to study the occurrence of multiple steady states in labor market dynamics. In a similar set-up, Laureys (2014b) focuses on quantitative effects of hiring externalities. The literature has further considered the influence of skill loss on labor market fluctuations (Lalé, 2018) and the contribution of differences in unemployment history to wage dispersion (Ortego-Marti, 2016). Laureys (2014a), Esteban-Pretel and Faraglia (2010), and Acharya et al. (2018) study the impact of monetary policy in the presence of human capital depreciation. I use a search and matching model with skill loss during unemployment that closely follows Laureys (2014b) and Sterk (2016) to study the optimal

[1] Shi (2018) proposes a similar model, but abstracts from distortions of fiscal policy.

[2] The persistent impact of distortionary fiscal policy during sovereign debt crises has only been studied in the context of the government's ability to raise taxes (Pappadà and Zylberberg, 2019) and regional migration (Gordon and Guerron-Quintana, 2019).

[3] In an alternative approach, Joo (2014) uses news shocks to explain differences in the cyclicality of fiscal policy across countries.

[4] Another strand of the literature builds on Ljungqvist and Sargent (1998, 2008), where longer unemployment durations and bigger skill losses arise from higher unemployment benefits which alter the workers' labor supply decisions.

fiscal policy during sovereign debt crises. Like Laureys (2014b), I restrict to parameterizations for which no multiplicity of steady states occurs.

Third, this paper builds on the literature on sovereign debt renegotiations. Yue (2010) endogenizes debt recovery rates by incorporating Nash bargaining in a sovereign debt model. Further contributions include dynamic bargaining with incomplete informations (Bai and Zhang, 2012), the dependence of recovery rates on the debtor's (Sunder-Plassmann, 2018) and the external creditors's business cycle (Asonuma and Joo, forthcoming), and stochastic bargaining to generate delays in debt renegotiations (Benjamin and Wright, 2013; Bi, 2008). While these papers assume that restructurings follow a default, Asonuma and Trebesch (2016) allow for preemptive restructurings. Hatchondo et al. (2014) study the possibility of voluntary debt exchanges with benefits to debtor and creditor. All these papers use endowment economies. Asonuma and Joo (2019) consider renegotiations in a production economy with productive public capital. I contribute to the literature by studying endogenous haircuts in a production economy with skill loss during unemployment.

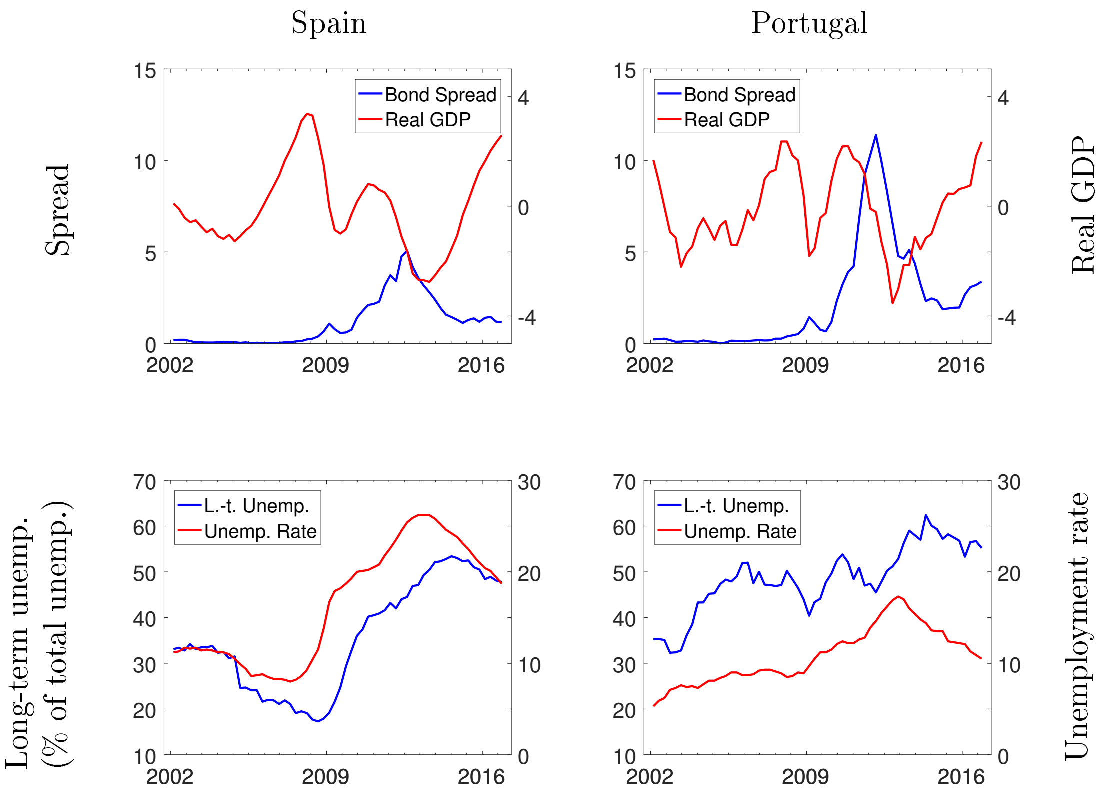
The remainder of the paper is structured as follows. In Section 1.2, I discuss the empirical evidence on unemployment and sovereign default risk in the Southern European countries during the Great Recession. I further review the empirical evidence on labor market dynamics during sovereign debt crises. In Section 1.3, I describe the theoretical model. Section 1.4 presents the quantitative results. Section 1.5 concludes.

1.2 Empirical Evidence on Austerity, Unemployment, and Sovereign Default Risk

During the European Sovereign Debt crisis, several economies faced a large increase in unemployment. Interest rates on bonds increased because of increasing doubts on the countries' ability to serve their debt. Figure 1.1 takes Spain and Portugal as examples and presents in the upper panels the spread between 10-year Spanish (Portuguese) and German government bonds (blue, left axis) and the cycles of HP-filtered real GDP (red, right axis) for the years from 2002 to 2016. The lower panels show the percentage share of long-term unemployed in the total number of unemployed (blue, left axis) and the unemployment rate (red, right axis).

While long-term interest rates before the crisis did not differ across the Euro zone, spreads strongly increased from 2008 to 2012 until the announcement of the Outright Monetary Transactions (OMT) program. Real GDP dropped, accompanied by rising unemployment rates and a lagged increase in long-term unemployment. Unemployment in general and long-term unemployment in particular remained at persistently high

Figure 1.1: Spain and Portugal during the Great Recession

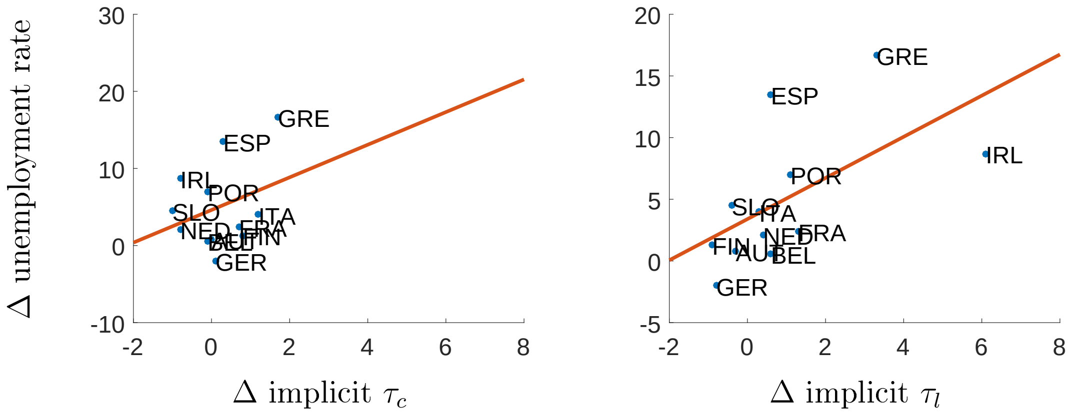


Notes: The upper panels show the spread between the interest rates on 10-year Spanish (Portuguese) and German bonds (blue line, left axis) and the cycles of HP-filtered real GDP (red line, right axis) of Spain (Portugal) from 2002 to 2016 in the left (right) column. The lower panels show the share of long-term unemployed in percent of total unemployment (blue line, left axis) and the unemployment rate (red line, right axis). All data is from Eurostat.

levels and did not return to pre-crisis levels until 2016.

In response to rising bond spreads and a reduction of revenues because of the recession, the Southern European economies implemented strong fiscal consolidation measures. Alesina et al. (2015) construct a narrative data set on fiscal consolidation plans. For Portugal between 2010 and 2013, they find government spending cuts of 0.1% to 0.8% of GDP and revenue increases via tax hikes of 0.4% to 0.6% of GDP per year. The austerity policies, however, had adverse economic effects: Blanchard and Leigh (2013) find that spending cuts and tax hikes caused a further increase of the unemployment rate. In a related study, Vegh and Vuletin (2014) provide empirical evidence suggesting that the increase in unemployment was stronger for countries with a more procyclical fiscal policy. They find that the change in unemployment varied positively with the correlation between GDP and government spending and conclude that countries with more fiscal space before 2008 could respond more actively and reduce the duration and

Figure 1.2: Cyclicality of Fiscal Policy and Change in Unemployment



Notes: The left (right) graph plots the change in the unemployment rate between 2008 and 2012 against the change in the implicit tax rate on consumption τ_c (on labor τ_l) during the same period. The data points refer to 12 Euro area members. All data is from Eurostat. The red lines denote OLS regressions.

the intensity of the crisis.[5] Figure 1.2 shows the correlation between unemployment and tax changes for 12 Euro area members, using data from Eurostat. In particular, I plot the change in the unemployment rate between 2008 and 2012 against the change in the implicit tax rates on consumption and labor during the same period. The red OLS regression lines suggest a positive relationship between taxation and unemployment, which also holds at shorter time horizons. The observations for the European economies are in line with empirical evidence by Agnello et al. (2014) and Ball et al. (2013) for spending- and tax-based consolidations in OECD countries between 1978 and 2009.

Apart from short-run costs related to lower production and higher unemployment, unemployment may also cause a depreciation of human capital. Numerous studies, e.g. Couch and Placzek (2010), find empirical evidence for a negative effect of unemployment on workers' income.[6] Ortego-Marti (2017) finds that wages depend on a person's entire unemployment history. He uses a search and matching model with skill loss during unemployment to explain the observed differences in total factor productivity across OECD countries.

During the European sovereign debt crisis, only Greece renegotiated its debt. In 2012, Greece received a haircut of 100 billion euro on its privately hold debt and was granted official financial assistance in return to the implementation of austerity policies. Despite

[5] Vegh and Vuletin (2014) argue that these results confirm the finding of reduced duration and intensity of crises in Latin American countries with countercyclical fiscal policy, specifically Brazil and Chile after 1998.

[6] E.g. Schmieder et al. (2016) consider German data and find a daily wage reduction of almost 1% per additional month of unemployment duration. For overviews of the findings in the early empirical literature on job displacements, see Fallick (1996) and Kletzer (1998).

the debt reduction, the debt ratio remained above 160% of GDP in 2013. Greek GDP further dropped and unemployment persistently increased.[7] The observations for Greece are in contrast to the experience with emerging economies. Levy Yeyati and Panizza (2011) examine 20 default episodes between 1980 and 2006 and find that in the quarters before defaults unemployment rates remain constant or increase and in the quarters following a default unemployment rates tend to decrease.

1.3 The Model

1.3.1 The Environment

I consider a small open economy inhabited by identical infinitely lived households and a continuum of identical profit-maximizing firms. Households consist of employed and unemployed workers, own the firms, and derive utility from private consumption. Following Sterk (2016) and Laureys (2014b), workers differ in their skills. Skill loss occurs during unemployment. Firms use labor as input and are subject to productivity shocks and matching frictions. In each period, they choose their optimal amount of hiring. The government imposes sales taxes and issues external debt on international financial markets. Debt contracts mature probabilistically as in Chatterjee and Eyigungor (2012), are not enforceable and subject to default risk. In each period, the government can decide to enter debt renegotiations. In renegotiation periods, the government loses access to international financial markets and suffers an exogenous one-time utility cost which depends on the realization of the productivity shock. The utility cost can be interpreted as a loss of reputation to the incumbent.[8] Following Yue (2010), debt renegotiations take the form of one-round Nash bargaining between the policymaker and the international creditors. Renegotations last one period and end with an agreement on the government's debt obligations in the following period.

Workers. At the beginning of each period, a share $n_t \in [0, 1]$ of workers is employed. Employed workers lose their job with exogenous probability ρ_x. I follow Pries (2008) and assume the job separation rate $\rho_{x,t} = \rho_x(z_t) \in [0, 1]$ to be a function of productivity shocks z_t.[9] Following the realization of the productivity shock, firms post vacancies and hire such that unemployed workers find a job with probability $\rho_{f,t} \in [0, 1]$. Workers are heterogenous with respect to their skills and are either high-skilled (H) or low-skilled

[7] C.p. Zettelmeyer et al. (2013) and Eurostat data.

[8] The formulation of the utility cost is similar to Bianchi et al. (2018) where the cost depends on the realization of an endowment shock. Alternative formulations of exogenous utility costs have been considered by Chang (2007), Müller et al. (2019), and Roch and Uhlig (2018).

[9] With constant separation rates, productivity shocks generate too small employment fluctuations in standard matching models with flexible wages.

(L). As in Sterk (2016), high-skilled workers become low-skilled after one period of unemployment. In particular, high-skilled workers lose a fraction ξ of their productivity. Low-skilled workers who find a job become high-skilled in the following period. The share p_t of low-skilled job seekers is

$$p_t = \frac{u_t}{u_t + \rho_{x,t}(1-u_t)}, \tag{1.1}$$

where $u_t = 1 - n_t$ is the fraction of unemployed workers at the beginning of a period before the productivity shock is realized. The denominator denotes the total share of job seekers consisting of previously and newly unemployed workers. I assume employed workers receive skill-dependent wages $w_t^{\{H,L\}}$. Job seekers who cannot find a job obtain transfers $T_t^{\{H,L\}}$ which equal a fixed share Ω of the respective wage $w_t^{\{H,L\}}$, such that newly unemployed workers receive higher payments.

Firms. Production uses labor as input, follows a constant return to scale production technology $f(n_t)$, $f : \mathbb{R}_+ \to \mathbb{R}_+$, and is subject to productivity shocks z_t. I assume that productivity $z_t \in \mathcal{Z}$ has a compact support, $\mathcal{Z} = [\underline{z}, \overline{z}] \subset \mathbb{R}_+$, and follows a Markov process with transition function $\mu(z_{t+1}, z_t)$. Firms pay sales taxes τ_t. After job separation, firms decide on hiring $h_t = n_{t+1} - (1-\rho_{x,t})n_t$, where n_{t+1} is the new optimal employment level. I follow Sterk (2016) and assume that firms cannot observe the skill status of new hires before hiring such that search for new hires is entirely random. However, I assume that firms know the skill level directly after hiring and pay wages w_t^H and w_t^L accordingly. A share p_t of hires is low-skilled with productivity reduced by a fraction ξ. In each period, firms post a number of vacancies v_t at a fixed cost $\kappa > 0$ per unit. When production is linear in labor, firms' per-period profits Π_t are given by

$$\Pi_t = (1-\tau_t)z_t(n_{t+1} - \xi p_t h_t) - (n_{t+1} - p_t h_t)w_t^H - (p_t h_t)w_t^L - \kappa v_t, \tag{1.2}$$

where

$$n_{t+1} = (1-\rho_{x,t})n_t + h_t \tag{1.3}$$

$$h_t = a_t v_t \tag{1.4}$$

$$h_t \geq 0. \tag{1.5}$$

Condition (1.3) is the transition equation of employment. Condition (1.4) defines hiring as the product of the vacancy yield a and vacancy posting. Condition (1.5) is the non-negativity constraint on hiring.

Matching follows a Cobb-Douglas function such that the number of hires is given by

$$h_t = s_t^{\alpha} v_t^{1-\alpha},$$

where $s_t = u_t + \rho_{x,t}(1-u_t)$ denotes the number of job seekers. As in Pissarides (2000), wage setting follows from repeated Nash bargaining on the total surplus of a job and is described in detail in Appendix B.[10] Households receive the firm profits.

Households. The representative household derives utility from private consumption c_t. Let preferences be described by a per-period utility function $u : \mathbb{R}_+ \to \mathbb{R}$, which is continuous, twice differentiable and strictly increasing in c_t, concave in c_t, and satisfies the Inada conditions. The household finances private consumption with profits from firms Π_t, wage income from employed workers and transfers from unemployed workers. A share n_{t+1} of workers is employed and receives a wage $w_t^{\{H,L\}}$, which depends on the skill level of the worker. A share p_t of newly employed workers is low-skilled (L), while all other employed workers are high-skilled (H). Unemployed workers receive transfers $T_t^{\{H,L\}}$. Only newly unemployed workers are high-skilled and receive the higher transfer payment T^H. The household budget constraint is given by

$$c_t = \Pi_t + (n_{t+1} - p_t h_t) w_t^H + (1-p_t)(1-n_{t+1}) T_t^H + p_t h_t w_t^L + p_t(1-n_{t+1}) T_t^L. \quad (1.6)$$

Government. The government has access to incomplete international financial markets. It uses revenues from sales taxes and issuance of non-contingent bonds to finance public consumption g_t and unemployment transfers $T_t^{\{H,L\}}$. I follow Chatterjee and Eyigungor (2012) and assume a bond to mature in the next period with probability δ and otherwise to imply a coupon payment ψ. I assume for simplicity that public consumption does not provide utility and set the size of public consumption to a constant share γ of private consumption such that $\frac{g_t}{c_t} = \gamma$. Let total transfer payments T_t be the sum of transfers to high-skilled and low-skilled unemployed:

$$T_t = (1-p_t)(1-n_{t+1}) T_t^H + p_t(1-n_{t+1}) T_t^L.$$

If the government repays its debt, the government budget constraint reads as

$$g_t + T_t = \tau_t z_t (n_{t+1} - \xi p_t h_t) - q_t(b_{t+1} - (1-\delta) b_t) + (\delta + (1-\delta)\psi) b_t, \quad (1.7)$$

where q_t denotes the unit price of a bond of size b_{t+1} when the government faces

[10] In the set-up with productivity shocks and sales taxes, endogenous wages ensure that the net present value of a firm is non-negative.

the productivity shock z_t and the firms choose the current period employment level n_{t+1}. In the following, similar to Aguiar et al. (2017), I will assume without loss of generality that the coupon payment ψ is equal to the real interest rate r. To prevent the government from choosing maximal debt dilution before renegotiations, I follow Chatterjee and Eyigungor (2015) and restrict new debt issuance to debt levels where the probability of renegotiations in the following period does not exceed an exogenous value $\phi \in (0, 1)$.[11]

If the government decides to enter renegotiations, it suffers an exogenous one-time utility cost $\chi(z_t)$ and is excluded from international financial markets for the rest of the period. The size of the utility cost $\chi(z_t)$ is exogenously determined by the realization of the productivity shock z_t, similar to the cost in Bianchi et al. (2019) and Bianchi et al. (2018) who consider an income utility cost depending on the realization of an endowment shock. The budget constraint reads as

$$g_t + T_t = \tau_t z_t (n_{t+1} - \xi p_t h_t). \tag{1.8}$$

The government regains access to international financial markets in the period after debt renegotiations.

International Creditors. There is a continuum of identical infinitely-lived international creditors. International creditors are risk-neutral and borrow from international markets at the constant risk-free interest rate r. They have perfect information about the state of the economy. International creditors demand a risk premium and internalize the risk of debt renegotiations and the expected return from an agreement.

Timing. The timing is as follows. At the beginning of a period, job separation occurs. The policymaker observes the realization of productivity z_t and chooses its optimal policies. The firms take the public sector policies as given and post vacancies. After hiring, production takes place with initially employed workers and new hires. At the end of the period, separated workers that have not found a job become low-skilled. If the government chooses to enter debt renegotiations at the beginning of the period, there will be an agreement on the new debt level before the firms decide on hiring.

[11] Chatterjee and Eyigungor (2015) refer to the observation of limits on the expected immediate default risk of newly issued bonds in sovereign debt markets. In a similar approach, Hatchondo et al. (2016) impose a lower bound on the bond price.

1.3.2 Recursive Equilibrium

In equilibrium, firms take the government's policy decision as given and maximize the expected discounted life-time profits subject to a non-negativity constraint on hiring. The government maximizes the expected life-time utility of households taking into account the optimal response in firms' decisions.[12] In each period, the government can choose to repay its debt or to enter debt renegotiations, where the government suffers a utility cost. Sovereign debt renegotiations take the form of one-time Nash bargaining between the foreign creditors and the policymaker. Foreign creditors are risk-neutral, borrow or lend from international financial markets at the risk-free interest rate r, have perfect information about the state of the economy, and charge a risk premium. The following subsections describe the optimization problems of the firms and the government, the details of the debt renegotiations, and the zero-profit condition of foreign creditors. The formal definition of the recursive equilibrium is provided in Appendix A.

1.3.2.1 The Private Sector

The firms take the public sector policies as given and maximize their expected discounted life-time profits. I assume that firms discount future profits with the stochastic discount factor of the households. As sales taxes are uniform, the decisions on vacancy posting and hiring are identical for all firms. The optimality condition of the firms is given by:

$$\begin{aligned}&(1-\tau)z(1-\xi p)-(1-p)w^H-pw^L+\lambda\\&+\beta\int_{z'}\frac{u'(c')}{u'(c)}(1-\rho_x(z'))\left((1-\tau')z'\xi p'-p'(w^{H'}-w^{L'})+\frac{\kappa'}{a'}-\lambda'\right)dz'=\frac{\kappa}{a},\end{aligned}\tag{1.9}$$

where λ is the Lagrange multiplier from the non-negativity constraint on hiring. The term on the right-hand side denotes the hiring costs per new hire. On the left-hand side, the term in the first line gives the expected profit from a newly hired worker to the firm in the current period. The term in the second line describes the present discounted expected benefit from having a high-skilled worker in the next period instead of hiring a new potentially low-skilled worker.

[12] Ortigueira (2006) shows that the quantitative results of a Markov equilibrium may change if the public and the private sector choose their policies simultaneously.

1.3.2.2 The Public Sector

In each period, the policymaker chooses between two options:

$$V(z,b,n) = \max\left\{V^R(z,b,n), V^D(z,n)\right\}. \tag{1.10}$$

$V^R(z,b,n)$ denotes the value function of the government in case of debt repayment. $V^D(z,n)$ is the value function in case of sovereign debt renegotiations. The discount factor $\beta \in [0,1]$ is common for all individuals in the economy.
When the government chooses to repay its debt, the value function solves:

$$V^R(z,b,n) = \max_{b',\tau,g}\left\{u(c) + \beta\int_{z'} V(z',b',n')\mu(z',z)dz'\right\} \tag{1.11}$$

subject to

$$\begin{aligned} g + T = \tau z(n' - \xi ph) - q(z,b',n')(b' - (1-\delta)b) + (\delta + (1-\delta)\psi)b \\ c = \Pi + (n' - ph)w^H + phw^L + T \\ \frac{g}{c} = \gamma \\ \eta(z,b',n') \leq \phi \\ p = \frac{1-n}{1-n+\rho_x n} \\ n' = \mathcal{N}(z,\tau,n), h = \mathcal{H}(z,\tau,n)), \end{aligned}$$

where $\eta(z,b',n')$ is the probability of debt renegotiations in the next period. The private sector policies n' and h follow from the optimality condition (1.9).
If the policymaker chooses to enter debt renegotiations, the economy is excluded from international financial markets for the rest of the period and the policymaker suffers a one-time utility cost $\chi(z)$. The government and external creditors bargain to find an agreement on the new debt level $\widetilde{b}$, which is independent from the size of renegotiated debt. The renegotiation mechanism is described in detail in Section 1.3.2.3. In the following period, the government can reenter financial markets and decides on serving the reduced debt stock. The value function associated with debt renegotiations is given by:

$$V^D(z,n) = u(c) - \chi(z) + \beta\int_{z'} V(z',\widetilde{b},n')\mu(z',z)dz' \tag{1.12}$$

subject to

$$\begin{aligned} g + T &= \tau z(n' - \xi ph) \\ c = \Pi + (n' - ph)w^H + phw^L + T \\ \frac{g}{c} = \gamma \\ p = \frac{1-n}{1-n+\rho_x n} \\ n' = \mathcal{N}(z,\tau,n), h = \mathcal{H}(z,\tau,n). \end{aligned}$$

The following indicator function describes the government's choice on entering debt renegotiations:

$$d(z,b,n) = \begin{cases} 1 & \text{if } V^R(z,b,n) < V^D(z,n) \\ 0 & \text{else.} \end{cases}$$

The set of productivity shocks $z \in \mathcal{R}_z$ for which the government enters debt renegotiations is given by:

$$\mathcal{D}(b,n) = \{z \in \mathcal{R}_z : d(z,b,n) = 1\}. \tag{1.13}$$

The probability of debt renegotiations reads as

$$\eta(z,b',n') = \int_{\mathcal{D}'(b',n')} \mu(z',z)dz'. \tag{1.14}$$

1.3.2.3 Debt Renegotiations

As in Yue (2010), debt renegotiations follow a generalized Nash bargaining game, in which an agreement implies a new debt level $\widetilde{b}$. The value of the agreement to the government is given by $V^D(z,n)$. The creditors receive the present value of the reduced debt in terms of expectations $q(z,\widetilde{b},n')\widetilde{b}$. The government's outside option to an agreement is permanent autarky, while external creditors would lose their investment. The expected continuation value of autarky reads as

$$V^A(z,n) = u(c) + \beta \int_{z'} V^A(z',n')\mu(z',z)dz',$$

where

$$\begin{aligned} g + T &= \tau z(n' - \xi ph) \\ c &= \Pi + (n' - ph)w^H + phw^L + T \\ \frac{g}{c} &= \gamma \\ p &= \frac{1-n}{1-n+\rho_x n} \\ n' &= \mathcal{N}(z,\tau,n), h = \mathcal{H}(z,\tau,n). \end{aligned}$$

The borrower's bargaining surplus is given by

$$\Delta_B(z,\widetilde{b},n) = V^D(z,n) - V^A(z,n),$$

where $V^D(z,n)$ changes with the debt level $\widetilde{b}$, see Equation (1.12).
The bargaining surplus of the international creditors reads as

$$\Delta_L(z,\widetilde{b},n) = q(z,\widetilde{b},n')\widetilde{b}.$$

Let θ denote the borrower's bargaining power. The bargaining problem[13] solves

$$\widetilde{b} = \underset{b}{\operatorname{argmax}} \left[\left(\Delta^B(z,b,n)\right)^{\theta} \left(\Delta^L(z,b,n)\right)^{1-\theta} \right] \tag{1.15}$$

subject to

$$\begin{aligned} \Delta^B(z,b,n) &\geq 0, \\ \Delta^L(z,b,n) &\geq 0. \end{aligned}$$

The recovery rate is given by the ratio of the debt stocks before and after the renegotiations $\frac{\widetilde{b}}{b}$.

1.3.2.4 International Creditors

International creditors are risk-neutral and internalize the risk of debt renegotiations and the expected return from an agreement. The bond price follows from the zero-profit

[13] For computational reasons, I deviate from Yue (2010) and omit the restriction on the new debt level such that recovery rates can exceed one, similar to Chatterjee and Eyigungor (2015) and Sunder-Plassmann (2018). The change only affects states in which the government would not enter renegotiations.

condition:

$$q(z,b',n') = \frac{1}{1+r}\int_{z'} (1-d(z',b',n')\left(\delta+(1-\delta)(\psi+q(z',b'',n'')\right)\mu(z',z)dz' \tag{1.16}$$
$$+\frac{1}{1+r}\int_{z'} d(z',b',n')\frac{\widetilde{b}'}{b'}q(z',\widetilde{b}',n'')\mu(z',z)dz'.$$

The spread is the difference between the internal rate of return $i(z,b',n')$ and the risk-free rate r, where i follows from $q(z,b',n') = (\delta+(1-\delta)\psi)/(\delta+i(z,b',n'))$. The bond price lies in the interval $[0, (\delta+(1-\delta)\psi)/(\delta+r)]$.

1.4 Quantitative Analysis

1.4.1 Calibration

For the quantitative analysis, I calibrate the model to Portugal for the time period from 1995 to 2017. A period in the model corresponds to a year. The annual calibration implies that a low-skilled worker has been unemployed for at least one year and can be considered as long-term unemployed. Kroft et al. (2013) provide empirical evidence for the U.S. which suggests that the probability of receiving an interview call-back is decreasing in unemployment duration, where most of the decline occurs within the first eight months of unemployment. Thus, it seems reasonable to assume that most of the human capital depreciation occurs during the first year after job loss. Table 1.1 summarizes the parameter values. I employ seasonally adjusted annual series for real GDP, real private consumption, real government consumption, the unemployment rate and the long-term interest rates of Portugal and Germany which are taken from Eurostat. For external debt statistics, I rely on OECD data.
I assume that the per-period utility of households is specified by the following constant relative risk-aversion (CRRA) utility function

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma},$$

where σ is the relative risk aversion. I set σ to 2, which is a standard value in the literature. The annual risk-free interest rate r of 4.2 percent corresponds to the average German 10Y-bond yield.

Following Cuadra et al. (2010), I assume that production is linear in labor, $f(n) = n$. Productivity shocks follow an AR(1) process:

$$\ln(z') = \rho_z \ln(z) + \epsilon,$$

Table 1.1: Calibration

	Parameter	Value	Empirical Target
r	Risk-free rate	0.042	Mean German 10-Y bond rate
σ	Relative risk aversion	2.0	Standard value
β	Discount factor	0.88	Mean external debt to GDP
γ	Public good weight	0.32	Mean of g/c
Λ_0	Utility cost (intercept)	0.88	Mean spread
Λ_1	Utility cost (slope)	7.3	$\|\Delta s\|$ 90% quantile[1]
θ	Borrower's bargaining power	0.44	Market value of renegotiated debt 23%
δ	Maturing probility	0.16	Mean residual maturity
α	Matching function elasticity	0.50	Petrongolo and Pissarides (2001)
ω	Workers' bargaining power	0.50	Laureys (2014a)
Ω	Size of transfers	0.50	Replacement rate 50%
ξ	Skill cost	0.48	$\|\Delta u\|$ 90% quantile[2]
κ	Vacancy cost	2.9	Mean unemployment rate
$\overline{\rho_x}$	Mean job separation rate	0.095	Mean short-term unemployment rate
σ_x	Separation rate sensitivity	9.8	Std. $u_{\text{long-term}}/u$
ρ	Productivity	0.85	Autocorrelation of real GDP
σ_ϵ	Standard deviation of ϵ	0.0112	Standard deviation of real GDP

[1] $|\Delta s| = |s - s_{-1}|$ denotes the absolute change in the bond spread.
[2] $|\Delta u| = |u' - u|$ denotes the absolute change in the unemployment rate.

where ϵ is i.i.d. $N(0, \sigma_\epsilon^2)$. The values for the parameters ρ_z and σ_ϵ are set to match the autocorrelation and standard deviation of the log-quadratically detrended annual Portuguese real GDP series between 1995 and 2017.

For simplicity, similar to Pries (2008), I assume the job separation rate ρ_x to be negatively correlated with the productivity shock z. In particular, I choose the following relationship which ensures that the job separation rate is always non-negative:

$$\rho_x = \overline{\rho_x} \exp(-\sigma_x \ln(z)),$$

where $\overline{\rho_x}$ is a constant around which the separation rate fluctuates. σ_x is a parameter for the sensitivity of the job separation rate to productivity z. I set $\overline{\rho_x}$ and σ_x to match the mean of the short-term unemployment rate and the standard deviation of the percentage share of long-term unemployed on total unemployment in Portugal.

In my model, the ratio of government consumption over private consumption is fixed. I set the parameter γ to 0.32, which corresponds to the empirical mean ratio of government to private consumption.[14] I follow Bianchi et al. (2018) and assume the utility

[14] For the time period from 1995 to 2017, this ratio has a standard deviation of 0.90% and fluctuates between 30.59% and 33.65%.

cost[15] to be specified by

$$\chi(z) = \max\{0, \Lambda_0 + \Lambda_1 \log(z)\}.$$

The slope Λ_0 is set to match the mean spread. In the data, the spreads are close to zero for a large share of periods and exhibit spikes after sequences of increasing default risk. In the model, spreads are permanently substantially larger than zero because the government has a low discount factor and chooses large debt levels. Thus, the spikes cannot be reproduced without triggering debt renegotiations and the spreads are less volatile. Given that the model is not able to replicate the volatility of the spread observed for Portugal, the intercept Λ_1 targets the 90%-quantile of the absolute change of the spread $|\Delta s| = |s - s_{-1}|$. With respect to the short length of the time series, I choose the 90%-quantile to ensure that the calibration does not target potential outliers. Portugal has not renegotiated its debt obligations over the past 100 years. I set the bargaining power of the borrower in debt renegotiations θ to match the market value of outstanding debt during debt renegotiations of 23%. This value corresponds to Greece in 2012 (Zettelmeyer et al., 2013), which has been the only case of a default on external debt during the European sovereign debt crisis. The analysis of Section 1.4.7 includes the results for alternative values of the bargaining power. The discount factor β is set to match the average external debt-to-GDP ratio of 50.18%. The value of the maturing probability δ corresponds to an average residual maturity of 6.3 years.[16] The upper limit on the renegotiation probability of new debt issuance ϕ is set to 75%. The numerical results are robust for values between 60% and 99%.

The matching function elasticity α is set to 0.5, which is in the range of estimates reported by Petrongolo and Pissarides (2001).[17] I follow standard practices and set the bargaining power of workers ω to the same value, which ensures that the congestion externality, which follows from the search frictions, is internalized when all job seekers find a match with the same probability (Laureys, 2014b). The Portuguese unemployment insurance system features a gross replacement rate of 65% and a net replacement rate of more than 90% (Esser et al., 2013). However, for 2011, Matsaganis et al. (2014) report shares of benefit recipients of only 37.4% on workers that are unemployed for 3 to 5 months as well as 42.9% and 23.2% for those with an unemployment duration of 6 to 11 months and more than 11 months, respectively. To take account of these factors,

[15]In Bianchi et al. (2018) the cost depends on the realization of an endowment. I slightly deviate from this specification in considering a production economy such that the utility cost depends on productivity.

[16]This value is based on monthly data from the Portuguese national statistics office for the time span from December 2000 to December 2017.

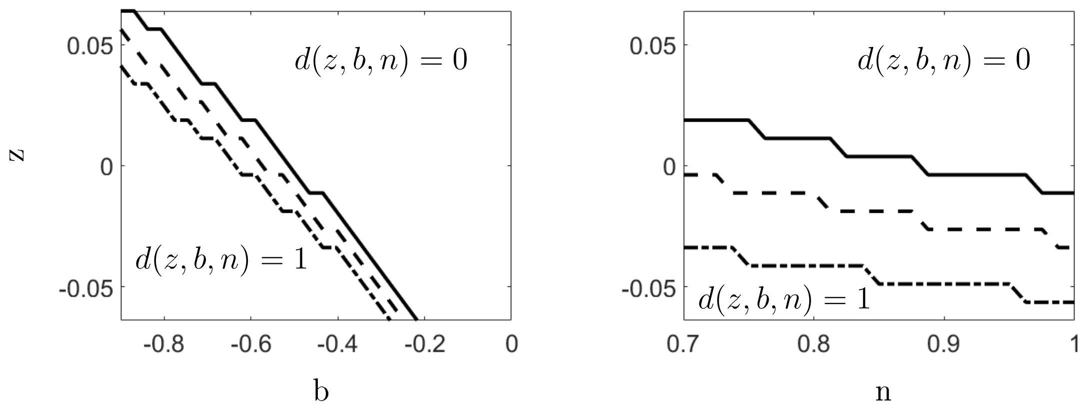
[17]This value ensures that there are no multiple steady states, see e.g. Pissarides (1992). Sterk (2016) studies multiple steady states using a calibration with $\alpha > 0.5$.

I set the size of transfers in terms of wages Ω to 0.5 and provide a robustness analysis on this parameter in section 1.4.8. The vacancy cost κ is set to match the empirical mean unemployment rate. The empirical target for the skill cost parameter ξ is the 90%-quantile of the absolute change in the unemployment rate $|\Delta u| = |u' - u|$.

1.4.2 Policy Functions

I first consider the optimal decision on entering debt renegotiations. The left panel of Figure 1.3 presents the combinations of productivity shocks z and debt levels b for which the government enters debt renegotiations. The solid line refers to an employment level n of 80%. The dashed (dashed-dotted) line shows the combinations for an employment level of 90% (100%). The right panel presents the optimal decision for combinations of productivity shocks z and employment n. The solid, dashed and dashed-dotted lines represent the choice for a high (-0.56), medium (-0.43), and low debt level (-0.31). In the areas to the left of the lines, the government enters debt renegotiations. Repayment is optimal for states to the right of the lines. The panels reveal that renegotiations are optimal when the realization of the productivity shock is low, debt is high, and employment is low.

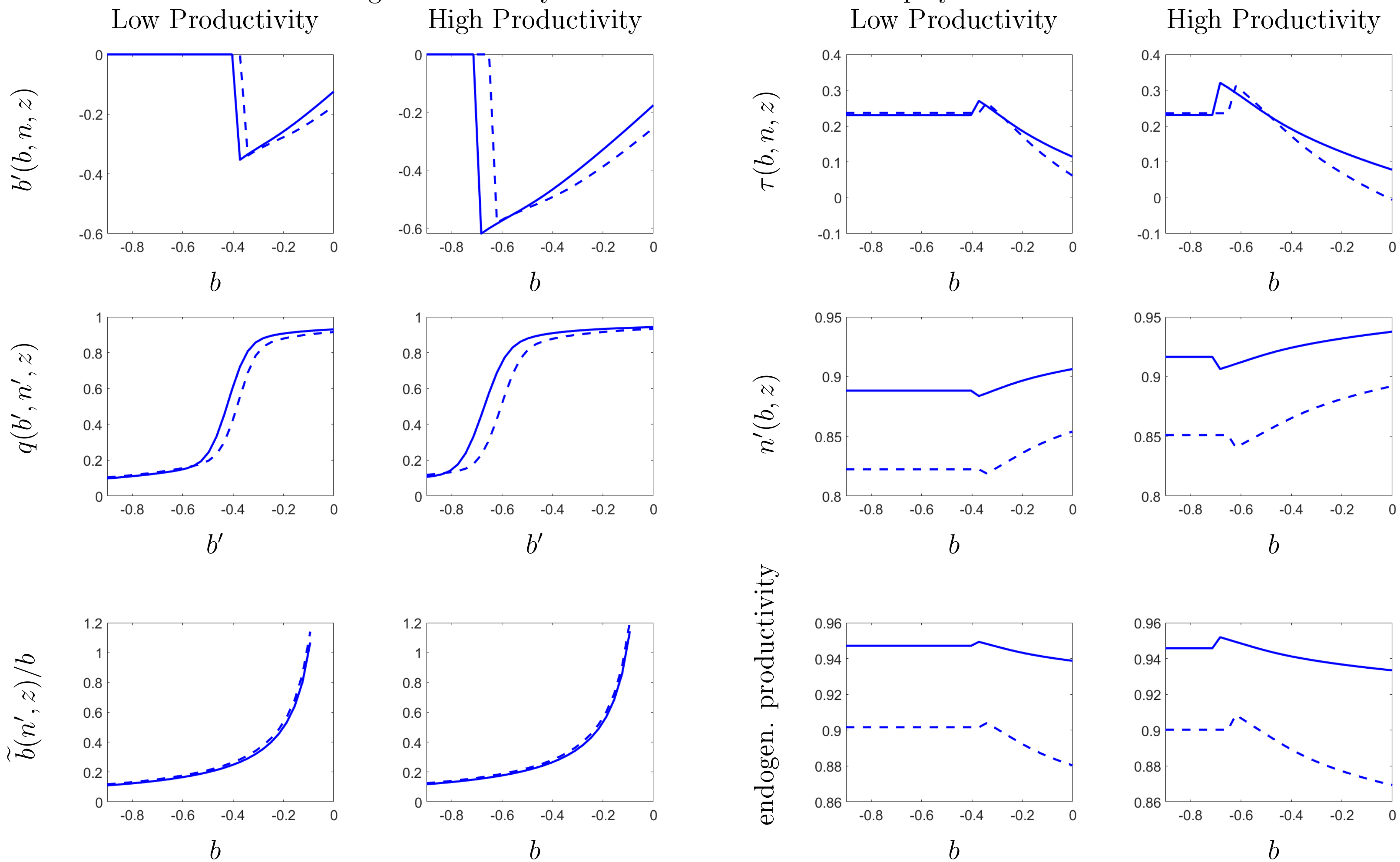
Figure 1.3: Renegotiation Decision



Notes: The left (right) panel shows the combinations for the productivity shock z and debt b (employment n) for which the government just prefers to enter debt renegotiations. Right of the lines, the government prefers to serve its debt obligations. The lines in the left panel refer to an initial employment level of 80% (solid), 90% (dashed), and 100% (dashed-dotted). The lines in the right panel refer to initial debt of -0.56 (solid), -0.43 (dashed), and -0.31 (dashed-dotted).

Figure 1.4 presents the borrowing decisions, the bond price functions, the recovery rates, the tax policies, the employment decisions, and endogenous productivity for employment levels of 90% (solid lines) and 80% (dashed lines) as functions of the debt level. Endogenous productivity refers to the share of employed workers who are high-skilled. The first and third (second and fourth) column refer to productivity realizations

Figure 1.4: Policy Functions - Fixed Initial Employment Level



Notes: The solid (dashed) lines represent the debt policies $b'(b, n, z)$, the bond prices $q(b', n', z)$, the recovery rates $\widetilde{b}(n', z)/b$, the tax policies $\tau(b, n, z)$, and the employment policies $n'(b, n, z)$ at different debt levels b for an employment level n of 90% (80%). Endogenous productivity denotes the share of employed workers who are high-skilled. In the first and third column, productivity is 2.6% below the trend. High productivity refers to a level 2.6% above the trend.

2.6% below (above) the trend. The panels reveal that the bond price is decreasing in the debt level and increasing in exogenous productivity z. For small debt levels, the government never finds it optimal to enter renegotiations such that the bond price converges towards the risk-free bond price. With increasing debt, the government has more incentives to dilute debt in the future and the probability of debt renegotiations increases. For high debt levels, the government always enters renegotiations and the bond price equals the expected bond price at the bargained debt level weighted with the debt recovery rate. Since the outcome of bargaining $\widetilde{b}$ is independent from the initial debt level b by assumption, the recovery rate $\frac{\widetilde{b}}{b}$ decreases in the debt level.[18]

For a lower level of employment, the government faces lower bond prices. Lower employment implies a smaller tax base, higher expenditures for unemployment transfers, and a lower expected skill level of new hires such that the government is less reluctant to enter debt renegotiations. The recovery rates are marginally increasing with higher unemployment. The underlying reason is the increased benefit from access to financial markets in form of the ability to set lower tax rates and thus to improve hiring incentives.

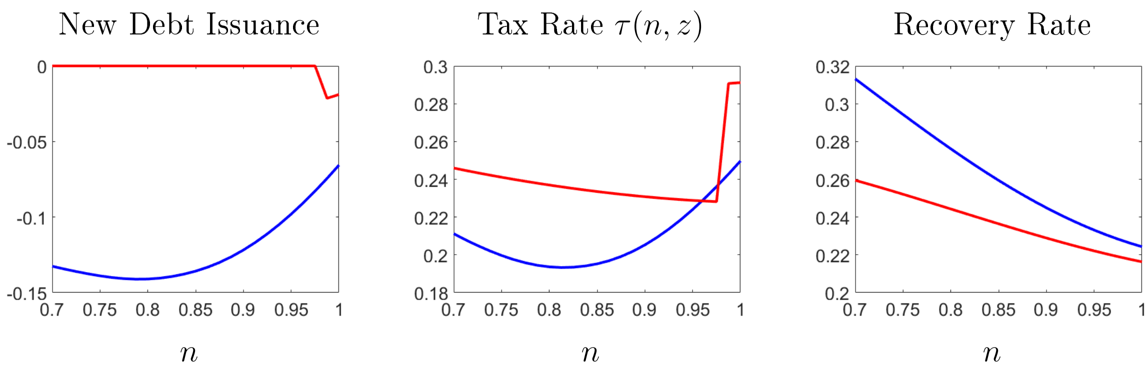
The third and fourth column of Figure 1.4 present the tax policies, the employment decisions, and endogenous productivity. With increasing debt, the government has to impose higher sales taxes to pay the interest rates on its debt obligations. The higher tax rates reduce the firms' benefit from hiring and the employment level decreases. Lower hiring implies a lower inflow of low-skilled workers such that the share of employed workers who are high-skilled increases. The employment level is increasing in initial employment and exogenous productivity z. The net change in employment decreases in the initial employment level because of increasing hiring costs per worker. Endogenous productivity is higher for low productivity shocks because lower hiring reduces the inflow of low-skilled workers and higher job separation rates increase the share of high-skilled job seekers and thus the share of high-skilled new hires.

When debt is low, the tax rate is increasing in the employment level. There are two underlying channels. First, higher taxes have a negative effect on the firms' hiring incentives. As a reduction in unemployment implies higher production and a higher skill level of newly hired workers in the future, the government has an incentive to set lower tax rates when unemployment is high. The government can reduce the taxes and improve hiring incentives by higher debt issuance. Second, when employment is low, firms have higher expenditures for vacancy posting. It follows that firm profits drop

[18] While the assumption of independence of initial debt is common to models with one-round bargaining, Cruces and Trebesch (2013) find that a higher debt-to-GDP ratio may imply longer durations of renegotiations. Benjamin and Wright (2013) provide evidence on the relation between renegotiation outcome and duration.

and private consumption declines overproportionally compared to the change in firms' output. Thus, the government needs a smaller share of total production to finance the public good which is proportional in size to private consumption.[19] The reduction in public consumption dominates increasing transfer payments. When debt is high, the government is more borrowing constrained such that the tax rate increases with higher unemployment rates. Additionally, higher debt service in the presence of lower employment necessitates a larger increase in sales taxes. It follows that high debt has a quantitatively smaller negative effect on the employment level when initial employment is high.

Figure 1.5: Policy Functions - Fixed Initial Debt Level



Notes: The graphs show the amount of new debt issuance, the tax policies, and the recovery rates at different employment levels n for a debt level of -0.43, which is close to the mean in simulations. Blue (red) lines refer to exogenous productivity 2.6% above (below) the trend. New debt issuance is defined as $b' - (1 - \delta)b$ in repayment and 0 if the government enters debt renegotiations.

Figure 1.5 shows the amount of new debt issuance, the tax policies, and the recovery rate at different employment levels n for a debt level of -0.43, which is close to the mean in the simulations of Section 1.4.3. New debt issuance is given by $b' - (1 - \delta)b$ if the government repays its debt and equals zero if the government enters debt renegotiations. Blue and red lines refer to exogenous productivity 2.6% above and below the trend, respectively. The government enters debt renegotiations when exogenous productivity is low, unless initial employment is very high, and repays its debt obligation when exogenous productivity is high (c.p. the dashed line in the right panel of Figure 1.3). During renegotiations, the government is excluded from international financial markets and has to impose higher tax rates at lower employment levels to finance rising unemployment benefits. When productivity is high, borrowing and tax rates are U-shaped in initial employment. At high employment levels, the government can react to an increase in unemployment with extended borrowing and tax cuts to increase the firms' benefits from additional hiring. When employment is low, the gov-

[19] Assuming a constant government spending would extinguish this channel. However, tax rates would have to strongly increase in unemployment.

ernment has to make higher total unemployment transfer payments and is more budget constrained such that it issues less new debt and has to set higher tax rates. Tax rates for high exogenous productivity exceed tax rates for low exogenous productivity at high employment levels if the government enters renegotiations for the worse productivity realization. The reason is that new debt issuance is lower than the amount of matured debt, which is about -0.07. High productivity also implies less job separation such that the hiring costs per worker are higher and firms post less vacancies. Firm profits are higher because of lower vacancy costs and private consumption increases. It follows that the share of total resources allocated to the proportional amount of public spending increases.

The increase of the recovery rate in unemployment is smaller when exogenous productivity is low. Since exogenous shocks are persistent and job separation is high, a large share of hiring is lost when productivity is low in the periods following a haircut. Thus, the employment increase after a haircut is short-lived which reduces the impact of initial employment on the recovery rate.

1.4.3 Cyclical Properties

In this section, I compare the cyclical properties of the Portuguese economy with the statistics from simulations of the model. The first column of Table 1.2 summarizes the statistics from the Portuguese data. I consider log-quadratically detrended series for the time period from 1995 to 2017. In column (2), I report the cyclical properties of the model simulations for the benchmark calibration. Out of a simulation of 500 000 years where the first 100 observations are discarded, I consider episodes of at least 23 periods without renegotiations, preceded by at least four periods of good credit standing.

Overall, the model describes the properties of the Portuguese economy well. In line with the sovereign debt literature, e.g. Arellano (2008) and Cuadra et al. (2010), private consumption is more volatile than output, sovereign bond yields are countercyclical and fiscal policy is pro-cyclical, in particular tax rates and output are negatively correlated. The behavior of fiscal policy corresponds to Vegh and Vuletin (2015) who find that Portugal belongs to the industrial countries with the most procyclical fiscal policy and is similar to emerging economies in terms of tax policy cyclicality. The mean and the 90%-quantile of absolute changes of the spread are close to the data. The model, however, does not match the distribution of spreads, especially the large number of spreads close to zero, such that the volatility is too low.[20]

Targeted statistics on the labor market are well matched, but the volatility of unem-

[20] Bocola et al. (2019) are able to generate higher shares of spreads close to zero by the introduction of domestic government debt.

ployment is too low. In line with the data, the model produces a larger autocorrelation for unemployment than for output.

1.4.4 The Dynamics of Unemployment and Sovereign Debt Renegotiations

In this section, I employ an event analysis to study the dynamics of unemployment and sovereign debt renegotiations. Out of the model simulations of 500 000 years, I consider episodes in which the government enters debt renegotiations at $t = 0$. Similar to the procedure for the simulation statistics, I restrict to renegotiations which have been preceded by at least 27 periods of good credit standing. Figure 1.6 shows the dynamics around renegotiations at $t = 0$, denoted by the grey bars. Productivity, output, and private consumptions are presented as percentage deviations from a log-linear trend, which I apply to the complete series.[21] The tax rate, initial debt-to-GDP, unemployment, the sovereign spread and the probability of renegotiations are denoted in percent. Endogenous productivity is the percentage share of high-skilled employed workers. The panels show the variables 4 years before and 12 years after the event at $t = 0$. The solid lines refer to the benchmark model.

Renegotiations are preceded by a drop in exogenous productivity and output as well as periods of increasing unemployment and high debt-to-GDP ratios. Simultaneously, the tax rates and the spread increase, reflecting an increased probability of debt renegotiations. While higher tax rates dampen hiring, firms still post more vacancies because of increased returns following from the increase in the number of job seekers in response to higher separation rates. The inflow of low-skilled workers prevents an increase in the share of high-skilled unemployed workers. In the period of renegotiations, the government can reduce the tax rates since it does not serve the coupon payments and the maturing debt. There is a haircut such that the debt-to-GDP ratio drops. In the year after the haircut, the government reenters international financial markets and uses new borrowing for tax cuts. The lower tax burden and increasing productivity improve the firms' hiring incentives such that the unemployment rate declines. Since unemployment is high in the previous period, the productivity of job seekers is low such that increased hiring is followed by a decline in endogenous productivity. The drop in unemployment is in line with the findings of Levy Yeyati and Panizza (2011) for sovereign defaults in emerging economies. In response to increasing output, private consumption peaks.

The decrease in the tax rate, however, is short-lived. Since the debt level rises again,

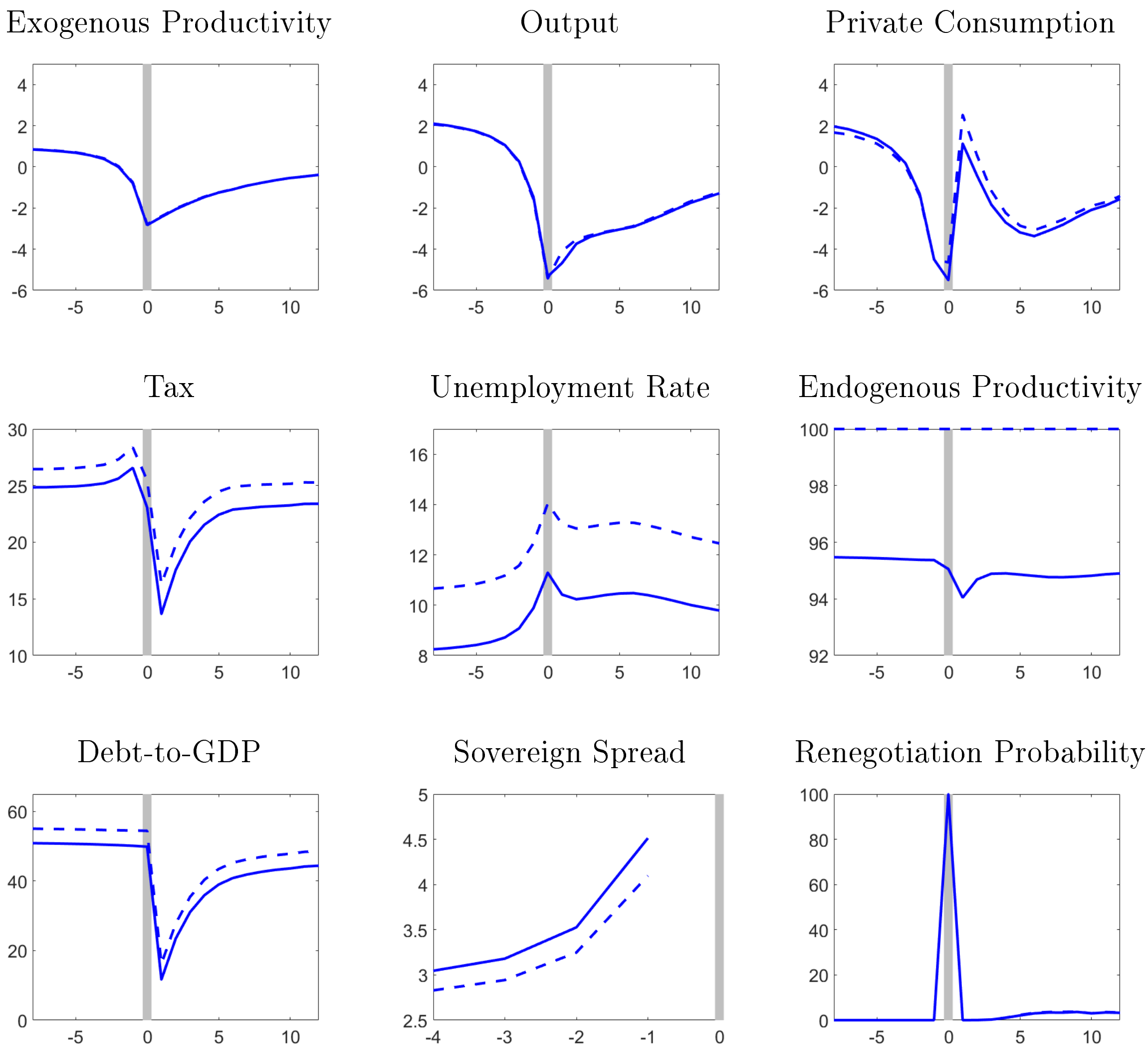
[21] I deviate from the procedure for the business cycle statistics because, for the complete series, the system is underdetermined in case of log-quadratic detrending. I use the complete series instead of short episodes to abstract from distortions on detrending around renegotiation episodes.

Table 1.2: Business Cycle Statistics

	Data	Model Simulations						
	(1)	(2) Benchmark	(3) $\xi = 0$	(4) $\xi = 0.25$	(5) $\xi = 0.75$	(6) $\theta = 0$	(7) $\theta = 0.5$	(8) $\theta = 1$
$\sigma(y)$	2.81	2.89	2.91	2.89	2.90	2.73	2.90	2.98
$\sigma(c)/\sigma(y)$	1.11	1.72	1.65	1.68	1.76	1.79	1.72	1.69
$\sigma(s)$	2.62	1.22	1.09	1.15	1.30	0.95	1.26	1.54
$\sigma(u)$	3.71	1.85	2.09	1.97	1.72	1.70	1.86	1.92
$\rho(c, y)$	0.95	0.96	0.96	0.96	0.95	0.95	0.95	0.96
$\rho(\tau, y)$	–	−0.37	−0.51	−0.44	−0.29	−0.39	−0.37	−0.36
$\rho(s, y)$	−0.52	−0.66	−0.70	−0.68	−0.63	−0.68	−0.66	−0.64
$\rho(y, y')$	0.71	0.73	0.69	0.72	0.75	0.72	0.74	0.74
$\rho(u, u')$	0.93	0.87	0.88	0.87	0.87	0.87	0.87	0.88
$E(s)$	2.55	2.90	2.70	2.80	3.02	2.29	2.98	3.50
$E(b'/y)$	50.18	49.63	53.86	51.66	47.33	64.95	48.37	39.79
$\lvert\Delta s\rvert$ 90% quantile	2.69	2.14	1.90	2.02	2.27	1.61	2.21	2.74
$E(u)$	8.67	8.62	11.08	9.73	7.42	8.82	8.61	8.58
$E(u_{\text{short-term}})$	4.34	4.25	4.72	4.48	3.94	4.30	4.24	4.23
$E(u_{\text{long-term}})$	4.33	4.37	6.36	5.25	3.48	4.52	4.36	4.34
$\sigma(u_{\text{long-term}}/u)$	6.86	6.80	6.19	6.52	7.08	6.29	6.83	6.99
$\lvert\Delta u\rvert$ 90% quantile	1.54	1.42	1.58	1.50	1.32	1.34	1.42	1.44
Market value of reneg. debt	23.10	23.10	29.54	26.14	19.79	44.56	20.50	0
Reneg. Prob.	–	3.13	3.23	3.17	3.10	3.68	3.08	2.78
Welfare equivalent (in %)	–	0.63	–	–	–	1.63	0.54	–

Notes: Column (1) is based on annual Eurostat data for Portugal and considers the time period from 1995 to 2017. y and c denote real output and real private consumption, respectively. y and c are log-quadratically detrended. s denotes the sovereign spread, calculated as the difference between the interest rates on Portuguese and German 10-year bonds. u refers to the unemployment rate. Shares and probabilities are given in %. Column (2) and (3) are based on simulations of 500 000 years, where I omit the first 100 observations. I refer to episodes of at least 23 years without renegotiations, which are preceded by at least 4 years without renegotiations. Column (2) reports the statistics for the benchmark model, columns (3) to (5) and (6) to (8) consider variations of the skill loss parameter ξ and the bargaining power θ, respectively. Renegotiation probabilities and welfare equivalents refer to the complete series of 499 900 years.

Figure 1.6: Event Analysis



Notes: The solid (dashed) lines present the statistics for episodes out of a model simulation of 500 000 years of the benchmark model (the model without skill loss), where the first 100 are omitted. I consider sovereign debt renegotiations which have been preceded by at least 27 years of repayment. The grey bars represent the event period. Productivity, output and private consumption are shown as precentage deviations from a log-linear trend. The tax rate, debt to GDP, unemployment, the sovereign spread and the probability of renegotiations are denoted in percent. Endogenous productivity denotes the percentage share of high-skilled employed workers. The panels show the variables 4 years before and 12 years after the event at $t = 0$.

the government has to increase taxes. As productivity has not yet fully recovered, the separation rate is still high. High separation rates and increasing taxes have a negative effect on hiring incentives such that the unemployment rate increases again in the medium run. Private consumption drops. In the long run, on average, productivity returns to the trend. Since the separation rate becomes lower, the unemployment rate falls and converges to its pre-crisis level. In a minor share of episodes, starting in the third period after the renegotiations, the government chooses to bargain on the remaining debt again.

1.4.5 The Impact of the Human Capital Depreciation

The intensity of human capital depreciation determines the level of employment and the response of fiscal policy on cyclical fluctuations. The degree of skill loss is implied by the difference in skills between high-skilled and low-skilled workers. Figure 1.7 shows the policy functions for two different values of the skill loss parameter ξ, given an employment level of 90%. The solid lines refer to the benchmark model with $\xi = 0.48$. The dashed lines present policy functions for the benchmark model without skill depreciation $\xi = 0$. When human capital depreciates during unemployment spells, the share of low-skilled workers is higher and, for identical initial states, the economy has less resources to serve its debt obligations. The benefits from entering debt renegotiations and avoiding higher tax rates to prevent higher employment losses are larger because the loss of productivity in the following periods can be avoided. Thus, the government is less reluctant to enter debt renegotiations and faces lower bond prices. Since lower bond prices imply a lower debt market value at any given debt level, the debt level after renegotiations is reduced and the debt recovery rate is lower.

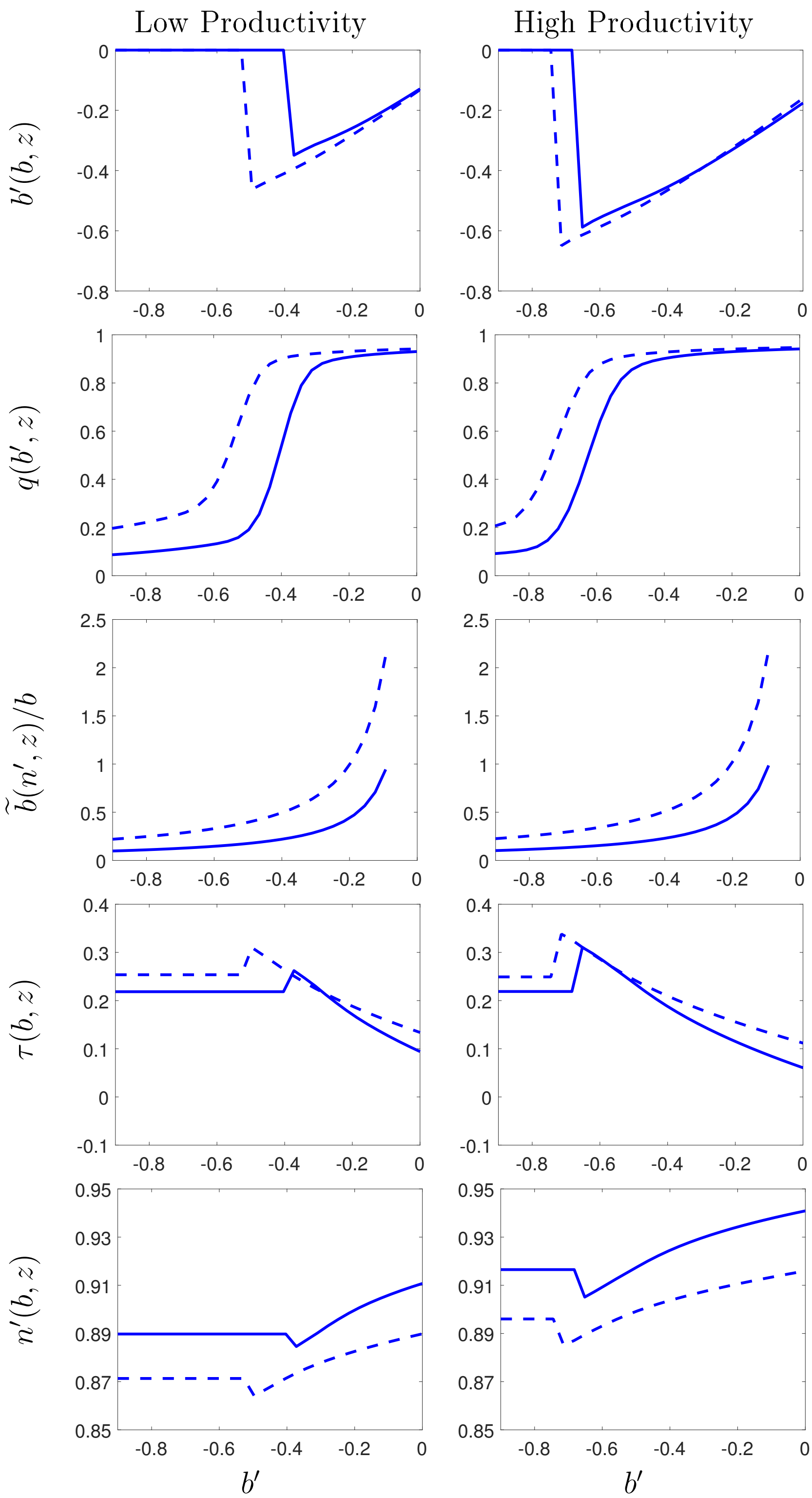
The firms' decision on employment is affected by two opposing forces. First, as skill loss occurs, the productivity of newly hired workers is lower which reduces the benefits from hiring. On the other hand, there are incentives for hiring to prevent skill depreciation of newly displaced workers. The second effect dominates such that firms increase their vacancy posting expenditures and the employment level is higher for any considered initial state of the economy. Note that this finding is in line with Laureys (2014b).

In the economy with skill loss, the tax rate is lower when bond prices are high and the government is not budget-constrained. Lower tax rates increase the firms' benefits from hiring and thus support higher employment levels. However, taxes are also lower during debt renegotiations when taxes cannot be reduced by debt issuance because higher employment levels imply lower expenditures on unemployment transfers. Additionally, since firms have higher expenditures on vacancy posting, firm profits are lower and the households have less resources to spend on private consumption. Due to the assumption of a constant ratio of public to private consumption, it follows that public consumption is also reduced and the government needs less income from sales taxes.[22]

The statistics in columns (3) to (5) of Table 1.2 confirm the reduction of unemployment and long-term unemployment in equilibrium. The volatility of unemployment decreases as both firms and the government provide more resources to keep employment at a high level. Instead of entering debt renegotiations more often, the government, from an ex ante perspective, issues less debt and enters debt renegotiations less frequently when

[22]The tax rate would increase when public consumption is instead assumed to be constant because the tax base is reduced when human capital depreciation is larger.

Figure 1.7: Policy Functions - Skill Loss Variation



Notes: The solid (dashed) lines represent the debt policies, the bond prices, the recovery rates, the tax policies and the employment policies at different debt levels b for the benchmark model with $\xi = 0.48$ (the model without skill loss $\xi = 0$), given an employment level of 90%. In the left column, productivity is 2.6% below the trend. High productivity refers to levels 2.6% above the trend.

human capital depreciation is larger. By choosing lower debt levels, the government avoids higher interest spreads and reduces the likelihood of larger tax increases in case of bad realizations of the exogenous productivity shock. It follows that the tax rates become less procyclical in the intensity of the skill loss, i.e. the negative correlation between output and tax rates declines. Cyclical fluctuations in the size of total transfer payments to unemployed workers, which also depends on the degree of skill loss, may be an important driver of fiscal policy cyclicality. In Section 1.4.8, I provide a robustness analysis on the size of transfers Ω. Despite lower debt-to-GDP ratios, the market value of renegotiated debt is lower with increasing skill loss because of decreased recovery rates and lower bond prices.

The dashed lines in Figure 1.6 show the dynamics around renegotiations for the model without human capital depreciation. Qualitatively the patterns do not deviate from the benchmark model except for private consumption in the year of renegotiations. While private consumption declines at $t = 0$ in the benchmark, there is a small increase in the case without skill loss. In the absence of human capital depreciation, firms are more reluctant to post vacancies if separation rates are high because of the high risk of separation of new hires in the next period, the low exogenous productivity realization, and the lack of impact on future endogenous productivity. Unemployment exhibits a stronger increase despite higher vacancy yields. Due to lower vacancy expenditures, firm profits increase and there are more resources for private consumption. Since the employment enhancing effects are reduced, the government uses less of its fiscal capacities immediately after renegotiations such that the return of the debt-to-GDP ratio to a higher level and the reduction in the unemployment rate occur at a slower speed. Since the government faces a lower debt-to-GDP ratio and thus a smaller debt service ratio in the model with skill loss, it can serve a stronger spread increase before renegotiations.

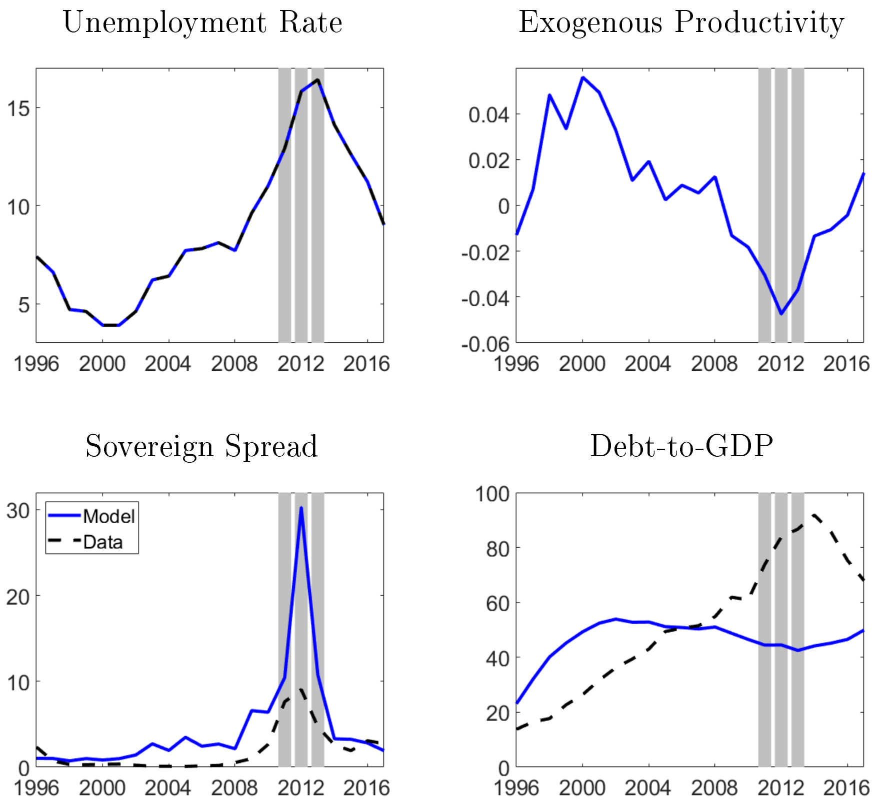
1.4.6 Case Study: Portugal 1996 - 2017

To evaluate the model predictions for Portugal, I employ the following experiment. I take the Portuguese unemployment rate in 1995 and assume that all workers are high-skilled in 1995. I calculate a value for debt based on the debt-to-GDP ratio in 1995 and define productivity to be on the trend in the initial period. Then, I run a simulation series of 22 years, for which I choose realizations of productivity z such that the unemployment rate of Portugal from 1996 to 2017 is matched. To ensure that the simulation series corresponds to the observed time period and does not contain debt renegotiation episodes, I extend the utility cost function of debt renegotiations by an exogenous stochastic component ϵ_{χ} as in Roch and Uhlig (2018). The shock to the utility cost can be interpreted as a change in political factors affecting the willingness to repay, e.g. third party interventions. The new specification of the utility cost function is given by

$$\chi(z) = \max\{0, \Lambda_0 + \Lambda_1 \log(z)\} + \epsilon_\chi.$$

Following Roch and Uhlig (2018), the stochastic component can take two values $\epsilon_\chi \in \{\epsilon_\chi^L, \epsilon_\chi^H\}$. I set the low realization ϵ_χ^L to 0 and the high realization ϵ_χ^H to a value which is large enough such that repayment is always optimal when the stochastic cost is high. I further assume that ϵ_χ takes the low value with a probability very close to 1 and the high value with a probability very close to 0. The choice of the probabilities ensures that the model with the cost shock is approximately equivalent to the benchmark model. For the experiment on Portugal, I assume that the stochastic cost is high in all episodes.

Figure 1.8: Model Prediction for Portugal without Renegotiations



Notes: As initial situation, the figure considers the unemployment rate of Portugal in 1995, a productivity realization on the trend, and the debt to GDP ratio of Portugal in 1995 under the assumption that all workers are high-skilled. In all periods, the shock component of the utiliy costs is equal to the high value ϵ_χ^H such that the government always repays its debt. For the time period from 1996 to 2017, a series of productivity realizations is generated such that the model produces the respective unemployment rates of Portugal. Unemployment rate, sovereign spread and debt-to-GDP are in percentage values, exogenous productivity denotes the log realization of the productivity shock z. Blue solid lines refer to the model outcome, black dashed lines to the Portuguese data.

Figure 1.8 shows the unemployment rate, the productivity realization, the spread and the debt-to-GDP ratio, where the blue solid and black dashed lines refer to the model outcome and the data series, respectively. The model matches the movements of the Portuguese spread, but overestimates the increase in the interest rates on Portugues bonds especially in 2012. The model cannot reproduce the increase in debt-to-GDP after 2008. For a low realization of the utility cost shock ϵ_χ, the model predicts renegotiations in 2011, 2012, and 2013, denoted by the grey bars. I assume for the renegotiations in the years 2012 and 2013 that the utility cost shock has been high in the previous years. The first predicted renegotiations in 2011 coincide with the year of the agreement on a 3-year economic adjustment program, which provided the Portuguese government with generous credits from the European Financial Stabilisation Mechanism, the European Financial Stability Facility, and the International Monetary Fund. While the model abstracts from the effect of bailouts, e.g. Fink and Scholl (2016) find that official financial assistance can help to prevent sovereign defaults in the short run. Bailouts provide the government with new liquidity and reduce the risk premia such that the government can increase its indebtedness at lower interest rates. Thus, the absence of fincancial assistance can explain differences in the spread and the debt-to-GDP ratio between the data and the model during the crisis.

Figure 1.9 shows the model outcome for the case that Portugal would have entered debt renegotiations in 2011 (red dashed), 2012 (red dashed-dotted), or 2013 (red dotted). Entry in debt renegotiations in 2011, 2012, and 2013 is accompanied by an immediate reduction of unemployment of 0.79, 1.11, and 0.69 percentage points, respectively. In the year after renegotiations, the government uses the low debt-to-GDP ratio at market reentry to issue new debt and set lower tax rates. The lower tax rates improve the firms' hiring incentives and unemployment is lowered by up to 3.50, 3.10, and 2.39 percentage points in the aftermath. In the following years, however, the government becomes more budget constrained because of increasing debt, faces higher spreads, and has to increase taxes. Spread, debt, and tax level converge to the level observed without renegotiations in 2017. However, in 2017, unemployment is still 1.01 (2011), 1.14 (2012), and 1.26 (2013) percentage points lower than in the case without renegotiations. The unemployment rate is lowest in 2017 if the government renegotiates in 2013 because of the timing of expansionary fiscal policy and the realization of bad productivity shocks and high separation rates. Since the government tends to use the new fiscal space after renegotiations directly to decrease tax rates, high separation rates in the following periods reduce the positive effect from renegotiations on employment.

The right panel in the second column shows for each year the recovery rate if the economy enters debt renegotiations. For the years 2011 to 2013, the haircuts are decreasing over time with recovery rates of 24.97%, 26.11%, and 28.85%, respectively.

Figure 1.9: Model Prediction for Portugal - Renegotiation Counterfactuals

Notes: The blue lines represent the model outcome for the years 2008 to 2017 for a model simulation where the exogenous productivity realizations are set to match the Portuguese unemployment rate. The full series starts in 1996 and takes the unemployment rate of Portugal in 1995, productivity on the trend, and the debt to GDP ratio of Portugal in 1995 under the assumption that all workers are high-skilled as initial situation. The dashed, dashed-dotted, and dotted red lines represent the model outcome when the government chooses to enter debt renegotiations in the years 2011, 2012, and 2013, respectively. Welfare equivalent denotes the welfare improvement from moving from the economy without renegotiations to the counterfactual economy with debt relief in terms of the equivalent variation in consumption. Recovery rate refers to the percentage of debt remaining in case the government enters debt renegotiations.

The decline follows from the reduced renegotiated debt stock. Despite the reduction of GDP in 2012 and 2013 following from increased unemployment and low productivity realizations, the debt-to-GDP ratio decreases after 2011 because matured debt is not completely replaced by new debt issuance. At the same time, the debt level after renegotiations, which is independent from the renegotiated debt stock, is lowest (-0.096) in 2012 which is the year of the weakest productivity realization. The debt level for renegotiations in 2013 (-0.100) is marginally higher than the one for 2011 (-0.099) despite the worse productivity shock. The policy functions in Section 1.4.2 show that the unemployment rate, which peaks in 2013, has a negative impact on the recovery such that higher unemployment implies a higher debt level after renegotiations.

To evaluate the welfare effects of debt renegotiations, I compute the equivalent variation in consumption Λ. The use of GHH-preferences allows me to follow Durdu et al. (2013) and to calculate the welfare gain of moving from an economy with a high realization of the utility cost shock ϵ_χ to the counterfactual economies in which the government enters debt renegotiations:

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left((1+\Lambda)\, c_t(\circ)\right) = E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t(*)\right).$$

'$\circ$' refers to the model with high realizations of the utility cost shock ϵ_χ, and '$*$' denotes the counterfactual model in which the government enters debt renegotiations. The equivalent variation follows from this equation as

$$\Lambda = \left(\frac{V^0(*)}{V^0(\circ)}\right)^{\frac{1}{1-\sigma}} - 1,$$

where V^0 is the expected lifetime utility. For welfare calculations, I use the expected lifetime utility realized by the households, i.e. I abstract from the one-time utility cost which the policy maker suffers. Renegotiations in 2011 imply the largest immediate welfare gains of up to 4.6%. The welfare gain for renegotiations in 2012 and 2013 is 4.37% and 4.15%, respectively. The reduction in the immediate benefit of a debt relief results from both the larger percentage debt relief and the lower unemployment peak following early renegotiations. Since the debt-to-GDP ratio and the unemployment rate converge back to the levels in the model outcome without renegotiations, welfare gains of being in the counterfactual economy decline over time. However, in 2017, the welfare gain is still in the range from 0.80% to 1.15%.

1.4.7 The Size and Welfare Effects of Haircuts

The size of haircuts is controlled by the borrower's bargaining power θ. Columns (6) to (8) of Table 1.2 provide the statistics for variations of θ. For lower bargaining power, the average recovery rate increases such that the borrower receives a smaller debt relief, reflected in the increasing market value of renegotiated debt. As smaller haircuts reduce the incentives to enter debt renegotiations, the government serves its debt obligations at higher debt levels, becomes less budget constrained and accumulates more debt. For the chosen debt levels, the government faces higher bond prices where the increased market value of renegotiated debt dominates the negative effect of an increased probability of debt renegotiations. The maximum recovery rate in terms of the market value of renegotiated debt is 44.56%, which is above the average of 40.01% found by Cruces and Trebesch (2013). Their analysis, however, includes a large number of renegotiations of emerging economies which may feature substantially lower debt-to-GDP ratios.

In the long run, employment increases in the bargaining power and employment becomes more volatile. There are two opposing forces at work. On the one hand, since the debt level is higher in the long run, debt service and thus tax rates are higher with decreasing bargaining power. Increased tax rates reduce the firms' benefit from hiring such that employment marginally decreases. On the other hand, since recovery rates increase with declining bargaining power, bond prices increase and the government becomes less borrowing constrained. More fiscal space allows the government to reduce taxes and improve hiring incentives. The first effect dominates.

The last row of Table 1.2 shows the percentage equivalent variation in consumption across the full simulation series from the perspective of the policymaker. Welfare is decreasing in the government's bargaining power. While a decreasing bargaining power implies smaller debt reductions after renegotiations, the government benefits from higher bond prices and access to larger amounts of debt. The benefit increases exponentially up to a maximum of 1.63%.

1.4.8 Robustness

In this section I study the impact of the size of transfers to unemployed workers paid the government Ω on the model dynamics. The first three columns of Table 1.3 present the statistics for variations of Ω given the benchmark choice of the skill loss parameter $\xi = 0.48$.

Table 1.3: Robustness Analysis: The Impact of Transfers

	$\xi = 0.48$			$\xi = 0$
	$\Omega = 0$	$\Omega = 0.25$	$\Omega = 0.75$	$\Omega = 0$
$\rho(\tau, y)$	-0.25	-0.32	-0.39	-0.35
$E(s)$	2.96	2.92	3.12	2.75
$E(b'/y)$	51.20	50.90	42.91	52.97
$E(u)$	10.87	10.12	5.16	10.59
Reneg. Prob.	3.44	3.34	2.64	3.15

Notes: All statistics are based on simulations of 500 000 years, where I omit the first 100 observations. I refer to episodes of at least 23 years without renegotiations, which are preceded by at least 4 years without renegotiations. The first three columns present variations of the size of transfers to unemployed workers Ω given a value for the skill loss parameter ξ of 0.48. The last column shows the statistics for the model without skill loss and without transfer payments. Renegotiation probabilities and welfare equivalents refer to the complete series of 499 900 years.

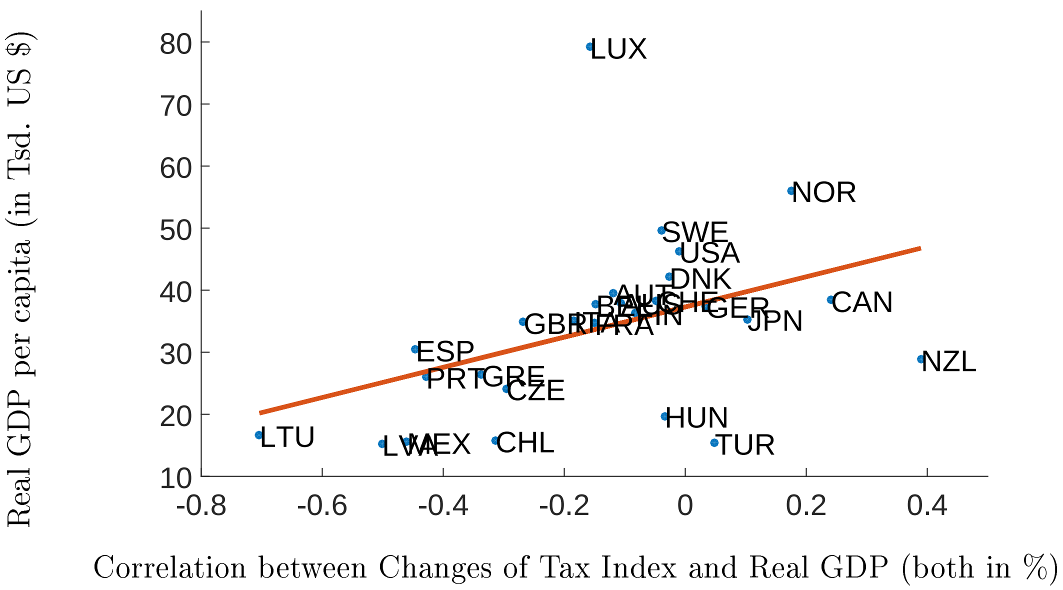
The size of total transfer payments T is highly sensistive to changes in the unemployment rate and cyclical fluctuations. It follows that with increasing transfer size, government expenditures become more volatile and more negatively correlated with the realizations of the exogenous productivity shock. A stronger increase in total transfer payments during an economic downturn demands increasing sales tax rates such that the tax policy becomes more procyclical. External creditors incorporate an increased renegotiation probability at high debt levels such that the government faces higher bond spreads and issues less debt.

Column (4) of Table 1.3 displays the statistics for the model without skill loss and without transfers. The comparison with column (1) shows that two thirds of the reduction in tax cyclicality and half of the debt reduction observed for the benchmark model in Table 1.2 cannot be explained by cyclical fluctuations of transfer payments.

1.4.9 Discussion

In this section, I compare the main implications of the model to empirical observations. To control for more procyclical fiscal policy in the presence of lower skill loss during unemployment, I consider the relation between GDP per capita as a measure of human capital intensity and a measure of tax cyclicality. Figure 1.10 plots the correlation between percentage changes in real GDP and a tax index against the average GDP per capita between 1996 and 2013 for 27 OECD economies. Real GDP per capita data is from the OECD. The tax index information is taken from Vegh and Vuletin (2015) and includes changes in corporate, personal, and value-added tax rates.

Figure 1.10: Tax Cyclicality and GDP per capita in OECD economies



Notes: The figure plots the correlation between the percentage changes of real GDP and the tax index of Vegh and Vuletin (2015) against the average real GDP per capita between 1996 and 2013 for 27 OECD economies.

In line with the model outcome, countries with higher GDP per capita follow a less procyclical fiscal policy. While developed economies tend to have an acyclical or procyclical tax policy, fiscal policy in Spain, Portugal and Greece is particularly procyclical while both countries also feature lower GDP per capita. The two latter economies, however, feature exceptionally high debt to GDP ratios, where the model would ex ante predict lower debt levels. An explanation may be that the model abstracts from several features which determine the sovereign's ability to issue debt. The literature has studied numerous aspects including political stability (Cuadra et al., 2010), the availability of bailout credits (Fink and Scholl, 2016), and domestic public debt (Bocola et al., 2019).

1.5 Conclusions

In this paper, I have developed a dynamic stochastic model of sovereign debt with endogenous haircuts, matching frictions, and skill loss during unemployment to study optimal fiscal policy when human capital is lost during terms of unemployment. While contractionary fiscal policy may serve to avoid a default, it has a negative effect on employment. Since skills are lost during unemployment, the economy's production potential may be reduced and there will be less resources to serve external debt obligations in the future. Thus, debt renegotiations may be considerd as an alternative.

In a quantitative exercise, I have applied the model to Portugal. The policy functions reveal that the government enters debt renegotiations when employment and productivity are low and debt is high. If debt is sufficiently low, the government responds to rising unemployment with tax reductions to increase the firms' hiring incentives. If debt is high, fiscal policy is contractionary and higher tax rates reduce the firms' benefit from hiring such that the government may prefer to enter debt renegotiations.

From an ex ante perspective, a higher intensity of skill loss during unemployment reduces the procyclicality of fiscal policy. For larger human capital depreciation, the government issues less debt, faces lower debt-to-GDP ratios and enters debt renegotiations less frequently. With lower debt levels, the government can avoid large tax hikes during economic downturns such that fiscal policy becomes less procyclical. Similarly, firms increase hiring in response to larger human capital depreciation and average employment rises. When the bargaining power of the government is lower, haircuts become smaller such that the fiscal space after renegotiations to reduce taxes and to improve the firms' benefit from hiring declines. However, since higher recovery rates imply lower spreads, the government becomes less borrowing-constrained and enters renegotiations more frequently. The long-term average of employment increases in the bargaining power. In equilibrium, there is a welfare gain to the sovereign from lower bargaining power and smaller haircuts.

For Portugal, the model predicts that renegotiations would have been optimal in 2011, 2012, and 2013 with a medium-run unemployment reduction of up to 3.5 percentage points. Early renegotiations imply a lower peak of the unemployment rate in the short run, but slightly higher unemployment rates in the medium run because persistently low productivity realizations reduce the long-term effects of expansionary fiscal policy. The model cannot match the debt increase after 2009 since it abstracts from bailouts. The question how financial assistance and conditionality should be tailored such that the persistent negative effects of austere fiscal policy are minimized is left for future research.

A Appendix: The Recursive Equilibrium

Definition. *The recursive equilibrium for the small open economy is defined as*

1. *a set of policy functions for private consumption* $c^R(b,n,z)$, $c^D(n,z)$,
2. *a set of policy functions for hiring, vacancy posting and employment* $h^R(\tau,n,z)$, $h^D(\tau,n,z)$, $v^R(\tau,n,z)$, $v^D(\tau,n,z)$, $n'^R(\tau,n,z)$, $n'^D(\tau,n,z)$,
3. *a set of wages* $w^{H,R}(\tau,n,z)$, $w^{H,D}(\tau,n,z)$, $w^{L,R}(\tau,n,z)$, $w^{L,D}(\tau,n,z)$ *and transfers to unemployed workers* $T^{H,R}(\tau,n,z)$, $T^{H,D}(\tau,n,z)$, $T^{L,R}(\tau,n,z)$, $T^{L,D}(\tau,n,z)$,
4. *a set of value functions for the firms' value of a high-skilled and low-skilled job* $J^H(\tau,n,z)$, $J^{H,R}(\tau,n,z)$, $J^{H,D}(tau,n,z)$, $J^L(\tau,n,z)$, $J^{L,R}(\tau,n,z)$, $J^{L,D}(\tau,n,z)$, *for the value of a job to a high-skilled and a low-skilled worker* $W^H(\tau,n,z)$, $W^{H,R}(\tau,n,z)$, $W^{H,D}(\tau,n,z)$, $W^L(\tau,n,z)$, $W^{L,R}(\tau,n,z)$, $W^{L,D}(\tau,n,z)$, *and the value of being unemployed* $U^H(\tau,n,z)$, $U^{H,R}(\tau,n,z)$, $U^{H,D}(\tau,n,z)$, $U^L(\tau,n,z)$, $U^{L,R}(\tau,n,z)$, $U^{L,D}(\tau,n,z)$,
5. *a set of policy functions for the government's borrowing choice* $b'(b,n,z)$, *government consumption* $g^R(b,n,z)$, $g^D(n,z)$, *and the tax policy* $\tau^R(b,n,z)$, $\tau^D(n,z)$,
6. *a default set* $\mathcal{D}(b,n)$,
7. *the bond price function charged by international creditors,* $q(b,n,z)$,
8. *the bond level determined in debt renegotiations,* $\widetilde{b}(n,z)$,
9. *a set of value functions for the government* $V(b,n,z)$, $V^R(b,n,z)$, $V^D(n,z)$,

such that

1. *taking as given the public sector policies and the firms' policy choices* $c^R(b,n,z)$ *and* $c^D(n,z)$ *satisfy the household's budget constraint (1.6),*
2. *taking as given the public sector policies, hiring* $h^R(\tau,n,z)$, $h^D(\tau,n,z)$ *and vacancy posting* $v^R(\tau,n,z)$, $v^D(\tau,n,z)$, *and employment* $n'^R(\tau,n,z)$, $n'^D(\tau,n,z)$ *satisfy the optimality condition (1.9) as well as the transition equation, the equation of the vacancy yield* a, *and the non-negativity constraint on hiring from the firms' profit maximization problem (1.2),*
3. *given the public sector policies and the firms' choices on vacancy posting and hiring, wages* $w^{\{H,L\},R}(\tau,n,z)$ *and* $w^{\{H,L\},D}(\tau,n,z)$ *solve the bargaining problems (1.23) and (1.24) and transfers to unemployed workers* $T^{\{H,L\},R}(\tau,n,z)$ *and* $T^{\{H,L\},D}(\tau,n,z)$ *equal a share* Ω *of wages,*

4. *the value functions for firms* $J^{\{H,L\}}(b,n,z)$, $J^{\{H,L\},R}(b,n,z)$, $J^{\{H,L\},D}(b,n,z)$, *and the value functions of employed workers* $W^{\{H,L\}}(b,n,z)$, $W^{\{H,L\},R}(b,n,z)$, $W^{\{H,L\},D}(b,n,z)$, *and unemployed workers* $U^{\{H,L\}}(b,n,z)$, $U^{\{H,L\},R}(b,n,z)$, *and* $U^{\{H,L\},D}(b,n,z)$ *fulfill equations (1.17), (1.18), (1.19), (1.20), (1.21) and (1.22),*

5. *given the bond price functions* $q(b',n',z)$, *the debt level after renegotiations* $\widetilde{b}(n,z)$, *and the private sector equilibrium, the government's value functions* $V(b,n,z)$, $V^R(b,n,z)$, $V^D(n,z)$, *the default set* $\mathcal{D}(b,n)$, *and the policy functions* $b^{'}(b,n,z)$, $g^R(b,n,z)$, $g^D(n,z)$, $\tau^R(b,n,z)$, $\tau^D(n,z)$ *solve (1.10), (1.11), (1.12) and (1.13),*

6. *given the bond price function* $q(b',n',z)$ *and the value function* $V^D(b,n,z)$, *the renegotiated debt level* $\widetilde{b}(n,z)$ *solves the bargaining problem (1.15),*

7. *given the expected debt level after renegotiations* $\widetilde{b}(n',z)$, *bond prices* $q(b',n',z)$ *fulfill equation (1.16), such that risk-neutral international creditiors earn zero expected profits.*

B Appendix: Wage Determination

Following Den Haan et al. (2000) and Rendahl (2016), I abstract from complete insurance markets across households and consider each worker as a single risk-neutral entity. Thus, the surplus of a job to a worker is the difference between the expected discounted values of receiving a wage and being high-skilled at the beginning of the next period and receiving unemployment benefits and being or becoming low-skilled. As in Pissarides (2000), wages are determined by Nash bargaining on the total surplus of the job. The firm's value J of a high-skilled and low-skilled job are

$$J^H = (1-\tau)z - w^H + \beta\frac{u'(c')}{u'(c)}E((1-\rho_x')J'^H) \tag{1.17}$$

$$J^L = (1-\tau)z(1-\xi) - w^L + \beta\frac{u'(c')}{u'(c)}E((1-\rho_x')J'^H). \tag{1.18}$$

The equilibrium condition of the private sector on hiring implies that the value of a vacancy V equals zero:

$$V = -\frac{\kappa}{a} + pJ^L + (1-p)J^H = 0.$$

The value of a job to a high-skilled and low-skilled worker are

$$W^H = w^H + \beta\frac{u'(c')}{u'(c)}E\left((1-\rho_x'+\rho_x'\rho_f')W'^H + \rho_x'(1-\rho_f')U'^H\right) \tag{1.19}$$

$$W^L = w^L + \beta\frac{u'(c')}{u'(c)}E\left((1-\rho_x'+\rho_x'\rho_f')W'^H + \rho_x'(1-\rho_f')U'^H\right). \tag{1.20}$$

The value of being unemployed is

$$U^H = T^H + \beta \frac{u'(c')}{u'(c)} E(\rho_f W'^L + (1-\rho_f) U'^L) \tag{1.21}$$

$$U^L = T^L + \beta \frac{u'(c')}{u'(c)} E(\rho_f W'^L + (1-\rho_f) U'^L), \tag{1.22}$$

where $T^H = \Omega w^H$ ($T^L = \Omega w^L$).

Let the Nash bargaining power of workers be denoted by ω. The equilibrium wages are given by

$$w^H = \text{argmax}\{(J^H)^{1-\omega}(W^H - U^H)^\omega\} \tag{1.23}$$

$$w^L = \text{argmax}\{(J^L)^{1-\omega}(W^L - U^L)^\omega\} \tag{1.24}$$

The surplus is divided between the firms and the workers such that the wages for high-skilled and low-skilled workers are respectively

$$\begin{aligned} w^H =& \omega(1-\tau)z \\ &+ \frac{(1-\omega)}{1-\Omega}\beta\frac{u'(c')}{u'(c)} E\left[\rho'_f W'^L + (1-\rho'_f)U'^L - \rho'_x\rho'_f W'^H - (1-\rho'_x\rho'_f)U'^H\right] \end{aligned}$$

$$\begin{aligned} w^L =& \omega(1-\tau)z(1-\zeta) \\ &+ \frac{(1-\omega)}{1-\Omega}\beta\frac{u'(c')}{u'(c)} E\left[\rho'_f W'^L + (1-\rho'_f)U'^L - \rho'_x\rho'_f W'^H - (1-\rho'_x\rho'_f)U'^H\right]. \end{aligned}$$

C Appendix: Numerical Algorithm

I solve the model using value function iteration. My algorithm closely follows Hatchondo et al. (2010) and employs cubic spline interpolations. I approximate the equilibrium as the equilibrium of the finite-horizon economy and execute simultaneously iterations on the value functions and the bond price function.

Given the budget constraints (1.6), (1.7), (1.8), and the relationship between private and public consumption, the tax rate τ can be written as a function of the employment policy n' and the debt policy b'. For a given choice of the debt level b', the optimal employment level n' follows from the optimality conditional of the private sector (1.9).

To solve the model, I employ the following algorithm. I define evenly distributed grid points for international debt $b \in [\underline{b}, \overline{b}]$, employment $n \in [\underline{n}, \overline{n}]$, and productivity $z \in [\underline{z}, \overline{z}]$. I set initial guesses for the value functions $V_{(0)}(b,n,z)$, $V^R_{(0)}(b,n,z)$ and $V^D_{(0)}(n,z)$, the values for firms $J_{(0)}(\cdot)$, employed workers $W_{(0)}(\cdot)$, unemployed workers $U_{(0)}(\cdot)$, the private and public sector policy functions and the bond price function $q_{(0)}(b,n,z)$. Given the guesses for the value functions, I employ a global search procedure to find candidate values for $b'_{(0)}(b,n,z)$ for every grid point $(b,n,z) \in [\underline{b},\overline{b}] \times [\underline{n},\overline{n}] \times [\underline{z},\overline{z}]$. Using these candidate values as initial guesses, I find optimal values with the FORTRAN optimization routine BCPOL from the IMSL library. The probability of debt renegotiations $\eta_{(0)}(z,b'_{(0)},n'_{(0)})$ and the bond price $q_{(0)}(z,b'_{(0)},n'_{(0)})$ follow from equations (1.14) and (1.16), respectively. The debt level after debt renegotiations $\widetilde{b}_{(0)}(n'_{(0)},z)$ is determined by the bargaining problem (1.15). Expected continuation values and expected policies are evaluated with Gauss-Hermite quadrature points and weights. I employ cubic spline interpolation to compute values for policies and productivity realizations off the grid using the FORTRAN routine by Habermann and Kindermann (2007).

Given the solutions found at each grid point, I update the value functions $V_{(0)}(b,n,z)$, $V^R_{(0)}(b,n,z)$ and $V^D_{(0)}(n,z)$ as well as the values for firms, workers, private and public sector policy functions and the bond price function. I iterate until the value functions converge.

CHAPTER 2

The Impact of Bailouts on Political Turnover and Sovereign Default Risk

2.1 Introduction

Rising government bond spreads in the aftermath of the 2007/08 financial crisis forced the Greek government to turn to the International Monetary Fund, the European Commission, and the European Central Bank requesting financial assistance. The first bailout was granted in May 2010 and two further bailout programs followed in 2012 and 2015. In return, the government committed to implement pre-specified austerity policies. The implementation of the program conditions was accompanied by domestic protests and political unrest. Formerly small and newly founded parties opposing austerity massively gained votes, destabilizing the government and giving rise to doubts on the commitment to repay debt and fulfill conditionality.

The events in Greece raise several important questions: What is the impact of bailout programs on the risk of political turnover? How do sovereign default risk, bailouts, and political turnover interact and how are macroeconomic outcomes affected? How does stricter conditionality affect the risk of political turnover and sovereign default in the short run and in the long run?

To address these questions, this paper analyzes the interaction of sovereign default risk, bailouts, and political turnover in a politico-economic model of sovereign debt. The theoretical framework features endogenous default risk, endogenous participation rates in bailout programs as well as endogenous political turnover. We consider a small open economy that is inhabited by infinitely-lived households. The government finances a public good by raising taxes and by issuing external debt. International financial markets are incomplete and debt contracts are subject to default risk. In addition to debt provided by international private creditors, an (unmodeled) international financial institution provides official loans below the market rate and, in return, restricts the set of fiscal policies by imposing a target on the primary surplus. The government decides whether to fulfill its debt obligations or to default. Moreover, taking conditionality as given, the government chooses whether to make use of a bailout program.

There is a two-party system in which both parties care about the population's welfare. Following Chang (2007), the parties differ in an exogenous one-time utility cost of default that can be interpreted as a personal cost of the policymaker due to a loss of reputation. Individuals are not affected by these utility costs, but differ in stochastic idiosyncratic ideological aspects, which are independent from economic policy. Political turnover is the endogenous outcome of the individual voting behavior, which is determined by the economic benefits from having the opponent rather than the incumbent in power as well as stochastic idiosyncratic ideological aspects. Risk-neutral international private creditors charge a premium that reflects the endogenous probability of a political turnover as well as the endogenous default risk.

In equilibrium, the probability of political turnover is a function of the productivity state and the debt policy. Implicitly, the turnover probability is affected by the bailout decision because the provision of official loans is conditional on the implementation of the pre-specified primary surplus target, which restricts the government's borrowing choice. The policy functions suggest that the party with the lower utility cost of default is more likely to come into power when debt is high and is more willing to exit a bailout program by declaring a default. Instead, the party with the higher utility cost of default is more likely to be in power when debt is low and is more willing to make use of official financial assistance. To highlight the interaction between bailouts and political turnover, we provide a comparison with a counterfactual economy in which official loans are not provided. Our analysis reveals that if debt is high, bailouts foster the probability that the party with the lower utility cost of default comes into power, which, in turn, raises sovereign default risk.

In a quantitative exercise we apply our theoretical framework to the Greek economy and explore how the interaction between bailouts and political turnover affect macroeconomic outcomes. To this end, we simulate our model and study the dynamics of a bailout event. In the years before the bailout, our model predicts a low sovereign interest spread and a small probability of political turnover due to good economic conditions. Because of low credit costs, the incumbent government is not borrowing constrained and runs a budget deficit. The debt crisis is triggered by an adverse economic shock that reduces the ability of the government to repay the outstanding debt. Due to the increase in the sovereign interest spread, the incumbent government decides to enter a bailout program. As official loans are conditional on the adoption of austerity policies, the incumbent government implements tax hikes and spending cuts, which raises the probability of losing power. Successively, the risk of political turnover elevates the sovereign interest spread. A comparison with the Greek bailout of May 2010 reveals that the model replicates the empirical pattern of output, consumption, and the sovereign interest spread quite well.

To quantify the impact of political risk on the sovereign interest spread during a bailout, we provide a comparison with a counterfactual economy in which political uncertainty is absent and the incumbent party remains in office forever. Our results suggest that the risk of political turnover increases the sovereign interest spread by 2 percentage points at the time of the entry into a bailout program.

In a policy analysis, we study the role of conditionality and vary the primary surplus target attached to the provision of official loans. We find that the frequency of political turnover is U-shaped in the strength of conditionality, which is driven by two opposing forces. On the one hand, fulfilling the primary surplus target is costly as it forces the incumbent to implement tax hikes and spending cuts, which foster the risk of losing power. On the other hand, a tighter fiscal constraint reduces debt in the economy, which decreases the probability that the party with the lower utility cost of default comes into power.

We show that while stricter conditionality raises the short-run risk of political turnover and sovereign default, in the long run, stricter conditionality reduces sovereign default risk and political turnover if the fiscal constraint is not too tight. These findings highlight the tension that policymakers face when designing bailout packages: While stricter conditionality may improve fiscal sustainability and political stability in the long run, it fosters political uncertainty and sovereign default risk in the short run.

Our paper is related to three different strands of literature. First, our paper builds on the politico-economic literature that analyzes the interaction of political turnover and public debt, see, e.g., Alesina and Tabellini (1990), Persson and Svensson (1989), Aghion and Bolton (1990), and the overview in Persson and Tabellini (2000). While the aforementioned papers mostly consider two-period models, Battaglini and Coate (2008), Song et al. (2012), Müller et al. (2016) and Dovis et al. (2016) develop fully dynamic politico-economic theories of public debt, but abstract from sovereign default risk. Chang (2007) and Chang (2010) study the interaction between political crises and financial crises and focus on the role of self-fulfilling expectations.

Second, we build on the recent quantitative literature on sovereign debt that allows for default in equilibrium, see, e.g., Aguiar and Gopinath (2006) and Arellano (2008). Hatchondo et al. (2009) and Cuadra and Sapriza (2008) consider exogenous political turnover rates and show that political instability increases debt accumulation and default risk. Scholl (2017) introduces the probabilistic voting approach in a quantitative model of sovereign debt to analyze the impact of endogenous electoral outcomes on sovereign default risk. She shows that endogenous election probabilities increase the disparities between the parties' debt and default policies. In a related study, Chatterjee and Eyigungor (2019) analyze the interaction of economic growth, election probabilities, and sovereign risk premia.[1] Our paper is related to Andreasen et al. (2019) who highlight that the implementation of austerity policies is subject to political constraints. However, Andreasen et al. (2019) abstract from the role of official loans and conditionality, which is our focus here.

Third, this paper is related to the literature that studies the role of international financial institutions and the macroeconomic impact of bailouts and conditionality.[2]

[1] In a similar vein, Novelli (2018) builds on Battaglini and Coate (2008) and introduces legislative bargaining in a quantitative model of sovereign debt and default.

[2] For a discussion of the empirical findings concerning bailout programs and conditionality we refer

Ardagna and Caselli (2014) discuss the politico-economic aspects of the Greek bailouts.[3] Several papers analyze the impact of official loans on sovereign default risk using stochastic dynamic models of sovereign debt, e.g., Aguiar and Gopinath (2006), Boz (2011), Juessen and Schabert (2013), Kirsch and Rühmkorf (2017), Hatchondo et al. (2017), Pancrazi et al. (2020), and Roch and Uhlig (2018). Fink and Scholl (2016) show that bailouts prevent sovereign defaults in the short run, but may come at the cost of a greater default probability in the long run. All these papers abstract from the role of political uncertainty, which is our focus here. Our paper contributes to the literature by studying the dynamic interaction between bailouts and political turnover and the short- and long-run effects of conditionality on political risk.

The remainder of the paper is structured as follows. In Section 2.2 we consider Greece as a case study and provide narrative evidence on the link between sovereign interest spreads, bailouts, and political turnover. In Section 2.3 we describe the theoretical framework. Section 2.4 presents the quantitative properties of the model and discusses the interaction between political turnover and conditional bailouts. Finally, Section 2.5 concludes.

2.2 Empirical Evidence on the Interaction of Bailouts, Political Turnover, and Sovereign Default Risk

2.2.1 The Greek Sovereign Debt Crisis

Starting in May 2010, Greece has agreed on three economic adjustment programs, often referred to as 'bailout packages', under the supervision of the International Monetary Fund (IMF), the European Central Bank (ECB), and the European Commission (EC) representing the Eurogroup. The programs provided financial assistance of substantial size. The bailout packages of May 2010, March 2012, and August 2015 amounted to 110 billion euro, 164.5 billion euro, and 86 billion euro, respectively. The interest rates on the official loans were below the rates charged on the bond markets. The second bailout package came along with a haircut on debt held by private creditors (100 billion euro).[4] In the context of the bailouts, the share of Greek general government debt owed to official institutions summed up to 71% at the end of 2015. 66% and 5% was held by the countries of the Eurogroup and the IMF, respectively (IMF, 2016).

The official loans were provided conditional on austerity measures to restore fiscal

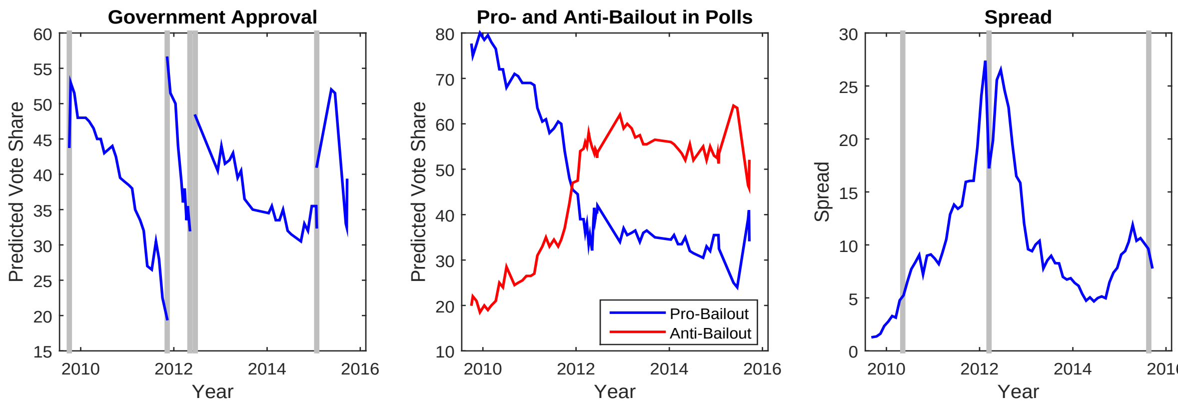
to the excellent surveys by Bird (2007), and the references therein.

[3] In a related paper, Arellano and Bai (2017) study the impact of austerity measures during the Greek debt crises, but they abstract from official loans.

[4] For details on the March/April 2012 debt exchange of 200 billion euro and the December 2012 buyback of exchanged debt, see e.g., Zettelmeyer et al. (2013).

sustainability. The fiscal targets were set in terms of a gradually improving primary surplus in percent of GDP. E.g., for the years 2015, 2016, 2017, and 2018, the third bailout package of August 2015 specified targets on the primary surplus of −0.25%, 0.5%, 1.75%, and 3.5% of GDP, respectively. To reach these targets, the bailout programs defined different austerity measures such as tax hikes and public spending cuts. The fiscal conditions of the first program included spending cuts of 7% of GDP, tax hikes resulting in a revenue increase of 4% of GDP, and structural fiscal reforms with respect to pensions, health sector, tax system, tax administration, and public financial management. The second program of March 2012 required public sector wage bill reductions of 1.5% of GDP, tax administration improvements of the same size, and a further 5.5% of GDP reduction in spending measures. The third program again included a set of austerity measures and structural reforms. In addition, all programs required specific financial sector policies, structural reforms, and privatization.[5] A detailed overview of the targets on the primary surplus and the austerity measures is provided in Appendix E.

Figure 2.1: Election Polls and Bond Spreads



Notes: The first two panels are based on *Public Issue* election polls from 2009 to 2015 (see *http://www.publicissue.gr*). Government approval refers to the predicted percentage vote share of the parties which are part of the government. The grey bars mark government turnovers. The second panel shows the predicted percentage vote share of the parties approving (blue) and refusing (red) the memorandum in June 2012, following Vasilopoulou and Halikiopoulou (2013). Changes of positioning as in case of ND in 2011 and DIMAR in 2012 are neglected. The third panel presents the spread between Greek and German 10-year government bonds in %, calculated from OECD data. Grey bars mark the dates of approval of the bailout programs.

During the time of the bailout programs, Greece faced political instability. George A. Papandreou and his Panhellenic Socialist Movement (PASOK) won the early elections in late 2009, but lost dramatically in the opinion polls after the implementation of

[5]European Commission (2010), European Commission (2012), European Commission (2015), ESM data.

the policies from the first bailout package in May 2010 (see Figure 2.1). Papandreou resigned in November 2011 and was followed by a caretaker cabinet supported by PASOK and the conservative New Democracy (ND), which had refused the first bailout package in parliament.[6] This government finalized the agreement on the second bailout program in March 2012. Continuing the consolidation policy, the coalition parties quickly lost support in the opinion polls, ending with heavy losses in the early elections of May 2012. The anti-bailout Radical Left (SYRIZA) gained from these losses and became the second strength in parliament. While there was a majority of seats for a large number of formerly small and newly founded parties which rejected the bailout policy, no coalition could be formed and early elections in June were announced and a caretaker cabinet took office.

The subsequent election campaigns debated the continuation of the bailout policy, in which ND and SYRIZA represented the pro- and anti-bailout camps, respectively.[7] ND, PASOK and the formerly bailout critical Democratic Left (DIMAR) formed a coalition in June 2012. The bailout policy was continued despite worsening results in the opinion polls and the DIMAR leaving the coalition in June 2013.

In December 2014, president elections failed implying early parliamentary elections in January 2015. In line with the opinion polls, Alexis Tsipras of the anti-bailout SYRIZA became the new prime minister. At the end of the negotiations on the third bailout package, the Greek government fell into arrears with the IMF in June 2015, which was resolved in the following weeks. Despite loss of support in his own party, Tsipras won the early elections in September 2015.

The times of political uncertainty were accompanied by rising bond spreads between Greek and German 10-year government bonds (see Figure 2.1). Spreads dropped in March 2012 after the agreement on the second bailout program, but increased again at the time of the two parliamentary elections until summer 2012. In fall 2014, bond spreads started rising again, in light of the upcoming negotiations on the third bailout package and the early Parliament elections in January 2015.

2.2.2 Beyond Narrative Evidence

The narrative evidence on the events in Greece supports the view that there is a dynamic interaction between political uncertainty, sovereign default risk, and conditional bailouts. Similar experiences have been made by several Latin American countries,

[6] The third supporter, the small right-wing Popular Orthodox Rally (LAOS), left the coalition in February 2012 in protest against the austerity policy.

[7] Details on the period between 2009 and June 2012 with respect to political campaigns, fragmentation of the party system, and the effects of the bailout policies on voting behavior can be found e.g. in Dinas and Rori (2013) and Karyotis and Rüdig (2015).

e.g., Ecuador in the early 2000s, Peru and Venezuela in the 1980s, and Argentina in 2001. Recently, in June 2018, Argentina entered a stand-by-arrangement with the IMF. Primary elections were held in early August 2019 and the incumbent lost a significant number of votes to the opposition.

There is an empirical literature that goes beyond the narrative evidence and performs econometric analyses of the link between sovereign default risk and political uncertainty, see Hatchondo and Martinez (2010) for an excellent overview. Citron and Nickelsburg (1987) report that the number of government changes within a period of five years is a significant determinant of default risk. Block and Vaaler (2004) and Vaaler et al. (2005) provide econometric evidence that electoral risk is associated with significant increases in sovereign spreads in developing countries. Similar results for the Brazilian economy can be found in Goretti (2005). Manasse and Roubini (2009) find that the probability of a debt crisis increases if an election takes place. More recently, Herrera et al. (2020) show that politico-economic factors are important predictors of financial crises in emerging market economies.

The link between bailouts and political stability has received less attention in the literature. Bienen and Gersovitz (1985, 1986) study the impact of financial assistance programs of the IMF. They report several cases in which the implementation of austerity policies generated political instability in the short run. However, governments were usually able to prevent a political turnover by rejecting the full implementation of the program conditions. Dreher (2004) and Dreher and Gassebner (2012) report evidence that IMF and World Bank programs affect re-election positively in times of low economic growth but negatively in times of high economic growth.

As conditionality typically implies the implementation of fiscal consolidation measures, there is also a relation to empirical studies on the effects of austerity policies on electoral outcomes. While, e.g., Alesina et al. (2013) and Alesina et al. (1998) do not find political costs from fiscal adjustments, Hübscher and Sattler (2017) report empirical evidence for a strategic timing of fiscal consolidation policies. Governments under electoral risk avoid austerity towards the end of the legislative term. Ponticelli and Voth (2020) provide empirical evidence on the relationship between austerity policies and social unrest. They find a significant increase in political instability in response to expenditure cuts.

2.3 The Model

2.3.1 The Environment

We consider a small open economy inhabited by a continuum of infinitely-lived individuals who have identical preferences over private consumption, leisure, and government spending. The government has access to international financial markets where it can issue external debt. International debt contracts are not enforceable and are subject to default risk. There is a two-party system with parties $j = A, B$. Both parties care about the population's welfare. We follow Chang (2007) and assume that the parties differ in an exogenous one-time utility cost of default.[8] This utility cost can be interpreted as a personal cost of the policymaker due to loss of reputation. In the following, suppose that party A faces a higher utility cost of default than party B. As in Scholl (2017), political turnover is the endogenous outcome of the individual voting behavior. We follow the probabilistic approach and assume that the individual voting behavior is determined by the economic benefits from the incumbent's and opponent's policies as well as stochastic idiosyncratic ideological aspects that are unrelated to economic policy and affect preferences additively.

Let the individuals' per-period utility, net of the idiosyncratic ideological aspects, be given as:

$$(1-\alpha)u(c,l) + \alpha v(g),$$

where c and l denote private consumption and labor supply, respectively. The per-period utility function $u : \mathbb{R}^2_+ \rightarrow \mathbb{R}$ is continuous, twice differentiable in both arguments, strictly increasing in c, strictly decreasing in l, jointly strictly concave in c and l, and satisfies the Inada conditions. g represents government consumption. The per-period utility function $v : \mathbb{R}_+ \rightarrow \mathbb{R}$ is continuous, twice differentiable, strictly increasing in g, strictly concave in g, and satisfies the Inada conditions. $\alpha \in (0, 1)$ is a preference parameter.

The individuals' budget constraint reads as:

$$(1+\tau)c = y, \tag{2.1}$$

where τ is a consumption tax raised by the government. The production of output y is determined by a constant returns to scale production technology $f(l)$, $f : \mathbb{R}_+ \rightarrow \mathbb{R}_+$,

[8]Exogenous one-time utility costs of default are also considered in, e.g., Roch and Uhlig (2018) and Müller et al. (2019).

and is subject to productivity shocks:

$$y = zf(l).$$

Productivity $z \in \mathcal{Z}$ is assumed to have a compact support, $\mathcal{Z} = [\underline{z}, \overline{z}] \subset \mathbb{R}_+$, and to follow a Markov process with transition function $\mu(z', z)$.

The government has access to incomplete international financial markets where it can issue non-contingent one-period bonds b, with $b < 0$ denoting debt. International private creditors are risk-neutral, have perfect information about the stochastic processes in the economy, and borrow at the risk-free interest rate r^f. $q_j(b', z)$ denotes the price of an international private debt contract if party j is in power. We follow Boz (2011) and Fink and Scholl (2016) and assume that, in addition to international debt owed to private creditors, the government has access to financial assistance offered by an (unmodeled) official creditor. If the government decides to enter a bailout program, the official creditor replaces a fraction $\lambda \in (0, 1)$ of the existing debt by official loans at price q^*. In this way, the maturity of a fraction of the existing debt gets extended. In return, the incumbent government is required to adopt austerity measures and to implement a pre-specified fiscal constraint on the primary surplus.

International private debt contracts as well as official debt contracts are not enforceable and the government has the option to default on all outstanding debt obligations. Note that we explicitly incorporate the possibility of a default on official debt which is in contrast to the literature on sovereign debt in emerging markets that assumes seniority of IMF loans, see, e.g., Boz (2011), Fink and Scholl (2016), Hatchondo et al. (2017). We assume limited enforceable official debt contracts to account for the events in summer 2015 when Greece fell into arrears with the IMF. This assumption reflects the ongoing debate on whether Greece will be able to repay its large amount of official debt. In particular, in its January 2013 report, the IMF expresses the need for further fiscal transfers or a substantial haircut on official debt (IMF, 2013).[9] Moreover, the largest share of official loans is provided by the EU and can be interpreted as bilateral loans, which are according to Schlegl et al. (2019) junior to IMF loans. In addition to the direct utility cost of default suffered by the incumbent policymakers, we assume that a sovereign default is associated with a temporary exclusion from international financial markets, as in, e.g., Arellano (2008). Moreover, in financial autarky, the country suffers from output losses, which are particularly relevant for the case of Greece since a default is likely to come along with an exit from the European Monetary Union.

[9]For a further discussion see, e.g., Avgouleas et al. (2018). For the case of Greece, Schumacher and Weder di Mauro (2015) suggest to restructure the official debt by extending grace periods and lowering interest rates. They find a potential need for additional measures due to future liquidity problems.

Conditional on being in a good credit standing, if the government chooses to fulfill the outstanding debt obligations without making use of official financial assistance, the budget constraint of the incumbent j is given by:

$$g + q_j(b', z)b' = \tau c + b. \tag{2.2}$$

If the government enters a bailout program and receives official loans of size λb at price q^*, the government budget constraint reads as:

$$g + q^* \lambda b + q_j(b', z)(b' - \lambda b) = \tau c + b. \tag{2.3}$$

This formulation implies that if the government enters or remains in a bailout program, the maturity of a fraction λ of the existing debt extends by one period. We assume that the price of official loans is given by:

$$q^* = \frac{1}{1 + r^f + k},$$

where k denotes a constant spread between the official lending rate and the risk-free rate. In bad economic times, q^* will be larger than $q_j(b', z)$ such that a bailout program offers a maturity extension as well as an interest rate reduction. In addition to official loans, the government can issue one-period debt from private creditors, $(b' - \lambda b) \leq 0$, where b' denotes total bond holdings.[10]

If the government makes use of a bailout program, the official creditors restrict the government's set of fiscal policy choices by imposing a target ζ on the primary surplus as share of output:

$$\frac{\tau c - g}{y} \geq \zeta.$$

The primary surplus target implies that the borrowing policy of the incumbent government is constrained during a bailout program.

If the government defaults on all outstanding debt obligations, the government is excluded from international financial markets and the budget constraint is given by:

$$g = \tau c. \tag{2.4}$$

The timing is as follows. At the beginning of each period, the incumbent observes the productivity realization z and chooses its optimal policies given the distribution of the

[10] The constraint $(b' - \lambda b) \leq 0$ rules out that the government borrows from official creditors but saves on private international financial markets.

stochastic idiosyncratic ideological aspects. At the end of the period, the ideological aspects realize. Individual i evaluates the idiosyncratic ideological aspects against the expected economic benefit of having the opponent instead of the incumbent in power next period. The individual prefers the opponent to come into power, if the expected continuation value of a political turnover is larger than the expected continuation value associated with the incumbent remaining in office. Details of the political turnover process and the distributional specification of the ideological aspects are described in Section 2.3.2.4.

2.3.2 Recursive Equilibrium

In equilibrium, the individuals take the policy choices of the incumbent government as given and maximize their expected lifetime utility subject to the budget constraint. The incumbent policymaker j takes the private sector equilibrium as given and maximizes the expected lifetime utility of the population, taking into account the utility cost of default as well as the probability of political turnover. Conditional on being in a good credit standing, the incumbent chooses whether to fulfill the outstanding debt obligations, whether to enter, continue or to exit a bailout program and whether to default. Risk-neutral foreign creditors incorporate the risk of default as well as the probability of political turnover when maximizing expected profits. The probability of political turnover is the endogenous outcome of the individual voting behavior. The following subsections describe the maximization problems of the private and the public sector, the zero-profit condition of the foreign creditors, and the details of the political turnover process as well as the distributional specifications of the ideological aspects. The formal definition of the recursive equilibrium is given in Appendix D.

2.3.2.1 The Private Sector

The private sector takes the public sector policies as given and maximizes the expected discounted life-time utility subject to the budget constraint (2.1). Since the tax on consumption is uniform, all individuals choose the same amounts of consumption and labor. The optimality condition of the private sector is given by:

$$-\frac{u_l(c,l)}{u_c(c,l)} = \frac{z f_l(l)}{(1+\tau)}, \tag{2.5}$$

where u_l and u_c are the marginal utility of labor and consumption, respectively, and f_l is the marginal product of labor.

2.3.2.2 The Public Sector

Conditional on being in a good credit standing, the incumbent j chooses between three different options:

$$V_j(b,z) = \max\{V_j^R(b,z), V_j^{CB}(b,z), V_j^D(z) - \chi_j\}. \tag{2.6}$$

$V_j^R(b,z)$ is the value function of incumbent j in case of debt repayment without making use of official financial assistance. $V_j^{CB}(b,z)$ denotes the value function when the incumbent enters or continues a conditional bailout program and honors the debt contracts. $V_j^D(z)$ is the value function associated with default on all debt obligations. $\chi_j > 0$ denotes the one-time utility cost that incumbent j faces when declaring default. Let $\beta \in [0,1]$ denote the discount factor, which is common for all individuals in the economy.

The value function associated with debt repayment solves:

$$\begin{aligned} V_j^R(b,z) = &\max_{\tau,b'} \{(1-\alpha)u(c,l) + \alpha v(g) \\ &+\beta\left((1-P_j(b',z))\int_{z'} V_j(b',z')\mu(z',z)dz'\right. \\ &\left.+P_j(b',z)\int_{z'} \overline{V}_j(b',z')\mu(z',z)dz'\right)\} \end{aligned} \tag{2.7}$$

subject to

$$\begin{aligned} g + q_j(b',z)b' &= \tau c + b \\ (1+\tau)c &= zf(l) \\ -\frac{u_l(c,l)}{u_c(c,l)} &= \frac{zf_l(l)}{(1+\tau)}. \end{aligned}$$

$\overline{V}_j(b',z')$ denotes the value function of party j if the opponent is in office next period and is defined in Appendix D. $P_j(b',z)$ denotes the probability of political turnover if party j is the incumbent, conditional on a good credit standing. The turnover probability is the endogenous outcome of the individuals' voting behavior and is shown to be a function of the newly issued external debt b' and the productivity state z in Section 2.3.2.4. If party j is the incumbent, the borrowing decision at the beginning of the period affects its probability of remaining in power at the end of the period. In addition, the incumbent's borrowing choice affects the opponent's set of policy choices in case a political turnover takes place because the level of external debt is inherited.

If the incumbent enters or continues a bailout program, it receives official loans of size λb at price q^*. In return, the incumbent faces conditionality that enters as a constraint on the primary surplus. The value function associated with a bailout is given by:

$$\begin{aligned} V_j^{CB}(b,z) = &\max_{\tau,b'} \{(1-\alpha)u(c,l) + \alpha v(g) \\ &+\beta \left((1-P_j(b',z)) \int_{z'} V_j(b',z')\mu(z',z)dz' \right. \\ &\left. +P_j(b',z) \int_{z'} \overline{V}_j(b',z')\mu(z',z)dz' \right) \Big\} \end{aligned} \tag{2.8}$$

subject to

$$\begin{aligned} g + q^*\lambda b + q_j(b',z)(b'-\lambda b) &= \tau c + b \\ (1+\tau)c &= zf(l) \\ -\frac{u_l(c,l)}{u_c(c,l)} &= \frac{zf_l(l)}{(1+\tau)} \\ \frac{\tau c - g}{y} &\geq \zeta \\ b' - \lambda b &\leq 0. \end{aligned}$$

Note that if the government makes use of a bailout program, the borrowing policy b' is constrained by the primary surplus target. Consequently, the bailout decision affects the probability of political turnover.

If the incumbent chooses to default, external debt b is not repaid and the economy is excluded from international financial markets and suffers from output losses, $m(z)f(l) \leq zf(l)$. The value function associated with a default on all debt obligations is given by:

$$\begin{aligned} V_j^D(z) = &\max_{\tau} \{(1-\alpha)\, u(c,l) + \alpha v(g) \\ &+\beta \Big[(1-P_j^D(z)) \left(\theta \int_{z'} V_j(0,z')\mu(z',z)dz' + (1-\theta) \int_{z'} V_j^D(z')\mu(z',z)dz' \right) \\ &+P_j^D(z) \left(\theta \int_{z'} \overline{V}_j(0,z')\mu(z',z)dz' + (1-\theta) \int_{z'} \overline{V}_j^D(z')\mu(z',z)dz' \right) \Big] \Big\} \end{aligned} \tag{2.9}$$

subject to

$$\begin{aligned} g &= \tau c \\ (1+\tau)c &= m(z)f(l) \\ -\frac{u_l(c,l)}{u_c(c,l)} &= \frac{m(z)f_l(l)}{(1+\tau)}. \end{aligned}$$

$P_j^D(z)$ denotes the turnover probability if party j is the incumbent, conditional on a bad credit standing. $\theta \in [0,1]$ is the exogenous probability of re-entering international financial markets. $\overline{V}_j^D$ is the value function of party j if the opponent is in office and the economy is in financial autarky. The definition can be found in Appendix D.

The default policy of incumbent j is described by the following indicator function:

$$d_j(b,z) = \begin{cases} 1 & \text{if } V_j^R(b,z) < V_j^D(z) - \chi_j > V_j^{CB}(b,z) \\ 0 & \text{else.} \end{cases}$$

The set of productivity shocks $z \in \mathcal{Z}$ for which incumbent j chooses to default reads as:

$$\mathcal{D}_j(b) = \{z \in \mathcal{Z} : d_j(b,z) = 1\}. \tag{2.10}$$

If party j is in office, the default probability is given by:

$$\eta_j(b',z) = \int_{\mathcal{D}_j(b')} \mu(z',z)dz'. \tag{2.11}$$

The decision of incumbent j whether to enter or to continue a bailout program is described by the following indicator function:

$$h_j(b,z) = \begin{cases} 1 & \text{if } V_j^R(b,z) < V_j^{CB}(b,z) \geq V_j^D(z) - \chi_j \\ 0 & \text{else.} \end{cases}$$

The set of productivity shocks $z \in \mathcal{Z}$ for which incumbent j chooses to make use of official financial assistance reads as:

$$\mathcal{H}_j(b) = \{z \in \mathcal{Z} : h_j(b,z) = 1\}. \tag{2.12}$$

2.3.2.3 International Private Creditors

Conditional on being in a good credit standing, the government can borrow from a large number of identical infinitely-lived risk-neutral international private creditors. International private creditors have perfect information about the realization of productivity shocks and the distribution of idiosyncratic ideological aspects. They borrow or lend from international financial markets at the constant risk-free interest rate r^f. International private creditors internalize the risk of a default as well as the probability of political turnover, which depends on the current incumbent j. As a result of competitive risk-neutral pricing, the bond price function is given by:

$$q_j(b', z) = (1 - P_j(b', z)) \left(\frac{1 - \eta_j(b', z)}{1 + r^f} \right) + P_j(b', z) \left(\frac{1 - \eta_{-j}(b', z)}{1 + r^f} \right). \tag{2.13}$$

$\eta_{-j}(b', z)$ denotes the default probability of the opponent $-j$.

2.3.2.4 Political Turnover

The political turnover probabilities $P_j(b', z)$ and $P_j^D(z)$ are determined endogenously. We follow Scholl (2017) and use the probabilistic voting approach, building on the political economy literature, see, e.g., Persson and Tabellini (2000).

We assume that the two parties differ in the size of the one-time utility cost of default, $\chi_A > \chi_B$. This may be interpreted as different reputational concerns of policymakers, see Chang (2007). Individuals are not affected by these utility costs, but differ in stochastic idiosyncratic ideological aspects, which are independent from economic policy. At the end of each period, individual i evaluates the realization of the idiosyncratic ideological shock against the expected benefit of having the opponent $-j$ instead of the incumbent j in office next period. The expected benefit follows from the comparison of the expected continuation values associated with both parties' policies.

In the following, suppose that party A is the incumbent. Conditional on a good credit standing, the population's expected economic benefit of having the opponent B instead of the incumbent A in office next period is given by:

$$W(b', z) \equiv \int_{z'} V_B^P(b', z')\mu(z', z)dz' - \int_{z'} V_A^P(b', z')\mu(z', z)dz'.$$

where $V_A^P(b, z)$ denotes the population's value function if party A remains in power. $V_B^P(b, z)$ is the population's value function if a political turnover takes place and the incumbent B makes the policy choices next period. $V_A^P(b, z)$ and $V_B^P(b, z)$ are defined in Appendix D.

Define δ_i to be the idiosyncratic ideological bias of individual i towards party A. The general popularity of party A is denoted by ω. We assume that δ_i and ω follow uniform zero-mean distributions with densities ϕ and Ω, respectively. δ and ω are uncorrelated over time.

If party A is the incumbent, individual i wants the opponent B to come into power if the expected economic benefit of having party B instead of the incumbent A in office next period exceeds the idiosyncratic ideological bias towards party A:

$$W(b', z) > \delta_i + \omega.$$

Given the distributional assumptions on the idiosyncratic ideological bias, δ_i, the total share of the population supporting a political turnover when party A is the incumbent is given by:

$$\pi_A(b', z, \omega) = \frac{1}{2} + \phi W(b', z) - \phi\omega.$$

We assume that a political turnover occurs if the oppositional party is favored by a population share larger than ξ. Given the uniform distribution of ω, it follows that the probability of political turnover from party A to party B is given by:

$$\begin{aligned} P_A(b', z) &\equiv Prob_\omega\left[\pi_A(b', z, \omega) > \xi\right] \\ &= \frac{1}{2} + \Omega\left(\frac{\frac{1}{2} - \xi}{\phi} + W(b', z)\right). \end{aligned} \tag{2.14}$$

Equation (2.14) shows that the probability of political turnover depends on the densities of the popularity shocks Ω and the individuals' ideology ϕ. The higher ϕ, the less ideological are the individuals such that economic policies have a larger effect on the probability of political turnover. The lower Ω, the larger are the popularity shocks and the smaller is the impact of economic aspects on the political turnover probability. The likelihood of a government change is decreasing in the required population share ξ favoring the oppositional party.

Similarly, in a bad credit standing, the political turnover probability faced by incumbent A is given by:

$$P_A^D(z) = \frac{1}{2} + \Omega\left(\frac{\frac{1}{2} - \xi}{\phi} + W^D(z)\right), \tag{2.15}$$

where

$$\begin{aligned} W^D(z) \equiv \Bigg[&\theta\left(\int_{z'} V_B^P(0, z')\mu(z', z)dz' - \int_{z'} V_A^P(0, z')\mu(z', z)dz'\right) \\ &+(1-\theta)\left(\int_{z'} V_B^{P,D}(z)\mu(z', z)dz' - \int_{z'} V_A^{P,D}(z)\mu(z', z)dz'\right)\Bigg]. \end{aligned}$$

2.4 Quantitative Analysis

2.4.1 Calibration

In our quantitative analysis, we apply our model to the Greek economy, considering the time period from 1998 to 2016. In the following, we specify the functional forms and calibrate the parameters to match specific empirical targets. Table 2.1 summarizes the calibration strategy and differentiates between the externally and internally calibrated parameter values. We employ annual series for real GDP, real private consumption, real government consumption, and interest rates, which are taken from the OECD Annual National Accounts. Furthermore, we use annual series for the budget deficit and primary balance from the IMF World Economic Outlook Database. We calculate the interest spread as the difference between the interest rate on Greek and German 10-year bonds.

Following Greenwood et al. (1988), we specify the per-period utility functions as:

$$\begin{aligned} u(c,l) &= \frac{\left(c - \frac{l^{1+\psi}}{1+\psi}\right)^{1-\gamma}}{1-\gamma}, \\ v(g) &= \frac{g^{1-\gamma}}{1-\gamma}, \end{aligned}$$

where $\gamma > 0$ denotes the parameter of relative risk aversion and ψ is the inverse of the intertemporal labor elasticity. We set ψ to 0.455, which is a standard value in the literature (see, e.g., Mendoza (1991), Neumeyer and Perri (2005), and Cuadra et al. (2010)). The coefficient of relative risk aversion γ is chosen to be equal to 2. The public good weight α is calibrated internally to match the average ratio of government consumption to private consumption of 31.24%. The annual risk-free interest rate of 3.2 percent corresponds to the average interest rate on German 10-year government bonds between 1998 and 2016.

Table 2.1: Calibration to the Greek Economy

	Parameter	Value	Source/Target
Externally calibrated parameters			
γ	Relative risk aversion	2.0	Standard value
ψ	Inverse labor supply elasticity	0.455	Mendoza (1991), Neumeyer and Perri (2005)
r^f	Risk-free rate	0.032	Mean interest on German 10-year government bonds
θ	Redemption probability	0.25	Gelos et al. (2011)
ρ_z	Productivity	0.83	Autocorrelation of real GDP
λ	Share of official debt	0.71	Share of public debt owed to official creditors in 2015
$1/q^* - 1$	Official interest rate	0.037	Mean spread between official loans and risk free rate
ζ	Conditionality constraint	0.0192	Mean primary surplus target
ξ	Vote threshold for turnover	0.6940	Mean government approval prior to a political turnover
Internally calibrated parameters			
α	Public good weight	0.77	Mean ratio of government to private consumption
β	Discount factor	0.87	Bailout participation rate
η	Asymmetric output cost	0.94	Mean improvement in budget balance after entering bailout
χ_A	Default utility cost, party A	0.6	Mean sovereign spread
χ_B	Default utility cost, party B	0.2	Standard deviation of sovereign spread
ϕ	Idiosyncratic ideology	9	Political turnover frequency during bailouts
σ_ϵ	Standard deviation of ϵ	0.015	Standard deviation of real GDP

We follow Cuadra et al. (2010) and assume that the production function is linear in labor, $f(l) = l$. Productivity shocks follow an AR(1) process:

$$\log(z') = \rho_z \log(z) + \epsilon,$$

where ϵ is i.i.d. $N(0, \sigma_\epsilon^2)$. We take the empirical autocorrelation of 0.83 as value for the parameter ρ_z and calibrate σ_ϵ internally to match the standard deviation of the annual Greek GDP between 1998 and 2016.

In our model, entering a bailout program allows the incumbent government to replace a fraction λ of existing debt by official debt at interest rate $1/q^* - 1$. We set the spread between the interest rate on official loans and the risk-free rate to 0.5%. This value corresponds to the lower bound of margins and fees demanded by the institutions, see Appendix E. In 2015, 71% of Greek public debt was owed to official creditors (IMF, 2016). We use this value to determine the share of official loans and set λ equal to 0.71. The provision of official loans is accompanied by conditionality in terms of restrictions on the primary surplus. The second and third bailout programs specify target values between -1% and 4.5%. Between 2016 and 2018, the average target value for the primary surplus was 1.92% of GDP (see European Commission, 2015 and Appendix E). Correspondingly, in the conditionality constraint, we set ζ equal to 0.0192 in our benchmark calibration. To study the interaction between conditionality and political turnover, we consider variations of ζ and carefully analyze the impact of conditionality on the variables of interest.

The incentives whether to default or to enter a bailout program are crucially affected by the default costs. In our model, the two parties face default utility costs χ_A and χ_B. In addition, following Arellano (2008), after a default, the government is temporarily excluded from international financial markets and faces an asymmetric output cost:

$$m(z) = \begin{cases} \eta E(z) & \text{if } z > \eta E(z) \\ z & \text{else,} \end{cases}$$

with $\eta \in (0,1)$. The probability of re-entering international financial markets θ is set externally to 0.25, which implies an average market exclusion of four years. This value lies within the range of estimates by Gelos et al. (2011). The parameters χ_A, χ_B, η, and the discount factor β affect the default risk, the bailout participation rate, and the budget balance. We calibrate these four parameters internally to match the following four targets. First, our model simulations replicate the empirical mean and volatility of the sovereign interest spread between 1998 and 2016. Second, we match the empirical bailout participation rate of 36.84%. This rate follows from the fact that between 1998 and 2016 Greece has been in bailout programs in 7 out of 19 years. Third, we match the mean improvement in the budget balance that occurs if a government makes use of official loans. In Greece, after entering the bailout program in 2010, the budget balance improved on average by 1.84% of GDP compared to the period from 1998 to 2009.

In our model, a political turnover takes place if the oppositional party is favored by a population share larger than ξ. We determine this threshold value from the *Public Issue* election polls and consider the average government approval during the three months prior to a political turnover. Between 2010 and 2016, prior to the two political turnovers in November 2011 and January 2015[11] the mean government approval was 30.60%. Accordingly, the threshold ξ is set to 0.6940. We assume the same distributions for the idiosyncratic ideology ϕ and the average popularity Ω. We calibrate Ω to match the turnover frequency in Greece during the bailout episode, which corresponds to two political turnover during the 7 years of bailout participation.

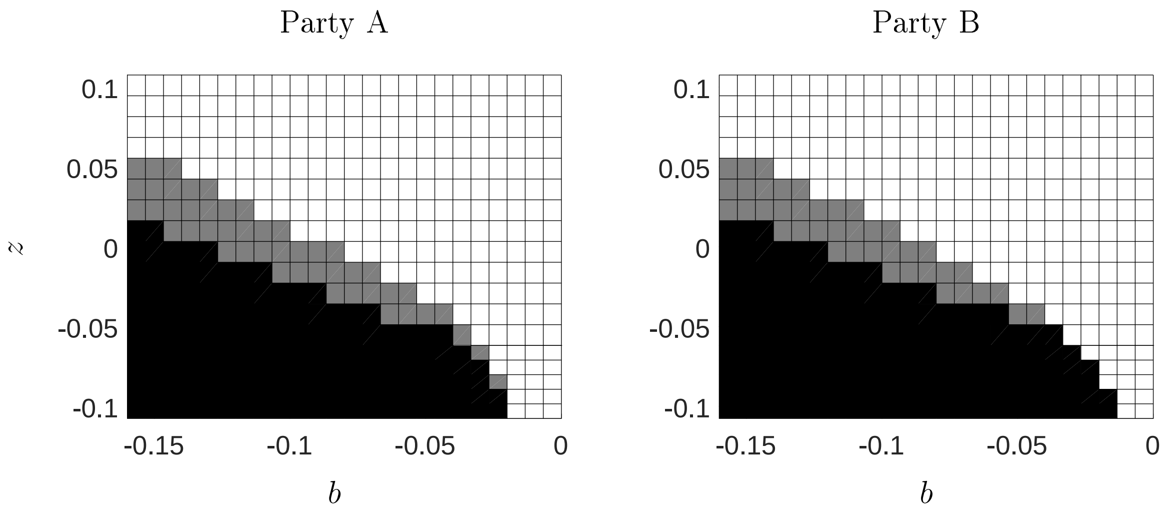
2.4.2 Policy Functions

We first consider the optimal decisions of the two parties regarding whether to repay without using official loans, or whether to enter/remain in a bailout program, or whether to default on all outstanding debt obligations. The left panel of Figure 2.2 presents the optimal policies of party A for different productivity realizations z and debt levels b. The right panel displays the policy decisions of party B. In the black areas, the parties choose to default on their debt obligations. The states in which they repay or enter/remain in a conditional bailout program are represented by the white and grey areas, respectively. The panels reveal that default is optimal for low productivity realizations and high debt levels. When indebtedness is low and productivity is high, both parties choose to repay their debt. In the intermediate states the government makes use of a bailout program accepting conditionality as a constraint on its fiscal policy choices. Clearly, party A is more reluctant to default than party B since it faces a higher utility cost of default. Comparing the two panels, it turns out that party B uses official financial assistance at lower debt levels than party A. Moreover, party B exits the bailout programs at lower levels of debt and for less adverse productivity realizations than party A.

Figure 2.3 plots the bond price functions and the political turnover probabilities as functions of borrowing b' if party A (solid blue lines) or party B (solid red lines) is the incumbent. The left (right) column refers to a productivity realization of 3.6% below

[11] As described in Section 2, in November 2011, Papandreou resigned and was followed by cabinets supported by PASOK and ND. In January 2015, a government change from PASOK and ND to SYRIZA and ANEL took place.

Figure 2.2: Default Set, Repayment Set, Bailout Set



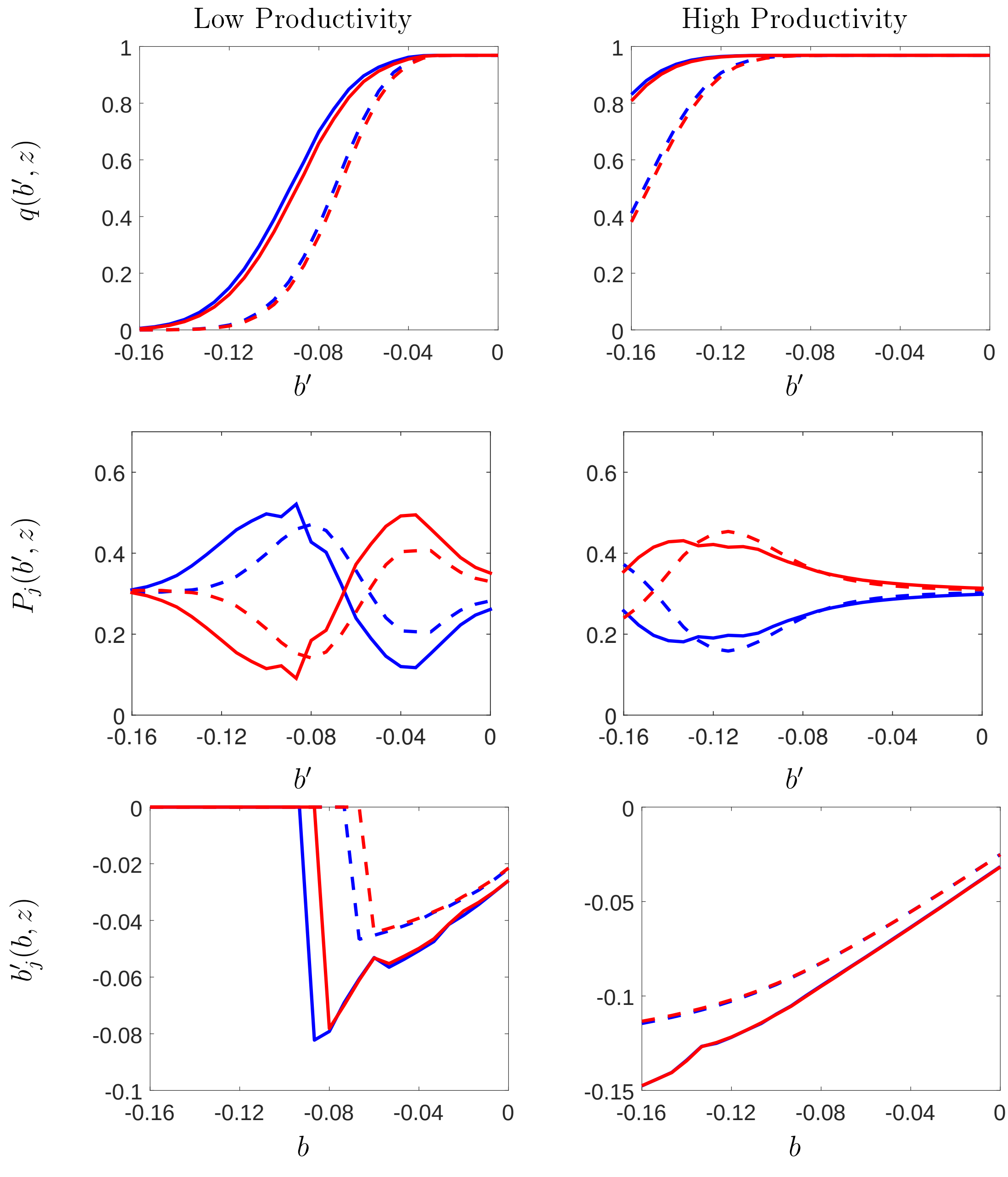
Notes: This figure displays the default set, the repayment set, and the bailout set for the benchmark calibration. The black and the grey areas denote the combinations of productivity z and government debt b for which the incumbent party $j = A, B$ chooses to default or to make use of a bailout program, respectively. In the white area, the incumbent repays its debt without using official loans.

(2.9% above) the trend. The figure reveals that bond prices are decreasing in the level of borrowing and increasing in productivity. With low borrowing, both parties never find it optimal to default such that bond prices are equal to the inverse of the risk-free rate. The default probability increases as more debt is issued, which is reflected in the decreasing pattern of the bond price. Moreover, the bond prices increase in productivity, since lower productivity negatively affects the ability to repay debt. Due to a higher default utility cost, party A is more reluctant to default than party B and faces lower credit costs.

For low productivity and high borrowing, both parties face equal turnover probabilities since both are expected to default at these states. The same occurs for low borrowing given high productivity since both parties are likely to repay their debt in these states. Whenever the parties choose the same policies, the turnover probability converges towards 30.60%, which reflects the required share of votes for a political turnover of 69.40% in the benchmark specification. For high productivity and high borrowing as well as for low productivity and low borrowing, party B faces a larger turnover probability than party A because it faces greater credit costs such that it has to choose a higher tax rate and lower level of government consumption.[12] In case of an adverse productivity realization, the pattern of the turnover probability changes if borrowing increases. For high debt, party B is likely to default while party A makes use of a conditional bailout. In these states, to party A the costs from conditionality are

[12]Note that this result is in line with Scholl (2017) who finds a similar pattern for a vote threshold of 50%.

Figure 2.3: Bond Prices, Political Turnover and Borrowing: Bailout vs. No Bailout



Notes: In the upper panels, the blue (red) lines represent the bond prices and turnover probabilities of incumbent party A (incumbent party B) for different borrowing choices b'. In the lower panels, the blue (red) lines represent the optimal borrowing policies of incumbent party A (B). Solid (dashed) lines refer to the model with (without) access to bailout programs. In the left column, productivity is 3.6% below the trend. High productivity refers to levels 2.9% above trend. All panels are based on the benchmark calibration.

lower than the default costs. However, conditionality is costly to the households as the constraint on the primary surplus forces the incumbent to reduce public spending and to raise the tax rate. Since they are not affected by the policymaker's utility cost of default, more agents favor a default. In consequence, more individuals prefer the economic policies of party B and the probability of a political turnover from A to B increases.

The lower panels of Figure 2.3 plot the optimal borrowing decisions of incumbent party A (solid blue line) and B (solid red line) given a low and high productivity realization. For high levels of debt, both parties find it optimal to default while they find it optimal to repay if debt is low. The higher default risk of party B raises its borrowing costs and makes party B more borrowing constrained than party A. As shown in Figure 2.2, for intermediate values of debt, the incumbent government enters a bailout program. The constraint on the primary surplus strongly reduces the issuance of new debt and makes the borrowing function steeper.

How do the policy functions look like if the government does not have access to official financial assistance? The dashed lines in Figure 2.3 refer to a counterfactual economy in which no bailout option is available. The pattern of the bond price reveals the insurance character of bailouts: For a given issuance of new debt, the availability of loans below the market rate reduces the default probability. Consequently, international private creditors charge a lower premium compared to the scenario in which no bailouts are available.

It turns out that the presence of bailouts intensifies the pattern of the turnover probability. If productivity is low, bailouts make it more likely that party A stays in power for low and medium levels of debt, while bailouts increase party A's probability of losing power if debt is high. The underlying mechanism is as follows. The existence of bailout programs provides insurance and reduces credit costs, which increases party A's popularity in regions of debt in which default is not optimal for either party. In contrast, if the government is severely indebted, party A is more likely to make use of a bailout program than party B who prefers to default instead. Because official loans come at the cost of conditionality requiring tax hikes and spending cuts, more households find a political turnover from party A to party B beneficial.

The optimal borrowing decision reveals that in the economy without bailouts, both parties are more borrowing constrained and optimal borrowing is substantially lower.

2.4.3 Cyclical Properties

In this section, we analyze whether our model replicates the cyclical properties of the Greek economy. The first column of Table 2.2 summarizes the business cycle statistics of the Greek data. We consider the time period from 1998 to 2016 and HP-filter the relevant time series with a smoothing parameter of 100. In column (2), we report the cyclical properties of our simulated benchmark economy. To provide a meaningful comparison with the data, out of a simulation of 1 million years[13] we consider episodes of at least 19 consecutive years in which the country is in a good credit standing and in which party A is initially in office.

Overall, the model provides a good description of the cyclical characteristics of the Greek economy. In particular, the targeted statistics such as the volatility of output, the mean of the sovereign interest spread, the bailout participation rate, and the mean ratio of public to private consumption are well matched. In line with the data, the sovereign interest spread is very volatile, however, the model slightly overstates the standard deviation. As reported in the literature, e.g., Arellano (2008) and Cuadra et al. (2010), the sovereign interest spread is counter-cyclical while fiscal policy is pro-cyclical. Moreover, consumption is more volatile than output. As most other models of sovereign debt and default, the model cannot match the huge budget deficit of the Greek government, but it replicates the improvement in the budget balance after entering the bailout programs.[14]

[13] We cut off the first 100 years to focus on the invariant distribution.

[14] One way to increase the level of debt is to allow for long-term bonds provided by private creditors, see, e.g., Hatchondo and Martinez (2009). This, however, would substantially increase the complexity of our model given that we allow for official loans and politico-economic aspects.

Table 2.2: Business Cycle Statistics

	Data	Benchmark	No Bailout	No Political Turnover	
				Party A	Party B
	(1)	(2)	(3)	(4)	(5)
$\sigma(y)$	5.14	5.14	5.12	5.08	5.11
$\sigma(c)/\sigma(y)$	1.02	1.11	1.08	1.11	1.11
$\sigma(g)/\sigma(y)$	0.88	1.51	1.53	1.48	1.55
$E(g/c)$	31.24	31.53	31.36	31.52	31.47
$\rho(c,y)$	0.96	1.00	1.00	1.00	1.00
$\rho(g,y)$	0.87	0.97	0.97	0.98	0.97
$\rho(nx/y,y)$	−0.61	−0.59	−0.68	−0.58	−0.61
$\rho(s,y)$	−0.54	−0.59	−0.75	−0.60	−0.63
$\sigma(s)$	5.62	6.55	1.27	5.96	5.69
$E(s)$	4.40	4.07	1.13	3.74	3.87
$E(s)$, if party A is in office	–	3.97	1.08	3.74	–
$E(s)$, if party B is in office	–	4.33	1.24	–	3.87
Mean budget balance (% of GDP)	−6.73	−0.46	−0.11	−0.46	−0.41
Mean budget balance, if party A is in office	–	−0.60	−0.16	−0.46	–
Mean budget balance, if party B is in office	–	−0.16	−0.03	–	−0.41
Mean improvement of budget balance in bailout	1.84	2.16	–	2.14	2.69
Mean $P(b',z)$, if party A is in office	–	20.25	21.17	0.00	–
Mean $P(b',z)$, if party B is in office	–	41.35	40.06	–	0.00
Frequency party A in office (in %)	–	69.43	66.33	100	–
Political turnover frequency, overall	21.05	26.58	27.51	–	–
Political turnover frequency, during bailouts	28.57	28.78	–	–	–
Mean bailout probability	36.84	36.41	–	36.42	34.89
Welfare effect of bailouts in consumption equivalents	–	1.22	–	1.12	1.09

Notes: Column (1) is based on annual OECD and IMF data and considers the time period from 1998 to 2016. y, c, g refer to real output, real private consumption, and real government consumption, respectively. y, c and g are HP-filtered with a smoothing parameter of 100. s refers to the sovereign interest spread measured as the percentage difference between the interest rates on Greek and German 10-year bonds. Shares and probabilities are given in %. The political turnover frequency refers to the percentage share of years in which a government change took place. Elections took place in 2000, 2004, 2007, 2009, May and June 2012, January 2015, and September 2015. Government changes were observed in 2004, 2009, 2011, and January 2015. Columns (2) to (5) are based on a simulation of 1 million years where the first 100 years are omitted. Column (2) considers episodes of at least 19 consecutive years in which the country is in a good credit standing and in which party A is initially in office. Column (3) refers to a counterfactual economy in which no bailout option is available. Columns (4) and (5) refer to the model without political turnover. All statistics refer to averages across simulated episodes.

Our calibration strategy targets the average frequency of political turnover during bailout episodes, which amounts to 28%.[15] If we consider the complete time period, the turnover rate drops to 26%. The model prediction that bailout episodes are characterized by a higher frequency of political turnover reflects the Greek experience. Note, however, that the increase in political turnover is underestimated by the model. In line with the policy functions shown in Figure 2.3, party A faces a lower sovereign interest spread than party B. Consequently, party A is less borrowing constrained and issues more debt, which is reflected in larger budget deficits. Because of lower credit costs, party A is more often in power and faces a lower probability of losing power than party B.

To study the impact of bailouts on sovereign default risk and political turnover, we report the statistical properties of the counterfactual economy in which bailouts are not provided (column (3)). In line with the policy functions shown in Figure 2.3, in the counterfactual economy, higher sovereign default risk translates into higher credit costs making the government borrowing constrained. Therefore, the mean budget deficit is smaller than in our benchmark economy. Similar to Fink and Scholl (2016) and Kirsch and Rühmkorf (2017), our analysis shows that the insurance character of bailouts generates lower credit costs, which allows the government to accumulate more debt in general equilibrium. In consequence, in our benchmark economy, a higher debt level increases the sovereign interest spread in general equilibrium.

As seen in Figure 2.3, the impact of bailouts on the probability of political turnover depends on the amount of borrowing. The borrowing policy, in turn, is affected by the conditions attached to the provision of official loans, i.e., the constraint on the primary surplus. A comparison of the invariant distributions of the benchmark economy and the counterfactual economy reveals that bailouts decrease party A's and increase party B's probability of losing power. Consequently, in the benchmark economy, party A is more often in power and the overall political turnover rate is lower compared to the counterfactual economy in which bailouts are not available. This result, however, depends on the strength of conditionality. In the benchmark economy, conditionality requires the incumbent government to implement a primary surplus target of 1.92%. In Section 2.4.5 we will see that weak conditionality in terms of a lower primary surplus target allows more borrowing and raises the overall political turnover rate compared to the counterfactual economy in which no bailouts are available.

To assess the welfare effects of bailouts, we compare the lifetime utility of the population in the benchmark economy and the counterfactual economy in which bailouts are not provided. We follow Durdu et al. (2013) and calculate the welfare gain as the equivalent

[15] In our simulations, we consider bailout epsiodes of at least 4 consecutive years.

variation in consumption net of disutility of labor Δ, given as

$$\Delta = \left(\frac{V^0(*)}{V^0(\circ)}\right)^{\frac{1}{(1-\sigma)}} - 1,$$

where V^0 denotes the expected lifetime utility of the population, and '$*$' and '$\circ$' refer to the model with access to official financial assistance and the model without bailouts, respectively. For the benchmark calibration, bailouts raise welfare by 1.22%, measured in consumption equivalents. Note that this welfare analysis abstracts from potential losses of official creditors.

2.4.4 The Dynamics of Bailouts and Political Turnover

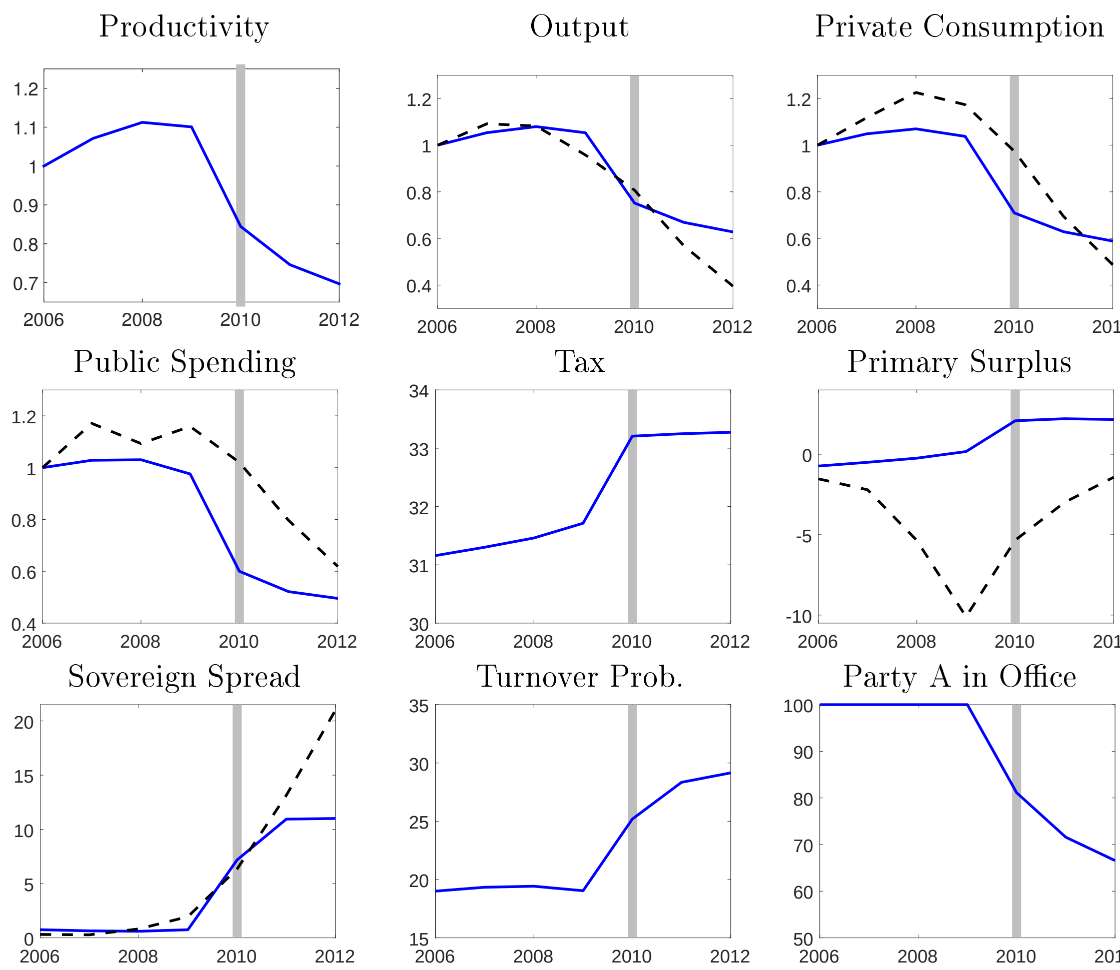
In this section, we study the interaction between bailouts and political turnover. We proceed in two steps. First, we analyze the dynamics of the economy in a bailout episode and compare it to the data. Second, we analyze the role of political turnover risk by studying the properties of a counterfactual economy in which political uncertainty is absent and the incumbent party remains in office forever.

First, we set up an event study that reproduces the Greek scenario regarding the bailout package of May 2010. To do so, in our model simulation, we consider episodes in which party A has been in office during the four years prior to the bailout program. Moreover, we assume that there is no bailout and no default before $t = 0$. We focus on bailout episodes that last for at least three years.

Figure 2.4 presents the macroeconomic dynamics around the bailout entry at $t = 0$ and shows average productivity, output, private consumption, and public spending. The variables are normalized to 1 in the initial period to facilitate a comparison with the data. The tax rate, the sovereign interest spread, and the turnover probability are displayed in percent. 'Party A in office' represents the percentage share of cases in which party A is the incumbent. The dashed lines refer to the empirical dynamics observed in Greece between 2006 and 2012.

In the years before the bailout, a rise in productivity increases production and consumption. Because of the good economic conditions the sovereign interest spread is low. The government can keep the tax rate at a moderate level such that the probability of political turnover is low. Since the government is not borrowing constrained, the primary surplus is negative and the government issues debt. At the time of the start of the bailout program, there is a decline in productivity, which reduces the ability of the government to repay and raises the sovereign interest spread. Conditionality requires the incumbent to fulfill the constraint on the primary surplus such that the tax rate rises and government spending decreases. In consequence, the probability of political

Figure 2.4: Event Analysis: Bailout



Notes: The solid lines consider bailout episodes out of a model simulation of 1 million years, where the first 100 are cut off. Only episodes are considered in which party A has been in office during the four years prior to the bailout. The bailout lasts for at least three years and there is no bailout and no default before $t = 0$. The dashed lines refer to Greek data from 2006 to 2012. The average values of productivity, output, private consumption, and public spending are shown and normalized to 1 in the initial period, while the averages of the sovereign interest spread, the tax rate, and the turnover probability are displayed in percent. The primary surplus is given as share of output. 'Party A in office' is the percentage share of cases in which party A is in power.

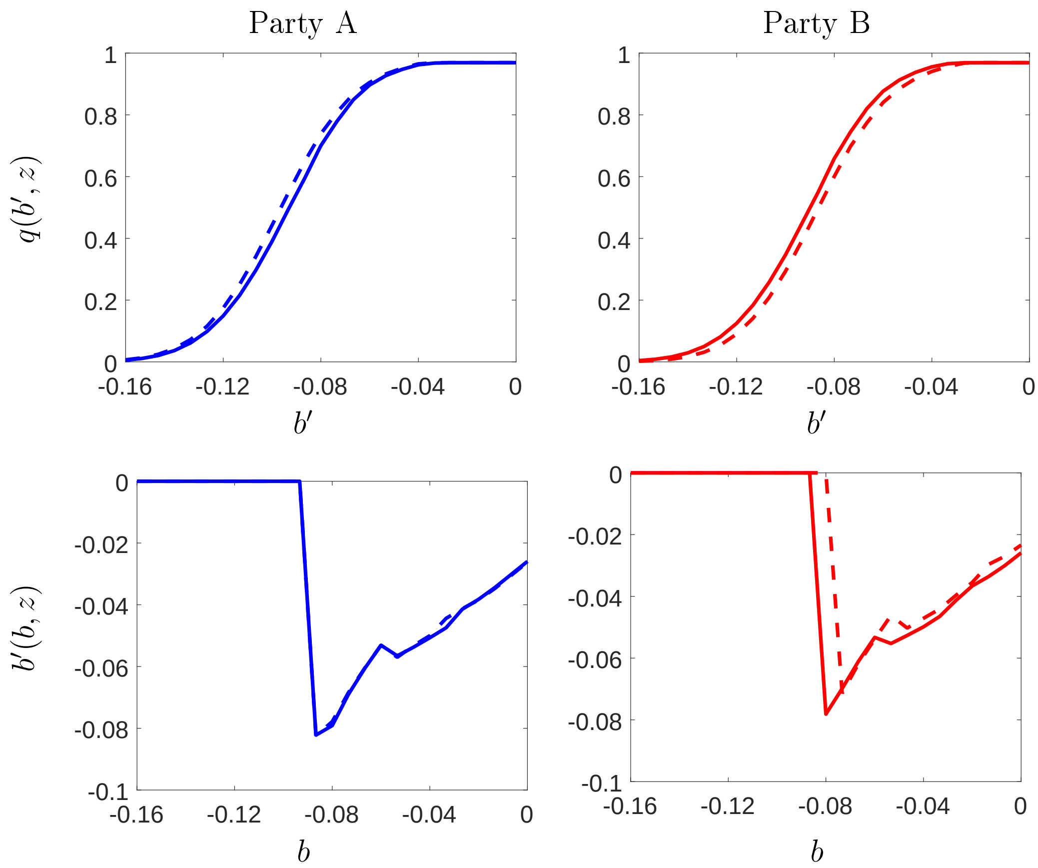
turnover increases and the percentage of cases in which party A is still the incumbent after entering the bailout program drops. Since party B is more likely to default, the sovereign interest spread rises even further.

Overall, the model matches the Greek pattern of output, private consumption, public spending, and the sovereign interest spread well. In particular, the model is in line with the fact that Greece was experiencing low sovereign interest spreads and positive growth rates of GDP, private consumption, and government consumption prior to the bailout of 2010. Moreover, the model replicates the fact that political turnover rates were low until 2009 and substantially increased after the government entered the bailout program. In line with the data, the model predicts that the sovereign interest spread rises during the bailout. However, quantitatively, the increase is underestimated. The model replicates the improvement in the primary surplus after entering a bailout program, but fails to match its absolute size. The empirical pattern of the primary surplus suggests that the targets specified by the European institutions and the IMF were not fulfilled. This is in line with Eichengreen and Panizza (2016) who show that large budget surpluses for longer time periods are very unlikely to be achieved. Moreover, as argued by Dovis and Kirpalani (2020), fiscal rules may be difficult to enforce. Therefore, in Section 2.4.5, we vary the parameterization of the primary surplus target and study how the strength of conditionality affects the variables of interest.

To study the role of political turnover during a bailout episode and to quantify the impact of political risk on the sovereign interest spread, we proceed by considering a counterfactual economy in which the incumbent party remains in power forever with certainty. Figure 2.5 considers a productivity realization of 3.6% below the trend and displays the policy functions of the economy without political turnover (dashed lines) in comparison with the policy functions of the benchmark economy (solid lines). The policy functions reveal that for a given b', the absence of political turnover risk reduces party A's credit costs. Party B, however, defaults at lower levels of debt and faces a higher sovereign interest rate compared to the benchmark economy. In columns (4) and (5) of Table 2.2 we report the cyclical properties of the invariant distribution if party A or party B is in power forever. In line with the policy functions, without political turnover risk, party A faces on average a lower sovereign interest spread than party B. Moreover, party A's sovereign interest spread is lower compared to the benchmark economy in which parties face the risk of losing power. Note that in the absence of political turnover risk, the average sovereign interest spread of party B is lower than in the benchmark economy. The reason is that with endogenous political turnover, party B comes into power in bad economic times in which credit costs are high.

To quantify the impact of political turnover on the sovereign interest spread during a

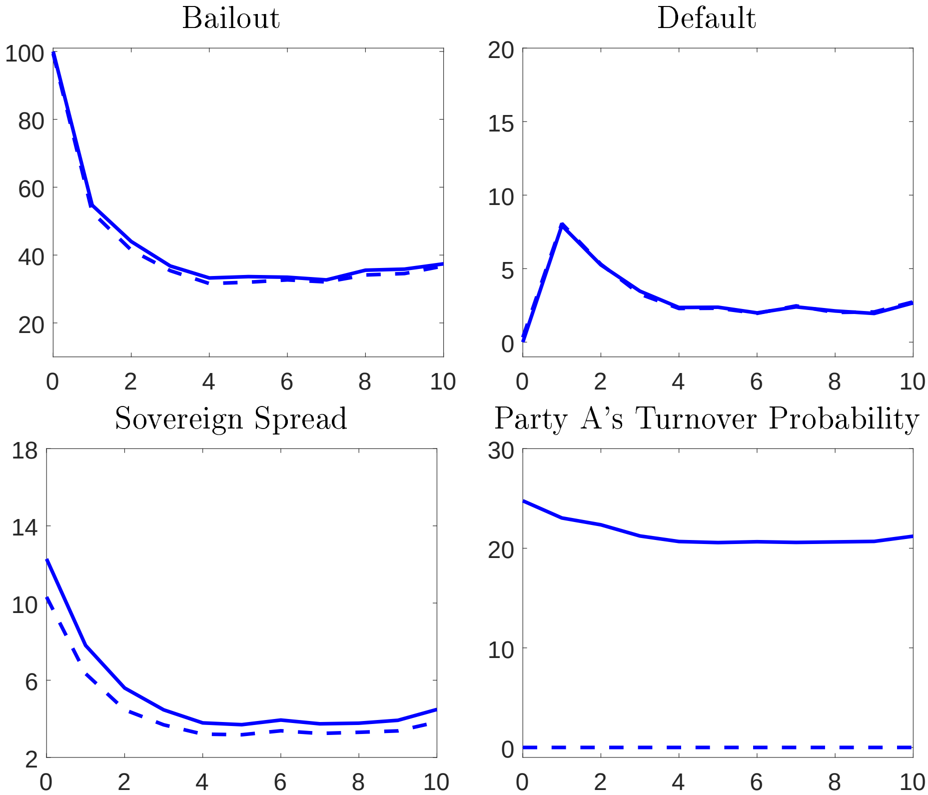
Figure 2.5: Bond Prices and Optimal Borrowing: The Role of Political Turnover



Notes: In the upper panels, the blue (red) lines represent the bond prices of incumbent party A (incumbent party B) for different borrowing choices b'. In the lower panels, the blue (red) lines represent the optimal borrowing policies of incumbent party A (B). Solid (dashed) lines refer to the benchmark model (the model without political turnover). All panels refer to productivity 3.6% below the trend.

bailout, we consider the following scenario. As initial situation, we take the average level of debt of our benchmark economy and assume that party A is in power. We simulate 100,000 of different productivity series and select the ones for which party A makes use of a bailout at time $t = 0$ and continuously stays in power for the subsequent 10 years. We then feed these productivity series into the counterfactual economy in which party A does not face political turnover risk and stays in power forever. We simulate the two economies and display the dynamics in Figure 2.6. For the benchmark economy (solid lines) and the counterfactual economy (dashed lines) we show the percentage of cases in which party A remains in the bailout program and the percentage of cases in which party A chooses to default. We also report the sovereign interest spread and the political turnover probability of party A. Our results highlight that party A's probability of losing power increases temporarily after entering a bailout program, which raises the sovereign interest spread. Compared to the counterfactual economy without political uncertainty, the risk of a political turnover from party A to

Figure 2.6: Political Turnover and Bailouts



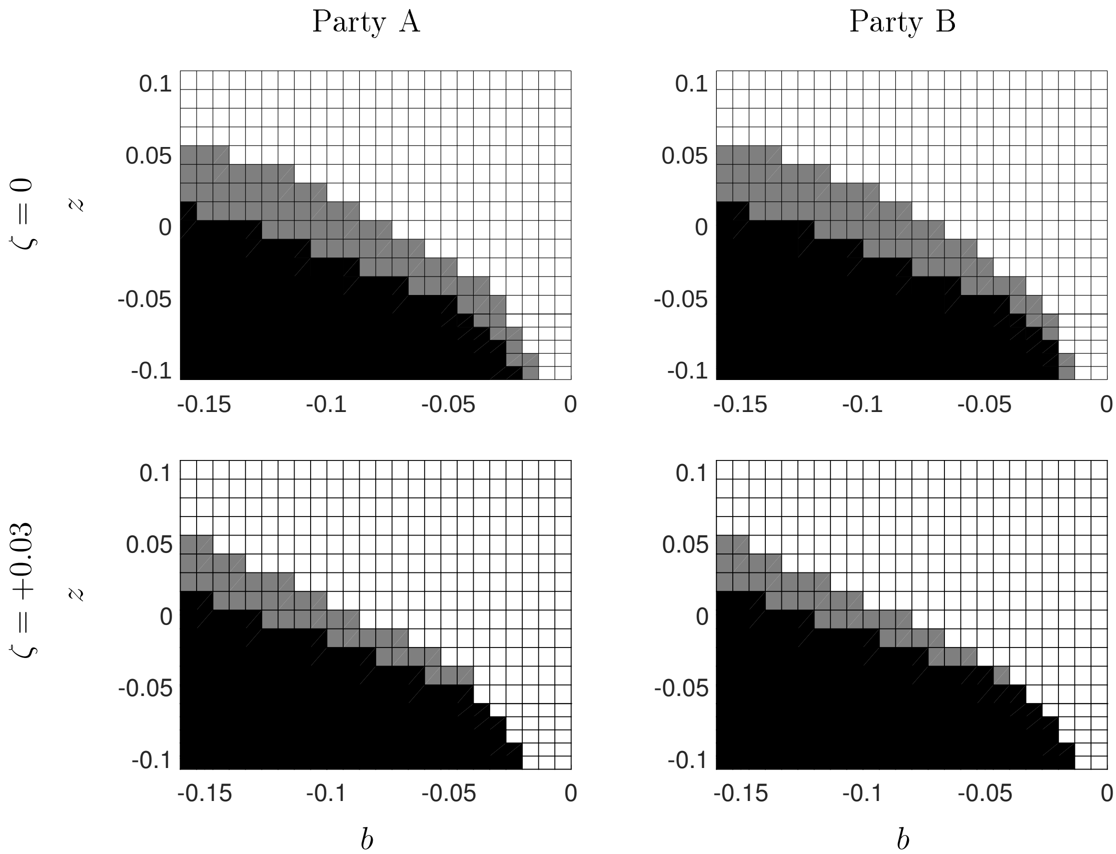
Notes: As initial situation, this figure considers the average level of debt of the simulated benchmark economy and party A as incumbent. Out of a simulation of 100,000 of different productivity series those are selected for which party A chooses a bailout at time $t = 0$ and continuously stays in power for the subsequent 10 years. These productivity series are fed into a counterfactual economy in which there is no political turnover and party A stays in office forever. The figure shows the percentage of cases in which party A remains in the bailout program, the percentage of cases in which party A chooses to default, the sovereign interest spread, and party A's probability of losing power. Solid (dashed) lines refer to the benchmark economy (counterfactual economy without political turnover risk).

party B elevates the sovereign interest spread by 1.97 percentage points at date $t = 0$.

2.4.5 The Impact of Conditionality on Sovereign Default Risk and Political Turnover

In this section, we study how the strength of conditionality affects sovereign default risk and political turnover. To do so, we vary the target on the primary surplus between -4% and $+8\%$ of GDP. We proceed in three steps. First, we analyze the impact of a tighter fiscal constraint on the policy functions of party A and B. Then, we study how conditionality influences sovereign default risk and political turnover in the long run. Finally, we analyze how the tightness of the fiscal constraint affects the bailout decision and political turnover risk in the short.

Figure 2.7: Default Set, Repayment Set, Bailout Set: $\zeta = 0$ vs. $\zeta = +0.03$

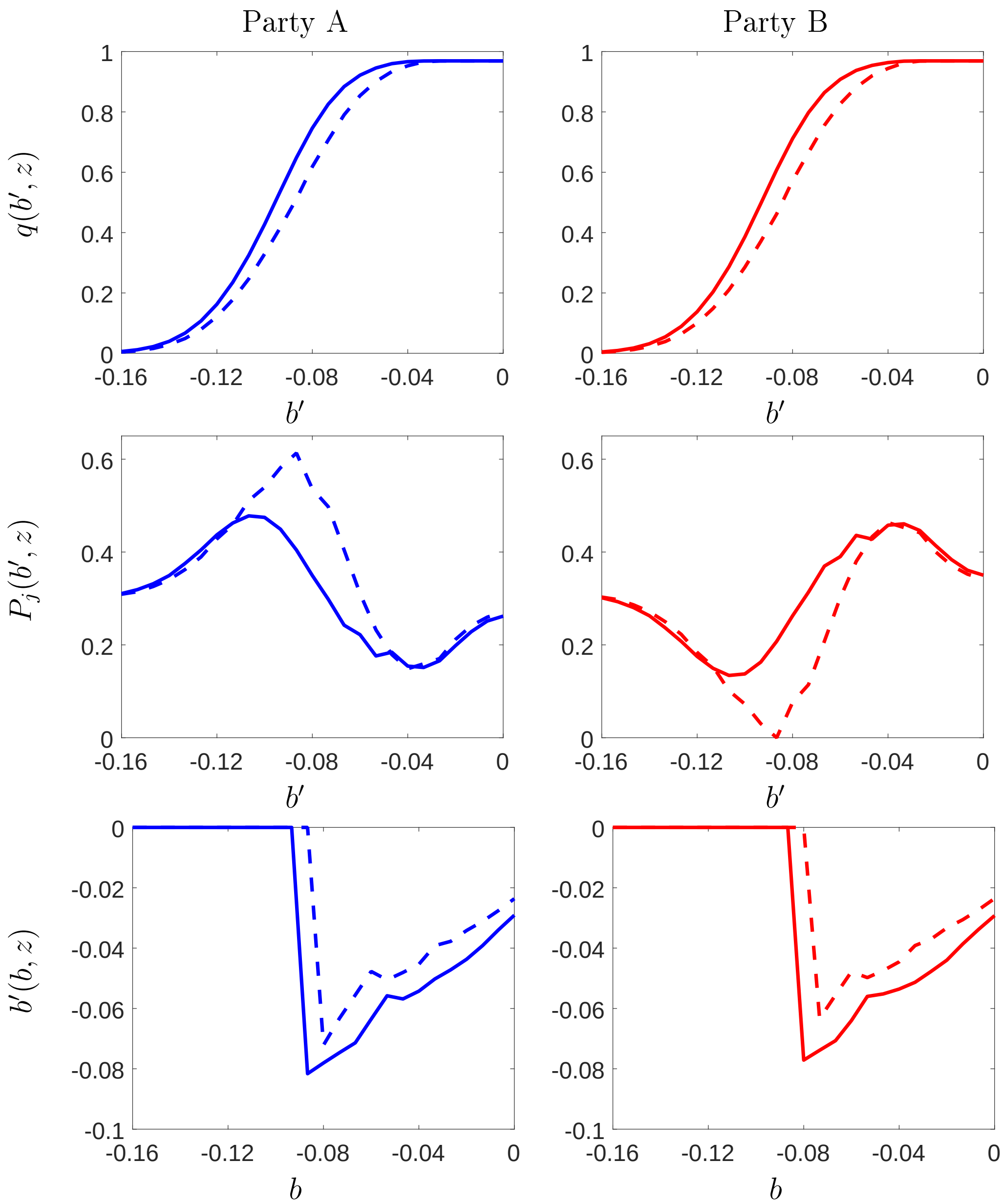


Notes: This figure considers $\zeta = 0$ and $\zeta = +0.03$ and displays the default set, the repayment set, and the bailout set. The black and the grey areas denote the combinations of productivity z and government debt b for which the incumbent party $j = A, B$ chooses to default or to make use of a bailout program, respectively. In the white area, the incumbent repays its debt without using official loans.

Figure 2.7 considers $\zeta = 0$ and $\zeta = +0.03$ and presents the decision of incumbent A and B whether to repay outstanding debt without using official loans, or whether to enter/remain in a bailout program, or whether to default. Clearly, stricter conditionality shrinks the bailout set such that default is chosen at lower levels of debt and for higher productivity realizations.

In Figure 2.8 we consider a low productivity realization (3.6% below trend) and compare the policy functions associated with weak conditionality $\zeta = 0$ (solid lines) and severe conditionality $\zeta = +0.03$ (dashed-dotted lines). The left (right) column refers to the policy functions if party A (B) is the incumbent. A stricter fiscal constraint increases the cost of conditionality and the incumbent is more likely to exit the bailout program by choosing default. In consequence, international private creditors charge higher interest rates on sovereign debt. Higher credit costs in combination with a tighter target on the primary surplus make the government more borrowing constrained such that

Figure 2.8: Bond Prices, Political Turnover and Optimal Borrowing: The Role of Conditionality



Notes: In the upper panels, the blue (red) lines represent the bond prices and turnover probabilities of incumbent party A (incumbent party B) for different borrowing choices b'. In the lower panels, the blue (red) lines represent the optimal borrowing policies of incumbent party A (B). Solid (dashed) lines refer to weak conditionality $\zeta = 0$ (severe conditionality $\zeta = +0.03$). All panels refer to productivity 3.6% below the trend.

the borrowing function becomes steeper. Moreover, stricter conditionality makes the pattern of the political turnover probability more pronounced, in particular for debt levels that are within the region in which the government chooses a bailout.

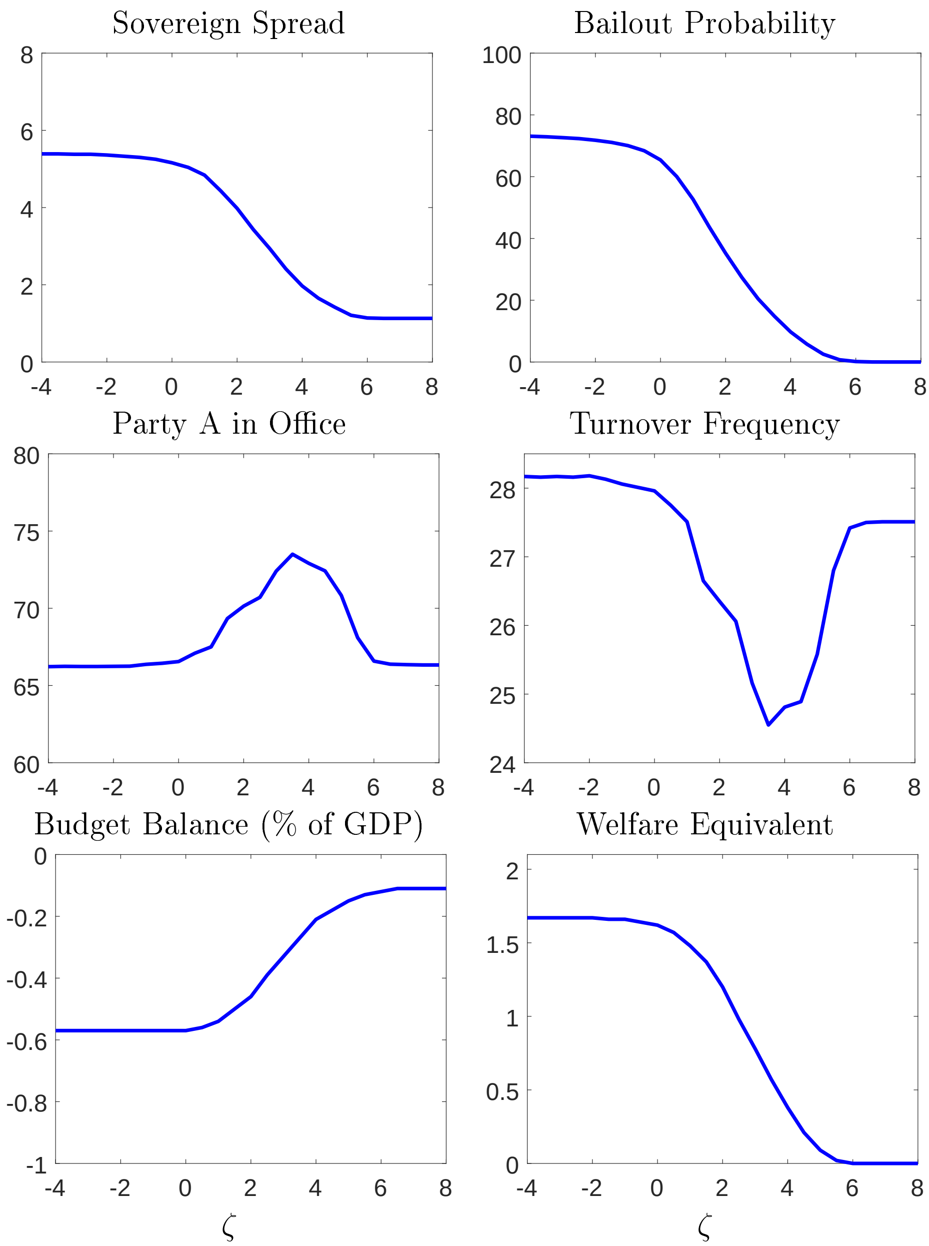
In Figure 2.9 we consider different values of ζ and simulate our model for 1 million years. We consider episodes of at least 19 consecutive years in which the country is in a good credit standing and in which party A is initially in office. This exercise follows our procedure in Section 2.4.3. We plot the average bailout probability, the mean sovereign interest spread, the share of cases in which party A is in power, the average frequency of political turnover, the budget balance, and the welfare measure for primary surplus targets between -4% and $+8\%$ of GDP. In line with Figure 2.7, the bailout participation rate decreases as conditionality becomes more severe. If the target on the primary surplus is larger than 5% of GDP, the bailout participation rate is below 1% and the outcomes are close to the ones of our counterfactual economy in which no bailout option is available.

We know from Figure 2.8 that for a given level of borrowing international private creditors charge a higher premium if conditionality becomes stricter. However, the simulated sovereign interest spread shown in Figure 2.9 decreases as the primary surplus target increases. This is due to a general equilibrium effect: A tighter fiscal constraint and higher credit costs make the government more borrowing constrained such that less debt is accumulated in equilibrium. A lower level of debt reduces the default probability and, hence, the sovereign interest spread.

Interestingly, the political turnover frequency is U-shaped in ζ which results from two opposing forces. On the one hand, a higher target on the primary surplus reduces debt in the economy. The policy functions in Figure 2.8 show that for lower levels of debt party A faces a smaller risk of losing office than party B. In consequence, the share of cases in which party A is in power increases as conditionality becomes stricter. On the other hand, a tighter fiscal constraint increases the cost of being in a bailout program. While party A is reluctant to default, party B is more likely to exit a bailout program by defaulting, which allows to reduce the tax rate and to raise public spending. In consequence, the probability of a political turnover from party A to party B increases and the number of cases in which party A is in power decreases. Figure 2.9 reveals that the second effect dominates if conditionality becomes very severe.

The lower right panel of Figure 2.9 shows the welfare gain for different degrees of conditionality. Conditional bailouts generate welfare gains of up to 1.67%, measured in consumption equivalents. Stricter conditionality decreases the welfare gain since the government reduces its bailout participation and issues less debt when fiscal constraints are tighter. While bailouts are beneficial to the population, our welfare analysis

Figure 2.9: The Impact of Conditionality



Notes: This figure is based on a simulation of 1 million years where the first 100 years are omitted. Out of the simulation, episodes are considered in which party A is initially in office and the country is in a good credit standing for at least 19 consecutive years. The figure displays the average turnover probability, the mean sovereign interest spread, the share of party A in office, the average bailout probability, the mean budget balance in % of GDP, and the equivalent variation in consumption relative to the model without bailouts for different conditionalities ζ. All variables are denoted in percentage values.

abstracts from the systematic losses of official creditors.

The previous analysis has focused on the invariant distribution of the economy and has highlighted the long-run impact of conditionality. To study how stricter conditionality affects sovereign default risk and political turnover in the short run, we consider the following scenario. As initial situation, we take the average level of debt of our benchmark economy and assume that party A is in power. We simulate 100,000 of different productivity series and select the ones for which party A makes use of a bailout at time $t = 0$. We then feed these productivity series into the model assuming weak conditionality ($\zeta = 0$) and severe conditionality ($\zeta = +0.03$). We simulate the model for 10 years and display the dynamics in Figure 2.10. For the economy with weak conditionality (solid lines) and the economy with severe conditionality (dashed lines) we show the pattern of debt and the percentage of cases in which party A is in power. We differentiate the cases in which party A and party B are in power and report the percentage of cases in which the parties make use of bailout programs, and the percentage of cases in which they default. We also report the sovereign interest spread and the political turnover probability faced by party A and party B when in power.

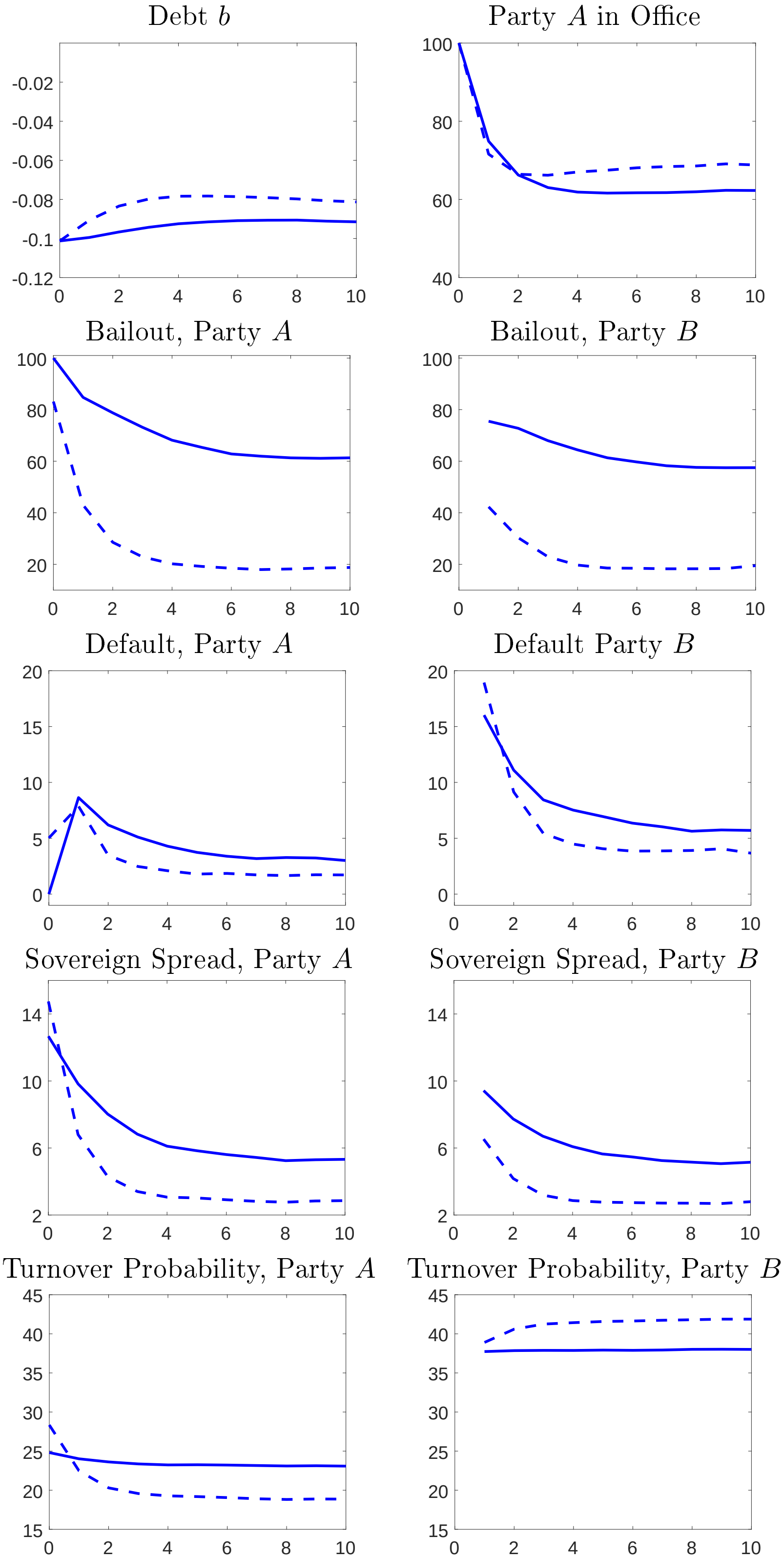
Stricter conditionality implies that party A is required to implement higher tax hikes and larger spending cuts at date $t = 0$. Since party B is more willing to default rather than meeting the costly conditions, party A faces an increased risk of losing office at $t = 0$. Stricter conditionality amplifies the probability of a political turnover from A to B. The increased probability that party B gains power raises the sovereign interest spread faced by party A at date $t = 0$. However, a tighter restriction on the primary surplus reduces the level of debt, which, in turn, has mitigating effects on political turnover and sovereign default risk in the medium and long run. Figure 2.10 highlights that while stricter conditionality fosters a political turnover from party A to party B and raises the probability of sovereign default in the short run, it reduces political and sovereign risks in the long run.

2.4.6 Robustness Analysis

In this section, we perform a robustness analysis with respect to several important parameters. In a first set of robustness checks, we vary the size of the bailout package and the interest rate on official loans. In a second set of robustness checks, we focus on the parties' default utility costs as well as the specification of the distribution of the popularity shocks.

In the left panel of Table 2.3, we consider different values for the spread k between the interest rate on official loans and the risk-free rate. In the first bailout package in 2010, the margin on the interest rate was initially 300 basis points and was then lowered to 50 basis points, see Table 2.5 in Appendix E. Therefore, in our robustness analysis, we consider spreads up to 3%. In the right panel we vary the size of the bailout package λ. We simulate the model and report the mean sovereign interest spread, the average bailout probability, the average frequency of political turnover, and the share of cases

Figure 2.10: Political Turnover and Conditionality



Notes: As initial situation, this figure considers the average level of debt of the simulated benchmark economy and party A as incumbent. Out of a simulation of 100,000 of different productivity series those are selected for which party A chooses a bailout at time $t = 0$. These productivity series are fed into an economy with weak conditionality ($\zeta = 0.00$, solid lines) and an economy with strict conditionality ($\zeta = 0.03$, dashed lines). The figure shows the dynamics of debt b, the percentage of cases, in which party A is in power, the percentage of cases in which party A and party B choose a bailout, the percentage of cases in which party A and party B default, the sovereign spread that party A and B face and the parties' probability of losing power.

Table 2.3: Robustness Analysis: The Interest Rate on Official Loans and the Size of Bailouts

	$k = 0$	$k = 0.015$	$k = 0.03$	$\lambda = 0.10$	$\lambda = 0.30$	$\lambda = 0.50$
$E(s)$	4.17	3.76	3.31	1.23	1.60	2.34
Bailout probability	39.97	29.39	20.49	15.18	20.97	27.03
Party A in Office	70.54	69.73	69.31	66.30	66.04	66.16
Turnover frequency	26.02	26.44	26.65	27.60	27.81	27.84

Notes: k determines the spread between the official interest rate and the risk-free rate. λ is the share of official loans. All other parameters are given by the benchmark calibration. Statistics are given in % and calculated from a model simulation of 1 million years where the first 100 years are omitted. Only episodes of at least 19 consecutive years of good credit standing are considered in which party A is in office initially.

in which party A is in power. The results indicate that a higher interest rate on official loans as well as a smaller bailout package reduce the bailout participation rate and increase the probability of a sovereign default for a given level of debt. In consequence, higher credit costs make the government more borrowing constrained such that in equilibrium a lower debt level reduces the average sovereign interest spread. k as well as λ have a minor impact on the frequency of political turnover.

Table 2.4 displays statistics for variations of the distribution Ω of the popularity shocks and party B's utility cost of default χ_B. A higher Ω implies smaller popularity shocks such that the voting outcomes are more affected by economic factors. While the spread and the bailout probability are hardly affected by changes in Ω, party A is substantially more often in power and the political turnover rate is lower if a party's popularity becomes less important. If instead, Ω is very small, the individual voting behavior is mostly affected by stochastic ideological aspects such that party A is in office in 50% of the cases. The turnover probability converges towards 30.60%, which is implied by the vote threshold ξ.

The difference in the default utility costs χ_A and χ_B crucially determines the differences in the optimal policies of the two parties. In Table 2.4 we keep χ_A constant and vary χ_B. If party B suffers from a lower default utility cost, party B is less reluctant to default. In consequence, party B faces higher credit costs than party A such that the economic benefit of having party A in power is higher. Thus, party A is more often in office and the frequency of political turnover decreases.

2.5 Conclusions

In this paper, we have analyzed the interaction of sovereign default risk, bailouts, and political turnover in a politico-economic model of sovereign debt. The theoretical

Table 2.4: Robustness Analysis: Popularity and Default Utility Costs

	$\Omega = 10^{-6}$	$\Omega = 6$	$\Omega = 12$	$\chi_B = 0.1$	$\chi_B = 0.3$	$\chi_B = 0.5$
$E(s)$	4.14	4.11	4.05	4.10	4.00	3.79
Bailout probability	36.93	36.58	35.73	36.08	36.22	35.99
Party A in Office	53.16	63.78	74.69	75.98	65.31	56.87
Turnover frequency	30.77	28.88	23.80	23.00	28.42	30.23

Notes: $\Omega = \phi$ refers to the distribution of the popularity shocks. χ_B denotes the utility default cost of party B. All other parameters are given by the benchmark calibration. Statistics are given in % and calculated from a model simulation of 1 million years where the first 100 years are omitted. Only episodes of at least 19 consecutive years of good credit standing are considered in which party A is in office initially.

framework features endogenous default risk, endogenous participation rates in bailout programs as well as endogenous political turnover.

In a quantitative exercise we have applied our theoretical framework to the Greek economy. Our findings suggest that if debt is high, bailouts foster the probability that the party with the lower utility cost of default comes into power, which, in turn, raises sovereign default risk. In the years before the bailout, the sovereign interest spread and the probability of political turnover are low due to good economic conditions. Low credit costs allow the incumbent government to accumulate debt. The debt crisis is triggered by an adverse economic shock that reduces the ability of the government to repay the outstanding debt. Due to the strong increase in the sovereign interest spread, the incumbent government decides to enter a bailout program. However, conditionality requires the implementation of tax hikes and spending cuts, which raises the probability of political turnover. In turn, the risk of political turnover elevates the sovereign interest spread. Our results suggest that the risk of political turnover increases the sovereign interest spread by 2 percentage points at the time of the entry into a bailout program.

We have studied the role of conditionality and have highlighted that the frequency of political turnover is U-shaped in the tightness of the primary surplus target. Importantly, stricter conditionality increases the probability of political turnover and sovereign default in the short run, but it may mitigate political turnover and default risk in the long run.

Our findings highlight the tension that policymakers face when designing bailout packages: While stricter conditionality improves fiscal sustainability and political stability in the long run, it fosters political uncertainty and sovereign default risk in the short run. In our theoretical framework we have modeled conditionality as an exogenous constraint. It is a particularly interesting avenue for future research to study conditionality as the endogenous outcome of negotiations between the incumbent government and official creditors. The analysis of the interaction between negotiations with international creditors and domestic political outcomes is left for future research.

D Appendix: The Recursive Equilibrium

Definition. *The recursive equilibrium for the small open economy is defined as*

1. *a set of policy functions for private consumption* $c_j(b,z)$, $c_j^R(b,z)$, $c_j^{CB}(b,z)$, $c_j^D(z)$, *and labor supply* $l_j(b,z)$, $l_j^R(b,z)$, $l_j^{CB}(b,z)$ $l_j^D(z)$, $j = A, B$,

2. *a set of policy functions for borrowing* $b_j'(b,z)$, $b_j'^R(b,z)$, $b_j'^{CB}(b,z)$ *government spending* $g_j(b,z)$, $g_j^R(b,z)$, $g_j^{CB}(b,z)$, $g_j^D(z)$, *and the tax policy* $\tau_j(b,z)$, $\tau_j^R(b,z)$, $\tau_j^{CB}(b,z)$, $\tau_j^D(z)$, $j = A, B$,

3. *a bailout set* $\mathcal{H}_j(b)$ *and a default set* $\mathcal{D}_j(b)$, $j = A, B$,

4. *turnover probabilities* $P_j(b',z)$, $P_j^D(z)$, $j = A, B$,

5. *the bond price function charged by international private creditors,* $q_j(b',z)$, $j = A, B$,

6. *a set of value functions* $V_j(b,z)$, $V_j^R(b,z)$, $V_j^{CB}(b,z)$, $V_j^D(z)$, $\overline{V}_j(b,z)$, $\overline{V}_j^R(b,z)$, $\overline{V}_j^{CB}(b,z)$, $\overline{V}_j^D(z)$, $V_j^P(b,z)$, $V_j^{P,D}(z)$, $j = A, B$,

such that

1. *taking as given the public sector policies, private consumption* $c_j(b,z)$, $c_j^R(b,z)$, $c_j^{CB}(b,z)$, $c_j^D(z)$, *and labor supply* $l_j(b,z)$, $l_j^R(b,z)$, $l_j^{CB}(b,z)$ $l_j^D(z)$ *satisfy the optimality condition (2.5) and the household's budget constraint (2.1).*

2. *Taking as given the bond price functions* $q_j(b',z)$, q^*, *the private sector equilibrium, the optimal policies of the opponent* $-j$, *and the political turnover probability* $P_j(b',z)$, *the incumbent* j*'s value functions* $V_j(b,z)$, $V_j^R(b,z)$, $V_j^{CB}(b,z)$, $V_j^D(z)$, *the bailout set* $\mathcal{H}_j(b)$, *the default set* $\mathcal{D}_j(b)$ *are given by (2.6), (2.7), (2.8), (2.9), (2.10), and (2.12), respectively. The policy functions* $b_j'^R(b,z)$, $g_j^R(b,z)$, $\tau_j^R(b,z)$ *solve (2.7).* $b_j'^{CB}(b,z)$, $g_j^{CB}(b,z)$, $\tau_j^{CB}(b,z)$ *solve (2.8).* $b_j'(b,z)$, $g_j(b,z)$, $\tau_j(b,z)$ *solve (2.6). In financial autarky,* $g_j^D(z)$ *and* $\tau^D(z)$ *solve (2.9).*

3. *Bond prices* $q_j(b',z)$ *fulfill equation (2.13), such that risk-neutral international private creditors earn zero expected profits.*

4. *The turnover probability* $P_A(b',z)$ *fulfills equation (2.14), and* $P_B(b',z) = 1 - P_A(b',z)$*; the turnover probability* $P_A^D(z)$ *fulfills equation (2.15), and* $P_B^D(b',z) = 1 - P_A^D(b',z)$.

5. *The value functions of the population* $V_j^P(b,z)$, $V_j^{P,D}(z)$ *are given by*

$$\begin{aligned} V_j^P(b,z) =&(1-\alpha)u(c_j(b,z),l_j(b,z))+\alpha v(g_j(b,z)) \\ &+\beta\Bigg((1-P_j(b_j'(b,z),z))\int_{z'}V_j^P(b_j'(b,z),z')\mu(z',z)dz' \\ &+P_j(b_j'(b,z),z)\int_{z'}V_{-j}^P(b_j'(b,z),z')\mu(z',z)dz'\Bigg), \end{aligned}$$

and

$$\begin{aligned} V_j^{P,D}(z) =&(1-\alpha)u(c_j^D(z),l_j(z))+\alpha v(g_j^D(z)) \\ &+\beta\Bigg[(1-P_j^D(z))\Bigg(\theta\int_{z'}V_j^P(0,z')\mu(z',z)dz' \\ &+(1-\theta)\int_{z'}V_j^{P,D}(z')\mu(z',z)dz'\Bigg) \\ &+P_j^D(z)\Bigg(\theta\int_{z'}V_{-j}^P(0,z')\mu(z',z)dz'+(1-\theta)\int_{z'}V_{-j}^{P,D}(z')\mu(z',z)dz'\Bigg)\Bigg]. \end{aligned}$$

6. *Given the policy choices of the opponent $-j$, $\overline{V}_j^R(b,z)$, $\overline{V}_j^{CB}(b,z)$, $\overline{V}_j^D(z)$ and $\overline{V}_j(b,z)$ solve*

$$\begin{aligned} \overline{V}_j^R(b,z) =&(1-\alpha)u(c_{-j}^R(b,z),l_{-j}^R(b,z))+\alpha v(g_{-j}^R(b,z)) \\ &+\beta\Bigg((1-P_{-j}(b_{-j}'^R(b,z),z))\int_{z'}\overline{V}_j(b_{-j}'^R(b,z),z')\mu(z',z)dz' \\ &+P_{-j}(b_{-j}'^R(b,z),z)\int_{z'}V_j(b_{-j}'^R(b,z),z')\mu(z',z)dz'\Bigg), \end{aligned}$$

and

$$\begin{aligned} \overline{V}_j^{CB}(b,z) =&(1-\alpha)u(c_{-j}^{CB},l_{-j}^{CB}(b,z))+\alpha v(g_{-j}^{CB}(b,z)) \\ &+\beta\Bigg((1-P_{-j}(b_{-j}'^{CB}(b,z),z))\int_{z'}\overline{V}_j(b_{-j}'^{CB}(b,z),z')\mu(z',z)dz' \\ &+P_{-j}(b_{-j}'^{CB}(b,z),z)\int_{z'}V_j(b_{-j}'^{CB}(b,z),z')\mu(z',z)dz'\Bigg), \end{aligned}$$

and

$$\begin{aligned}\overline{V}_j^D(z) =&(1-\alpha)u(c_{-j}^D(z), l_{-j}^D(z)) + \alpha v(g_{-j}^D(z)) \\ &+ \beta \Bigg[(1-P_{-j}^D(z))\left(\theta \int_{z'} \overline{V}_j(0,z')\mu(z',z)dz' \right. \\ &\left. \qquad +(1-\theta)\int_{z'} \overline{V}_j^D(z')\mu(z',z)dz'\right) \\ &+P_{-j}^D(z)\left(\theta \int_{z'} V_j(0,z')\mu(z',z)dz' + (1-\theta)\int_{z'} V_j^D(z')\mu(z',z)dz'\right)\Bigg],\end{aligned}$$

with

$$\overline{V}_j(b,z) = \begin{cases} \overline{V}_j^R(b,z) & \textit{if } d_{-j}(b,z)=0 \textit{ and } h_{-j}(b,z)=0 \\ \overline{V}_j^{CB}(b,z) & \textit{if } d_{-j}(b,z)=0 \textit{ and } h_{-j}(b,z)=1 \\ \overline{V}_j^D(z) & \textit{if } d_{-j}(b,z)=1. \end{cases}$$

E Appendix: The Economic Adjustment Programs: The Case of Greece

Greece received bailout packages in 2010, 2012, and 2015. Table 2.5 lists the initially provided size of financial assistance and the total amount of disbursements. The interest rates differ across official lenders and consist of a base rate (e.g., costs of funding), a margin and occasionally fees. Table 2.6 provides an overview of the conditions that Greece was required to fulfill.

Table 2.5: The Economic Adjustment Programs for Greece

	1st Program	**2nd Program**	**3rd Program**
	2010	**2012**	**2015**
Initial Amount	€110 billion	€165.4 billion[a]	up to €86 billion
Total Disbursements	€73 billion of which: GLF[b]: €52.9 billion IMF: €20.1 billion	€153.8 billion of which: EFSF: €141.8 billion IMF: €12 billion	€31.7 billion (end 2016, all ESM)
Interest Rate	GLF: Euribor 3M + margin: originally 300, lowered to 50 basis points (bps) IMF: $\sim$ 3.96%	EFSF: guarantee fees cancelled, deferral of some interest payments by 10 years[c], margin: 0 bps[d] IMF: 2.85% to 3.78%	ESM: base rate (funding costs), commitment fees, service fees (upfront, 0.5 bps per year), margin: 5 - 75 bps[e]

[a] The program further included interest rate reductions and maturity extensions on existing official debt as well as the return of profits from the Securities Markets Programme by the ECB.

[b] Greek Loan Facility (summarizes the bilateral credits provided by the Euro area countries in the first bailout program)

[c] Only applied to credits under the Greek Master Financial Assistance Facility Agreement, but not to Private Sector Involvement and bond interest facilities, which represent 25% of the total EFSF credits.

[d] The planned raise in the margin of 200 basis points on credits from the buyback operation in December 2012 was waived in 2016.

[e] E.g. loans: 10 bps, precautionary financial assistance: 35 bps, financial assistance for direct recapitalization of institutions: 75 bps. For details, see European Stability Mechanism (2014).

Sources: European Stability Mechanism (2017), European Stability Mechanism (2016)

Table 2.6: Overview Conditionality

	1st Program (2010)	2nd Program (2012)	3rd Program (2015)
Public Finances	• Target: general government deficit below 3% of GDP by 2014 • Savings from upfront measures (e.g. cut in public sector wage bill and pension outlays, VAT increase): 2.5% of GDP in 2010 • Savings through 2013 by: expenditure cuts (around 7% of GDP) and revenue increase (around 4% of GDP) • Structural fiscal reforms: pensions, health sector, tax system • Improved management of public finances • Review of debt management strategy (transparency and predictability)	• Target as primary surplus (% of GDP): −1% (2012), 1.75% (2013), 4.5% (by 2014) • Reduced public sector wage bill (savings: 1.5% of GDP by 2015) • Social spending (4% of GDP additional savings given already implemented reforms): pension reform, reduction of public health expenditures, improved targeting of benefit programs • Savings from public administration restructuring • Tax reform: budget-neutral, simplified system, broader tax base, rebalanced tax burden • Improved management of public finances (e.g. spending controls)	• Target as primary surplus (% of GDP): −0.25% (2015), 0.5% (2016), 1.75% (2017), 3.5% (2018 and beyond) • Measures: tax hikes, reduction of public spending; structural measures (in % of GDP: at least 0.75% in 2017, 0.25% in 2018) • Reform of tax codes, income tax, property tax • VAT: simplification, broader tax base • Improved management of public finances and public procurement • Social welfare: pension reform (savings: 0.25% of GDP in 2015, 1% of GDP in 2016), health care reform, implementation of reformed and targeted welfare system

Fiscal Institutions	• Improvements in tax collection • Structural reforms regarding tax compliance and administration	• Improvements in collection of taxes and social security contributions • Revenue administration reform • Dispute resolution system, anti-corruption measures, larger number of auditors, reduction of tax evasion	• Improvements in collection of taxes and social security contributions • Larger capacity of tax administration • Reduction of tax evasion
Privatization	• Review of divesting state assets • Overview of state-ownership	• Privatization of assets (such as state enterprises, concessions, real estate) • Expected total proceeds: EUR 50 billion (at least 19 billion in 2015)	• Asset Development Plan (revenues in EUR: 1.4 bn in 2015, 3.7 bn in 2016, 1.3 bn in 2017) • New Fund (target: EUR 50bn)
Financial Stability	• Extension of existing banking assistance • Independent Financial Stability Fund as safety net for bank equity • Corporate debt restructuring legislation and personal debt restructuring law • Intensified supervision by the Bank of Greece with increased resources	• Financial sector reform • Legislation and financing for bank recapitalization and resolution (estimated EUR 50 billion) • Access to central bank liquidity support • Reform of governance arrangements of Hellenic Financial Stability Fund, Hellenic Deposit & Investment Guarantee Fund and in the Bank of Greece	• Recapitalization of the banking sector and resolution of non-viable banks • Resolution of non-performing loans of the banking sector • Hellenic Financial Stability Fund: independence and reinforced governance structure • No government interventions in bank governance

Structural Reforms	• Labor market reform, increase in private wage flexibility • Strengthening of competition in markets and improved business environment • More transparency, efficiency improvements and reduction of losses of state enterprises • Improved use of EU structural and cohesion funds	• Labor market reform (target: decline in unit labor cost of about 15%); reduction of wage rigidities and non-wage labor costs, adjustment of minimum wage • Reduction of rigidities in service sector and product market • Facilitation of price flexibility, more competition in product markets • Improved business environment • More efficient judicial system	• Labor market reform, reduction of undecleared work, improvements in education and vocational training • Strengthening of competition in markets and improved business environment • Modernization and more competition in the energy market
Public Administration	• Modernization; efficiency improvements and transparency • ELSTAT: independence, improvement of statistical systems • Improved collection of general government data	• Modernization; efficiency improvements • Reform of ELSTAT governance	• Modernization, depoliticization • New Code of Civil Procedure • Anti-corruption measures • ELSTAT: independence, compliance on international stastitical standards

Note: The table provides an overview of the most central conditions listed in the memoranda of the bailout programs, see European Commission (2010), European Commission (2012), European Commission (2015).

F Appendix: Numerical Algorithm

We solve the model using value function iteration. The algorithm is based on Hatchondo et al. (2010) and uses cubic spline interpolations. The equilibrium is approximated as the equilibrium of the finite-horizon economy. Iterations on the value functions, the bond price functions and the turnover probabilities are executed simulateneously.
From the optimality condition of the private sector (2.5), optimal labor supply can be written as function of the tax rate τ:

$$l = \left(\frac{z}{1+\tau} \right)^{\frac{1}{\psi}}. \tag{2.16}$$

Given equation (2.16) and the budget constraints (2.1), (2.2), (2.3) and (2.4), optimal private and government consumption can be determined as functions of the decision variables b' and τ.
The model is solved by the following algorithm. We define equidistantly spaced grids for international debt $b \in [\underline{b}, \overline{b}]$ and productivity $z \in [\underline{z}, \overline{z}]$. Given initial guesses for the value functions $V_{j(0)}(b,z)$, $V^{R}_{j(0)}(b,z)$, $V^{CB}_{j(0)}(b,z)$ and $V^{D}_{j(0)}(z)$, we find candidate values for $\tau_{j(0)}(b,z)$, $\tau^{D}_{j(0)}(z)$ and $b'_{j(0)}$ via (2.6), (2.7), (2.8) and (2.9) for every grid point $(b,z) \in [\underline{b}, \overline{b}] \times [\underline{z}, \overline{z}]$ using a global search procedure. Given these candidate values as initial guesses, optimal values are found with the FORTRAN optimization rountine BCPOL from the IMSL library. Given the initial guess, the default probability $\eta_{j(0)}(b'_{(0)}, z)$ follows from equation (2.11). The bond price function $q_{j(0)}(b'_0, z)$ and the turnover probabilities $P_{j(0)}(b', z)$ and $P^{D}_{j(0)}(z)$ are determined via equations (2.13), (2.14) and (2.15), respectively. The computation of expected continuation values is based on Gauss-Hermite quadrature points and weights. Expected continuation values for policies and productivity realizations which do not lie on the grid are evaluated with cubic spline interpolations. The value functions $V^{R}_{j(0)}(b,z)$, $V^{CB}_{j(0)}(b,z)$ and $V^{D}_{j(0)}(z)$ are updated given the solutions found at each grid point. We iterate until the value functions converge.

CHAPTER 3

Bailouts and the Maturity of Sovereign Debt

3.1 Introduction

Empirical evidence suggests that, during debt crises, emerging economies tend to choose shorter maturities for new debt issuance, which is cheaper, but also makes them more vulnerable to rollover crises (e.g. Broner et al., 2013). In crisis times, international financial institutions frequently support sovereigns with credit at low interest rates. This raises the question whether official loans affect the maturity of government debt held by private creditors. Such effects may depend on the types of bailout programs, which differ e.g. in the maturity of institutional credits.[1] The International Monetary Fund (IMF) provides loans through different programs with ex ante defined debt maturities and numbers of grace periods. For instance, repayment of credits granted in a Stand-by Arrangement (SBA) is due within 3.25 and 5 years of disbursement. In case of Extended Fund Facilities (EFF), loans have to be repaid within 4.5 and 10 years of disbursement. In contrast, the European Stability Mechanism (ESM) is flexible on the choice of maturity and number of grace periods and decides on a case-by-case basis.

In this paper, we study the impact of bailouts with different predetermined repayment schedules for official debt, i.e. different maturities and grace periods, on macroeconomic outcomes. In particular, we consider the effect of institutional debt on the maturity of public debt owed to private creditors and how the maturity of institutional debt affects default.

To study these questions, we build a dynamic stochastic model of sovereign debt with endogenous default risk, endogenous bailout participation, endogenous maturity choice on private debt, and long-term institutional debt. We consider an endowment economy, in which the sovereign has access to incomplete international financial markets where it can borrow from risk-neutral private creditors. Following Sánchez et al. (2018), the government can choose size and maturity of external debt obligations with a flat repayment schedule. Debt contracts are not enforceable and the government may default on its external debt obligations. In case of a default, the economy is temporarily excluded from international financial markets and suffers an output loss. Conditional on a good credit standing, the government can also enter a bailout program. As in Boz (2011) and Fink and Scholl (2016), an un-modeled official creditor provides non-defaultable loans at low interest rates conditioned on a fiscal constraint. Official loans have a predetermined maturity and repayment may be subject to grace periods. In each period, the economy may be hit by an i.i.d. sudden stop shock such that the government cannot issue bonds on international financial markets, but still has access to official financial assistance.

[1] See empirical evidence e.g. by Erce (2012), Mina and Martinez-Vazquez (2002), and Saravia (2013).

In our quantitative analysis, we apply the model to Colombia. We find that the availability of bailout credits reduces the maturity of privately held government debt. Long-term bonds provide the possibility to hedge against the future risk of low endowment realizations. However, due to uncertain future endowment, private creditors charge a higher premium for long-term debt than for short-term debt. Bailouts provide an insurance against endowment risk. By requesting official loans at low interest rates, the government can generate more additional resources than by the issuance of long-term bonds at high interest rates. The government can increase consumption by issuing large amounts of short-term bonds without a strong increase in the bond interest rate because it can serve its obligations in the next year by requesting official financial assistance. Total indebtedness increases because the government repeatedly issues short-term bonds in one year and enters a bailout and replaces privately held debt by long-term official debt in the next year. Since bailouts imply a reduction of consumption through conditionality, more frequent transitions between years of repayment and years of bailout participation increase the volatility of consumption relative to output.

We study the impact of stricter conditionality and find that the government reduces bailout participation and uses more long-term bonds to hedge against income risk such that the portfolio maturity increases. With reduced insurance by official loans, there is a stronger correlation between output and bond spreads and thus default risk. Default occurs more frequently for low endowment realizations. However, due to lower indebtedness, the overall default rate declines.

We employ an event analysis to study the dynamics around a bailout entry. Bailouts are preceded by high output, increasing indebtedness, increasing bond spreads, and decreasing portfolio maturity. Bailout entry is accompanied by a drop in output, a disproportionally high frequency of sudden stops (around 30%) and a drop in government bond spreads. Due to the low portfolio maturity in the pre-bailout years, the government replaces large shares of maturing privately held debt by official debt. Bailouts are followed by a significant rate of follow-up bailout programs. Compared to the pre-bailout years, the debt level is lower and the portfolio maturity increases after a bailout.

Longer maturities for official loans and grace periods reduce the debt service in the next year and thus make bailouts and the draw of larger amounts of official loans more attractive. It follows that the bailout frequency and indebtedness increase. The maturity of debt held by private creditors drops. With lower maturities, the debt service increases and the government can replace more debt by official loans at bailout entry. The repeated transition from bailout periods, in which the government has to fulfill conditionality, and repayment periods with issuance of large amounts of short-term bonds and vice versa increases the volatility of consumption and the volatility of the trade balance.

Related Literature. The paper connects two strands of the literature. First, the paper is related to the literature on the maturity of sovereign debt. While the initial quantitative sovereign debt literature[2] focuses on one-period government bonds, Chatterjee and Eyigungor (2012) and Hatchondo et al. (2009) introduce long-term bonds with fixed maturities in quantitative sovereign debt models. Arellano and Ramanarayanan (2012) allow for simultaneous issuance of one-period bonds and long-term bonds with pre-defined maturity. They are able to reproduce the decline in debt maturity in the presence of increasing short-term spreads. In their model, long-term debt issuance implies a trade-off between hedging against future fluctuations and repayment incentives. Building on their framework, Mihalache (2020) studies debt restructuring with the option of maturity extensions. Hatchondo et al. (2016) focus on the impact of debt dilution on default risk and welfare benefits from the elimination of dilution. While long-term debt in these models implies an infinite front-loaded repayment schedule, Bai et al. (2015) allow for the simultaneous choice of maturity and payment schedule of government debt to match the cyclical behavior of bond issuance. Sánchez et al. (2018) endogenize the maturity choice with a flat repayment schedule. They reproduce upward-sloped yield spread curves in normal times and inverted curves during times of financial stress. Extending their framework, Dvorkin et al. (forthcoming) consider debt renegotiations with face value reductions and maturity extensions. Unlike the previous literature, they solve the model using Generalized Extreme Value distributed additive preference shocks. Bocola and Dovis (2019) apply a model of self-fulfilling debt crises with endogenous government maturity structure to Italy and identify shares of fundamental and non-fundamental risk in 2008-2012 interest spreads. We build on Sánchez et al. (2018) and Dvorkin et al. (forthcoming) and introduce bailouts with long-term credits in a sovereign debt model with maturity choice on government bonds.[3]

Second, the paper builds on the literature that uses dynamic stochastic models of sovereign debt to study the impact of bailouts on sovereign default risk. Aguiar and Gopinath (2006) and Roch and Uhlig (2018) consider bailouts as unconditional grants and bailout guarantees without conditionality, respectively. Kirsch and Rühmkorf (2017) and Juessen and Schabert (2013) study the impact of conditional bailout credits which are subject to default risk. In Boz (2011) and Fink and Scholl (2016), the government can request non-defaultable official loans in return for the commitment

[2]See Aguiar and Gopinath (2006) and Arellano (2008).

[3]Theoretical contributions on the sovereign's choice on debt maturity include among others Aguiar et al. (2019), Dovis (2019), Niepelt (2014), and Perez (2017).

to fiscal conditionality. Fink and Scholl (2016) show that the access to official debt reduces the risk of a default in the short run, but relaxes credit constraints in the long run, resulting in higher indebtedness and a higher default frequency. While they allow the government to choose the size of the official loan subject to conditionality, Pancrazi et al. (2020) study the welfare gains of bailouts in a model with fixed size of official assistance and the government deciding on the time of repayment of official loans. We instead consider predetermined maturities for bailout credits. Prein and Scholl (2019) analyze the impact of bailout programs on political turnover risk in a model with endogenous bailout participation and endogenous political turnover. They find that bailouts foster the probability of a political turnover, which, in turn, amplifies the sovereign default risk. All these papers abstract from long-term debt.

Hatchondo et al. (2017) study the welfare gains from a limited option to issue one-period non-defaultable debt in a sovereign default model with long-term credits. In contrast, we consider non-defaultable official loans with maturities of more than one period and allow for a choice on the maturity of bonds held by private creditors. In a theoretical contribution, Erce (2012) analyzes the impact of bailout grants on the government's choice on the debt maturity structure. He finds that expectations of a bailout may amplify the preference for short-term borrowing. Corsetti et al. (2019) build a quantitative model with two types of official lending to compare the impact of financial assistance by the IMF and the ESM on fiscal policy decisions. They model the IMF and the ESM as institutions that provide short-term loans with high interest rates and long-term loans with low interest rates, respectively. In their model, the sustainability effect of official debt is more amplified for maturity increases than for interest rate reductions. They abstract from the government's choice on the debt maturity. We contribute to the literature by studying the dependence of the macroeconomic effects of bailouts on the maturity of official loans and the impact of bailout credit maturity on the maturity of government debt held by private creditors.

The remainder of the paper is structured as follows. In Section 3.2, we present empirical evidence from the literature on the maturity composition of sovereign debt around the business cycle and stylized facts on the maturity of bonds at the time of participation in an IMF program. Section 3.3 describes the theoretical model. In Section 3.4, we present the quantitative results. Section 3.5 concludes.

3.2 Empirical Evidence

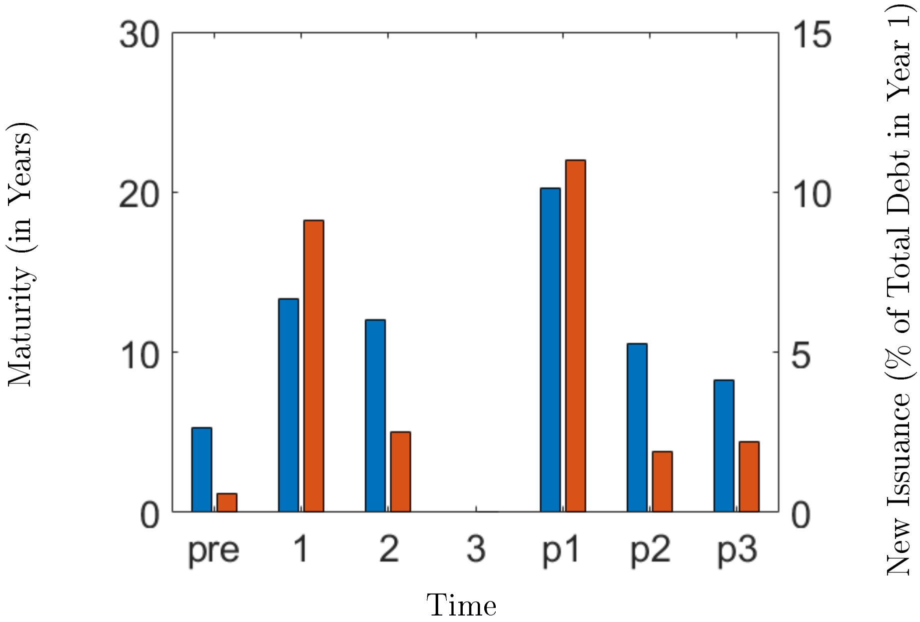
The empirical literature has extensively studied the maturity choice and the consequences of the maturity composition of government debt. Rodrik and Velasco (1999) provide evidence suggesting that the probability of a debt crisis increases in the level of short-term debt. For emerging economies, Broner et al. (2013) find that short-term borrowing is cheaper than long-term borrowing. During debt crises, interest rate spreads increase and governments tend to issue debt with shorter maturities, which may actually increase the vulnerability to a rollover crisis. Their evidence in consistent with the empirical analyses by Arellano and Ramanarayanan (2012) and Bai et al. (2015).

The empirical literature on the impact of bailouts on the maturity of debt owed to private creditors provides mixed evidence. Mina and Martinez-Vazquez (2002) study the impact of IMF programs on the maturity of external debt in emerging and developing economies for the time period from 1992 to 1997. They find an increase in the average debt maturity of net total foreign debt flows in response to expected IMF lending via SBAs and EFFs. For SBAs, higher expected withdrawn resources reduce the maturity of debt flows. Saravia (2013) considers changes in the maturity of government bond issuances during participation in IMF lending programs for bonds with at least one year maturity in emerging economies from 1991 to 2001. He finds on average a reduction in the maturity of sovereign bonds for economies with sound fundamentals. The bond maturity increases for economies with weak fundamentals. For the time period from 1995 to 2008, Erce (2012) also finds reduced maturities of sovereign bonds, in particular in response to EFF programs. A larger share of official loans to GDP implies shorter maturities for new bond issuances.

While the literature has focused on the maturity of new debt issuance before and during bailout programs, we are also interested in the maturity after a bailout, e.g. during grace and repayment periods. To derive stylized facts, we use data for 5 emerging economies which have participated in a total of 8 IMF programs during the time period from 1988 to 2018. We restrict ourselves to program participation, in which the country has actually drawn credits from the IMF, and which is preceded and followed by at least 365 days without participation in another program. A detailed list of the IMF programs included in the analysis can be found in Appendix G. We use all active and inactive bonds listed in the GOVSRCH-App from Eikon (Thompson Reuters). Among others, the dataset contains the maturity date, the issuance date, and amount issued (in US$). For the debt level of the economies, we rely on Worldbank Data.

As a measure of the size of bond issuance, we calculate the ratio of the annualized sovereign bond issuance in private markets and the debt stock at the end of the calendar year when the debt was issued.

Figure 3.1: Maturity and Size of Private Debt Issuance around SBA Programs



Notes: The blue (red) bars represent the average maturity in years and the share of new debt issuance in percent of total debt in the year of bailout entry on the left (right) axis for the time 1 year before to 3 years after participation in SBA programs. 'pre' ('p1', 'p2', 'p3') refer to the 365 days before (first, second, and third 365 days after) the entry (exit) in an SBA program, which has a duration of up to 3 years by definition. All values refer to 8 program participations of 5 emerging economies.

Figure 3.1 shows the average maturity (blue, left axis) and the share of new debt issuance in private markets in percent of total government debt at the end of the calendar year when the debt was issued (red, right axis). The values are shown for the period from 1 year before to 3 years after participation in a SBA program. We define the year before the bailout as the 365 days prior to the bailout date and a year after the bailout as 365 days after the end of the bailout program. Thus, 'pre' ('p1', 'p2', 'p3') refer to the 365 days before (first, second, and third 365 days after) the entry (exit) in an SBA program. An SBA program may have a duration of up to 3 years ('1', '2', '3'). In our sample, 7 programs last for more than one and less than 2 years and one program lasts longer than 2 years (Mexico 1995). However, for the Mexican program, there are no debt issuances in the third program year.

Private debt issuance increases after the start of the program and decreases in the second year. Compared to the pre-program period, the maturity of private debt also increases. In the third year, no private debt issues are observed in our sample. After the program, debt issuance initially increases at higher maturity and then declines over time. Note that only in one program in our sample there was a follow-up program at the end of the second year and in one case during the third year after the end of the program.[4] While our model does not replicate the immediate increase in the maturity of private debt at bailout entry, consecutive bailout periods are characterized by increasing average maturity and after bailout exit the maturity remains above the pre-bailout level, which is in line with the data.

3.3 The Model

We consider a small open economy with infinitely lived households, a benevolent government and a stochastic endowment, building on the set-up of Dvorkin et al. (forthcoming). The government can issue external debt of different maturities on international financial markets, where debt is held by risk-neutral international private creditors. Debt contracts are not enforceable and subject to default risk. We follow Sánchez et al. (2018) and assume that repayment is structured as a constant stream of payments b served over a number of periods m, where a period corresponds to a year.[5] In each period, the economy may be hit by a sudden stop shock, such that the government temporarily loses access to external credit.

Conditional on a good credit standing, the government also has access to official debt a, provided by (unmodeled) international financial institutions. Following Boz (2011), official debt is non-defaultable. As in Fink and Scholl (2016), we assume that official financial assistance requires the implementation of pre-specified conditionality. Additionally, we allow for pre-specified longer maturities of official debt, m_a, and repayment beginning after a number of grace periods Ω.

For technical reasons, we follow Dvorkin et al. (forthcoming) in assumptions on the support of assets and on the integration of additive preference shocks to the policy choices, such that we can use their discrete choice method to solve the model numerically. Private and official debt have a discrete support, where the grids have a total of $\mathcal{B}$ and $\mathcal{A}$ points, respectively. The maturity of the portfolio of debt held by private creditors and official debt is a natural number, $m' \in \{1, 2, ..., \mathcal{M}\}$ and $m'_a \in \{1, 2, ..., \mathcal{M}_a\}$.

If the government repays its debt, it chooses a new external debt level b' and a new portfolio maturity m'. We follow Sánchez et al. (2018) and restrict the choice to a change of one period at maximum, i.e. $m' \in \{m-1, m, m+1\}$. In case of a bailout, the government additionally chooses the size of official debt a'. The maturity of official debt is $\mathcal{M}_a$ at the entry in a bailout and $\max\{m_a - 1, 0\}$ otherwise. Thus, if the government repays its debt obligations with or without official financial assistance,

[4] Balima and Sy (2019) find lower debt-to-GDP and fiscal deficit-to-GDP ratios after the agreement on an IMF bailout program.

[5] As Sánchez et al. (2018) note, the possibility of adjustments of debt b and maturity m in each period imply that the actual payments are not necessarily constant despite the specified flat payment schedule.

there is a total of $\mathcal{J} = \mathcal{B} \times 3 \times (1 + \mathcal{A})$ combinations of choices on the privately held debt portfolio and official debt.[6] To describe the policy choices, we follow Dvorkin et al. (forthcoming) and define vectors b, m, a, and m_a with $\mathcal{J}$ elements, where policy j is described by the jth element of each vector, i.e. $(b_j, m_j, a_j, m_{a,j})$. The vectors are given by

$$b = \Big[\underbrace{b_1, b_2, ..., b_{\mathcal{B}}}_{\text{grid for } b}, \underbrace{b_1, b_2, ..., b_{\mathcal{B}}}_{\text{grid for } b}, ..., \underbrace{b_1, b_2, ..., b_{\mathcal{B}}}_{\text{grid for } b}\Big]^T$$

$$m = \Big[\underbrace{\underbrace{m_{t-1} - 1, ..., m_{t-1} - 1}_{\text{repeated } \mathcal{B} \text{ times}}, \underbrace{m_{t-1}, ..., m_{t-1}}_{\text{repeated } \mathcal{B} \text{ times}}, ..., \underbrace{m_{t-1} + 1, ...m_{t-1} + 1}_{\text{repeated } \mathcal{B} \text{ times}}}_{\text{repeated } 1+\mathcal{A} \text{ times}}\Big]^T$$

$$a = \Big[\underbrace{a_{t-1}, ..., a_{t-1}}_{\text{repeated } \mathcal{B}\times 3 \text{ times}}, \underbrace{a_1, ..., a_1}_{\text{repeated } \mathcal{B}\times 3 \text{ times}}, \underbrace{a_2, ..., a_2}_{\text{repeated } \mathcal{B}\times 3 \text{ times}}, ..., \underbrace{a_{\mathcal{A}}, ..., a_{\mathcal{A}}}_{\text{repeated } \mathcal{B}\times 3 \text{ times}}\Big]^T$$

$$m_a = \Big[\underbrace{\max\{m_{a,t-1} - 1, 0\}, ..., \max\{m_{a,t-1} - 1, 0\}}_{\text{repeated } \mathcal{B}\times 3 \text{ times}}, \underbrace{\mathcal{M}_a, ..., \mathcal{M}_a}_{\text{repeated } \mathcal{B}\times 3\times\mathcal{A} \text{ times}}\Big]^T,$$

where T is an operator which denotes the transpose. The vectors m, a, and m_a depend on the policy choice of the previous period. The actually available number of choices on bailout credits $\mathcal{A}$ as well as the number of possible combinations of size and maturity of privately held debt may be lower due to conditionality constraints. Then, the adjusted vectors have a length of $\mathcal{J} < \mathcal{B} \times 3 \times (1 + \mathcal{A})$. During a sudden stop, due to the loss of access to international financial markets, the number of policy options reduces to a maximum of $\mathcal{J}_s = 1 + \mathcal{A}$.

There are additive preference shocks given by the random vector $\boldsymbol{\epsilon}$ which has $\mathcal{J} + 1$ entries ϵ_j. The shocks can be interpreted as realized or perceived costs and benefits to the policymaker regarding default and portfolio characteristics.[7] The first $\mathcal{J}$ entries of the vector $\boldsymbol{\epsilon}$ are assigned to the potential policy choices under repayment and bailout. The $(\mathcal{J} + 1)$-th element is associated with the default option. The vector $\boldsymbol{\epsilon}$ is assumed

[6] With initial maturity of $m = 1$ or $m = \mathcal{M}$ the set of policy choices reduces to $\mathcal{J} = \mathcal{B} \times 2 \times (1 + \mathcal{A})$.

[7] Other examples for utility shocks with direct impact on fiscal policy decisions can be found e.g. in Arellano et al. (2019), Müller et al. (2019), and Roch and Uhlig (2018).

to be drawn from a multivariate distribution, where $F(\boldsymbol{\epsilon}) = F(\epsilon_1, \epsilon_2, ..., \epsilon_{\mathcal{J}+1})$ and $f(\boldsymbol{\epsilon}) = f(\epsilon_1, \epsilon_2, ...\epsilon_{\mathcal{J}+1})$ denote the cumulative density function and the joint density function, respectively. Following Dvorkin et al. (forthcoming), the expectation of a function $X(\boldsymbol{\epsilon})$ with respect to all elements of $\boldsymbol{\epsilon}$ will be given by

$$E_{\boldsymbol{\epsilon}} X(\boldsymbol{\epsilon}) = \int_{\epsilon_1} \int_{\epsilon_2} ... \int_{\epsilon_{\mathcal{J}+1}} X(\epsilon_1, \epsilon_2, ..., \epsilon_{\mathcal{J}+1}) f(\epsilon_1, \epsilon_2, ...\epsilon_{\mathcal{J}+1}) d\epsilon_1 d\epsilon_2 ... d\epsilon_{\mathcal{J}+1}.$$

3.3.1 Households

There is a continuum of identical risk-averse households with preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t),$$

where $\beta \in [0, 1]$ denotes the discount factor. The per-period utility function $u : \mathbb{R}_+ \to \mathbb{R}$ is continuous, twice differentiable, strictly increasing in c_t, concave in c_t, and satisfies the Inada conditions.

Time is discrete. In each period, households receive a stochastic endowment y which has a compact support and follows a Markov process with transition probability $\mu(y', y)$.

3.3.2 Government

In each period, the government is committed to serve its pending debt obligations with institutional creditors, $a < 0$. The government enters a period facing the realizations of the endowment y and an i.i.d. sudden stop stock s as well as a portfolio of privately held and official debt obligations, determined by the previous period policy decision, $(b_i, m_i, a_i, m_{a,i})$. The economy is hit by a sudden stop shock $(s = 1)$ with exogenous probability ρ_s.

Conditional on being in a good credit standing, the government has three different policy choices:

$$\begin{aligned} V(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) = \max\{ & V^R(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}), \\ & V^B(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}), \\ & V^D(y, a_i, m_{a,i}, \epsilon_{\mathcal{J}+1})\}, \end{aligned}$$

where V^R, V^B, and V^D denote the values to the policymaker of serving private external debt obligations $(b < 0)$ without official financial assistance, entering a bailout program, and defaulting on external debt held by private creditors, respectively. For repayment (bailout), there are up to $B \times 3$ $(B \times 3 \times A)$ possible borrowing policy options

j. The different values of repayment V^R (bailout V^B) depend on entry $j \in \{1, B \times 3\}$ ($j \in \{B \times 3 + 1, \mathcal{J}\}$) of the additive preference shock vector $\boldsymbol{\epsilon}$.

3.3.2.1 Repayment

If the government has a good credit standing and does not face a sudden stop ($s = 0$), repayment implies that the government serves its private and official debt obligations and chooses a new combination of debt and maturity of debt held by private creditors. The value function associated with debt repayment is given by

$$V^R(y, 0, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) = \max_j u(c_{ij}) + \beta E_{y'|y} E_{s'} E_{\boldsymbol{\epsilon}'} V(y', s', b_j, a_j, m_j, m_{a,j}, \boldsymbol{\epsilon}') + \epsilon_j$$

such that

$$c_{i,j} = y + b_i + g(a_i, m_{a,i}) + q(y, 0, b_j, a_j, m_j, m_{a,j}; m_i - 1)b_i - q(y, 0, b_j, a_j, m_j, m_{a,j}; m_j)b_j$$

$$a_j = \begin{cases} a_i & \text{if } m_{a,i} > 1 \\ 0 & \text{else.} \end{cases}$$

$$m_{a,j} = \max\{m_{a,i} - 1, 0\}$$

$$j \in \{1, 2, ..., B \times 3\},$$

where c_{ij} denotes consumption at state i and policy choice j. The function $g(a_i, m_{a,i})$ determines the current period service of official debt depending on the size of per-period payment a_i and maturity $m_{a,i}$, i.e. repayment may begin after a number of grace periods. The details on bailout participation follow in Section 3.3.2.2.

Consumption, c, equals the endowment, y, net of debt service, b_i and $g(a_i, m_{a,i})$, plus net income from issuance of external debt on international financial markets denoted by the last two summands. The first term represents the market value of outstanding debt obligations. The corresponding bond price $q(y, 0, b_j, a_j, m_j, m_{a,j}; m_i - 1)$ depends on the current realizations of the exogenous states, y and s, and the amount and portfolio maturity of outstanding debt obligations at the beginning of the next period, b_j, m_j, a_j and $m_{a,j}$, which determine the probability of a default. $m_i - 1$ denotes the next period residual maturity of a bond that already exists at the beginning of the current period. The second term covers the market value of total external debt obligations at the end of the current period. Overall, the two summands capture the net income from new debt issuance and from the change of the portfolio maturity.[8]

For simplicity, we assume that the government cannot reduce the residual official debt

[8]Without maturity adjustment, the term reduces to $q(y, 0, b_j, a_j, m_i - 1, m_{a,j}, m_i - 1)(b_j - b_i)$.

obligations via buybacks. Thus, the size of official debt a does not change unless the residual maturity m_a is 0 and all official debt obligations have been served.

If the economy is hit by a sudden stop shock ($s = 1$), the problem associated with debt repayment reduces to

$$\begin{aligned} V^R(y, 1, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) =& u(y + b_i + g(a_i, m_{a,i})) \\ &+ \beta E_{y'|y} E_{s'} E_{\boldsymbol{\epsilon}'} V(y', s', b_i, a_i, m_i - 1, m_{a,i} - 1, \boldsymbol{\epsilon}') + \epsilon_{j_s}, \end{aligned}$$

where $j_s = 1$.

3.3.2.2 Bailout

If the government has a good credit standing, it can decide to enter a bailout and request for official financial assistance. The government can choose both the new size and maturity of debt held by private creditors, b and m, and the new size of non-defaultable official loans a. The maturity of newly requested official debt m'_a is predetermined by the institutions and takes a value of $\mathcal{M}_a$. Repayment of official debt begins after a number of grace periods Ω. In return for financial assistance, fiscal policy has to satisfy a conditionality constraint. In particular, we assume that there is a restriction on new net borrowing. The value function associated with a bailout is given by

$$V^B(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) = \max_j u(c_{ij}) + \beta E_{y'|y} E_{s'} E_{\boldsymbol{\epsilon}'} V(y', s', b_j, a_j, m_j, \mathcal{M}_a, \boldsymbol{\epsilon}') + \epsilon_j$$

such that

$$\begin{aligned} c_{i,j} = y + b_i + g(a_i, m_{a,i}) + q(\cdot; m_i - 1)b_i - q(\cdot; m_j)b_j + q^a(a_i, m_{a,i})a_i - q^a(a_j, \mathcal{M}_a)a_j \\ q(\cdot; m_j)b_j - q(\cdot; m_i - 1)b_i + q^a(a_j, \mathcal{M}_a)a_j - q^a(a_i, m_{a,i})a_i - b_i - g(a_i, m_{a,i}) \geq \lambda y \\ b_j m_j \leq b_i \max\{m_i - 1, 0\} \\ j \in \{(B \times 3) + 1, ..., \mathcal{J}\}, \end{aligned}$$

where $(\cdot)$ in the bond price functions $q(\cdot; m)$ represents the current exogenous states and debt policy decisions, $(y, 0, b_j, a_j, m_j, \mathcal{M}_a)$. The second condition denotes the conditionality constraint which limits new net borrowing to a share λ of the current period endowment. To prevent the government from replacing privately held debt by official loans excessively, we impose that the new face value of debt held by private creditors cannot fall below the face value of non-matured privately held debt (third condition).

The current period debt service on official debt $g(a_i, m_{a,i})$ is given by

$$g(a_i, m_{a,i}) = \begin{cases} a_i & \text{if } m_{a,i} \in \{1, ..., \mathcal{M}_a - \Omega\} \\ 0 & \text{else.} \end{cases}$$

Following Boz (2011), the bond price of institutional debt decreases in institutional debt. For the case of long-term debt, it follows that

$$q^a(a_j, m_{a,j}) = \frac{1}{1 + r - \kappa a_j m_{a,j}} + \frac{1}{1+r} q^a(a_j, m_{a,j} - 1),$$

where $\kappa > 0$. The official interest rate thus consists of the real interest rate and an interest rate premium which increases linearly in the face value of official financial assistance $a_j m_{a,j}$. Since official debt is non-defaultable, the official interest rate does not depend on the default probability. The interest rate premium allows for controlling of the share of official debt on total government debt.

In case of a sudden stop, the government loses access to international financial markets and can only decide on the size of official debt subject to the conditionality constraint:

$$V^B(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) = \max_j u(c_{ij}) + \beta E_{y'|y} E_{s'} E_{\boldsymbol{\epsilon'}} V(y', s', b_i, a_j, m_j, \mathcal{M}_a, \boldsymbol{\epsilon'}) + \epsilon_j$$

such that

$$\begin{aligned} c_{i,j} &= y + b_i + g(a_i, m_{a,i}) + q^a(a_i, m_{a,i}) a_i - q^a(a_j, \mathcal{M}_a) a_j \\ q^a(a_j, \mathcal{M}_a) a_j - q^a(a_i, m_{a,i}) a_i - b_i - g(a_i, m_{a,i}) &\geq \lambda y \\ m_j &= \max\{m_i - 1, 0\} \\ j_s &\in \{2, ..., \mathcal{J}_s\}. \end{aligned}$$

3.3.2.3 Default

If the government chooses to default, the government does not repay external debt obligations held by private creditors. The economy will be excluded from international financial markets for a stochastic number of periods, lose access to official lending, and suffer from output losses $f(y) \leq y$. The value function associated with a default is given by:

$$\begin{aligned} V^D(y, a_i, m_{a,i}) = & u(c_{ij}) + \beta E_{y'|y} E_{s'} E_{\boldsymbol{\epsilon'}} \left[(1-\theta) V^D(y', a_j, m_{a,j}) + \theta V(y', s', 0, 1, a_j, m_{a,j}) \right] \\ & + \epsilon_{\mathcal{J}+1} \end{aligned}$$

such that

$$
\begin{aligned}
c_{ij} &= f(y) + g(a_i, m_{a,i}) \\
a_j &= \begin{cases} a_i & \text{if } m_{a,i} > 0 \\ 0 & \text{else.} \end{cases} \\
m_{a,j} &= \max\{m_{a,i} - 1, 0\} \\
& \qquad\qquad j = \mathcal{J} + 1.
\end{aligned}
$$

With exogenous probability $\theta \in [0,1]$, the government re-enters international financial markets in the next period with zero external privately held debt. The maturity m will be set to 1. The size of official debt obligations a will depend on the residual maturity m_a.

The indicator function $d(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon})$ describes the government's default decision:

$$
d(\cdot) = \begin{cases} 1 \quad \text{if} & V^D(y, a_i, m_{a,i}, \epsilon_{\mathcal{J}+1} \geq V^R(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) \\ & \wedge\, V^D(y, a_i, m_{a,i}, \epsilon_{\mathcal{J}+1} \geq V^B(y, s, b_i, a_i, m_i, m_{a,i}, \boldsymbol{\epsilon}) \\ 0 \quad \text{else.} & \end{cases}
$$

3.3.3 International Private Creditors

During times of good credit standing, if no sudden stop occurs, the government has access to credit from a continuum of identical infinitely-lived international creditors. International private creditors are risk-neutral, borrow from international markets at the risk-free interest rate r, and have perfect information about the state of the economy. They demand a premium which reflects the probability of a default on outstanding debt obligations.

Following from the zero-profit condition, the price of a bond with residual maturity $n > 0$, given the current endowment y and the choices on the annual repayment of private debt b_j and official debt a_j as well as the portfolio maturities $m_j > 0$ and $m_{a,j} > 0$, is given by:

$$
q(y, b_j, a_j, m_j, m_{a,j}; n) = \frac{E_{y'|y} E_{s'} E_{\boldsymbol{\epsilon}'}}{1+r} \left\{(1 - d(y', s', b_j, a_j, m_j, m_{a,j}, \boldsymbol{\epsilon}'))\right. \tag{3.1}
$$

$$
\left. (1 + q(y', s', B(\cdot), A(\cdot), M(\cdot), M_a(\cdot); n-1)\right\}, \tag{3.2}
$$

where $B(\cdot)$, $A(\cdot)$, and $M(\cdot)$ denote the policy functions for debt issuance on international financial markets, official debt, and portfolio maturity of international private debt, respectively. $M_a(\cdot)$ depends on the bailout policy choice and is $\mathcal{M}_a$ at bailout entry and $\max\{m_{a,j}-1,0\}$ otherwise.

3.4 Quantitative Analysis

3.4.1 Calibration

In our quantitative analysis, we apply the model to Colombia, following closely the calibration strategies of Sánchez et al. (2018) and Dvorkin et al. (forthcoming). Colombia is a typical emerging economy and has agreed on 18 SBA and EFF programs with the IMF since 1957, most recently in 2005. Table 3.1 summarizes the calibration strategy for externally and internally calibrated parameters. We employ annual series of public and publicly guaranteed external debt from World Development Indicators, provided by the World Bank. We refer to Dvorkin et al. (forthcoming) for the target values of the moments of real GDP and the trade balance as well as the standard deviations of duration and debt to output. For maturity data, they use information covering the years from 2001 to 2014. During this time, Colombia has participated in 3 IMF programs. The duration is calculated according to the Macaulay definition. Details on the calculation of the duration and the yield to maturity can be found in Appendix I.

A period in the model corresponds to a year. We assume that the per-period utility of households is specified by the following constant relative risk-aversion (CRRA) utility function

$$u(c)=\frac{c^{1-\gamma}}{1-\gamma},$$

where γ is the relative risk aversion. We set γ to 2, which is a standard value in the literature. The values for the annual risk-free interest rate r of 3.2% and the redemption probability of 0.17 are borrowed from Arellano and Ramanarayanan (2012).

The endowment realizations follow an AR(1)-process:

$$ln(y')=\rho ln(y)+\nu,$$

where ν is i.i.d. $N(0,\sigma^2)$. We set the parameters ρ and σ to the values of the autocorrelation and standard deviation for the log income process of Colombia given by Sánchez et al. (2018). We also follow Sánchez et al. (2018) in the assumption that the maturity can be adjusted by at most one year per period, such that $m'\in\{m-1,m,m+1\}$, and set the upper limit of the maturity to 10 years. Additionally, we borrow from them and assume that a sudden stop occurs with a probability ρ_s of 14.3%.

Following Arellano (2008), we assume that, after a default, the economy is temporarily excluded from international financial markets and suffers an asymmetric output cost:

$$f(y) = \begin{cases} \eta E(y) & \text{if } y > \eta E(y) \\ y & \text{else,} \end{cases}$$

with $\eta \in (0, 1)$. We set η to match a ratio of the volatility of the trade balance over output and the volatility of output of 1.36, where we borrow the value from Dvorkin et al. (forthcoming). The median of public and publicly guaranteed external debt-to-GDP of Colombia between 2001 and 2014 was 15.23%. We choose this value as target for the discount factor β.

Table 3.1: Calibration

	Parameter	Value	Source/Target
Externally calibrated parameters			
γ	Relative risk aversion	2.0	Standard value
r	Risk-free rate	0.032	Arellano and Ramanarayanan (2012)
θ	Redemption probability	0.17	Arellano and Ramanarayanan (2012)
$\mathcal{M}_a$	Maturity of official debt	3	Maturity of SBA credits
Ω	Grace period on official debt	0	Grace periods for SBA credits
ρ_s	Sudden stop probability	0.143	Sánchez et al. (2018)
ρ	Persistence of endowment	0.86	Sánchez et al. (2018)
σ	Std. of endowment	0.019	Sánchez et al. (2018)
Internally calibrated parameters			
β	Discount factor	0.96	Debt / output 15.23%
η	Asymmetric output cost	0.90	$\sigma(TB/y)/\sigma(log(y)) = 1.36$
κ	Official debt interest premium	0.2	Official debt / total debt 6.03%
λ	Conditionality	0.145	Bailout Probability 18.18%
ρ_ϵ	Correlation parameter	0.25	Std. duration 0.9
σ_ϵ	Variance parameter	0.005	Std. debt/output 8.0

Note: The values for debt-to-output, the ratio of the volatility of the trade balance over output and the volatility of output, and the standard deviations of duration and debt-to-output are based on Dvorkin et al. (forthcoming).

Colombia participated in 3 IMF programs between 2001 and 2014. In 2003 and 2005 Colombia agreed on SBAs, which expired in 2005 and 2006, respectively.[9] Additionally, Colombia participated in an EFF program from 1999 to 2002. While SBA credits are repaid in 8 equal quarterly payments, EFF loans are repaid over a period of 6 years.

[9]We abstract from the repeated arrangement of Flexible Credit Lines with the IMF from 2009 on, which have a strong precautionary character, aim at prevention of crises and improving market confidence, and are not subject to ongoing conditionality.

We take the average of 2 SBA and 1 EFF program and set the maturity of new bailout credits to $\mathcal{M}_a = 3$, such that official loans are repaid in equal installments over 3 years. SBA repayment typically begins after a grace period of 3 years. However, the time period over which credits are disbursed to the economy also lasts up to 3 years such that repayment begins in the first year after the last disbursement. Since programs in our model only last one period unless the government immediately enters another bailout in the following period, we set the number of grace periods Ω to 0 for our benchmark economy and consider alternative choices for Ω in Section 3.4.5.

The conditionality λ targets a frequency of participation in an IMF program of 18.18%. Colombia has entered 2 SBAs between 2001 and 2014 and participated in an ongoing EFF. Bailouts in our model last for only one year and require an active participation decision in each period. We thus calculate the share of 18.18 as the ratio of 2 active entries in bailout programs over 11 years in which Colombia either entered a new bailout program or decided not to participate in a bailout program. We abstract from those years in which there was no need to make a decision on a bailout entry because of an ongoing program.[10] The official debt interest premium parameter κ is set to match a share of official debt on total debt of 6.75 in the year of bailout entry in our simulations. The share is the median of the ratio of the amount of credit agreed with the IMF and external public and publicly guaranteed debt obligations in the year of the arrangement, referring to the 2003 and 2005 SBA programs and the 1999 EFF.[11,12]

As in Dvorkin et al. (forthcoming), we assume that the additive preference shocks $\boldsymbol{\epsilon}$ follow a Generalized Extreme Value distribution.[13] The distribution and the implied expressions for the value function and the bond price can be found in Appendix H. The impact of the preference shocks on the choice of size and maturity of debt increases in the preference shock variance. As Dvorkin et al. (forthcoming) show, the effect is particularly reflected in the standard deviation of debt and maturity. The two parameters from the preference shock distribution, ρ_ϵ and σ_ϵ, are thus set to match the standard deviation of the duration of government bonds of 0.9 and the standard deviation of debt to output of 8.0.

We solve the model numerically using value function iteration. The details of the

[10] This refers to the years 2001 and 2002, when Colombia had access to official debt through the 1999 EFF program, as well as 2004 during the first SBA program.

[11] The mean of this ratio would be 6.03.

[12] Columbia has actually not drawn any credits related to IMF programs from 1999 on. In such a case, the program may be considered as precautious and as commitment device. E.g. Eichengreen et al. (2006) consider precautionary programs and find catalyzing effects on external finance.

[13] Generalized Extreme Value distributed preference shocks have also recently been introduced in the quantitative sovereign debt literature by Gordon (2019). McFadden (1974) note that for Type-I extreme value distributed shocks, there is a closed form expression for the probability of each policy choice.

computational algorithm are described in Appendix J.

3.4.2 Business Cycle Statistics and the Impact of Conditionality

In this section, we compare the cyclical properties of the Columbian economy with the statistics from simulations of the model in Table 3.2. Column (1) presents the statistics from the Columbian economy, where, for the statistics in the first three blocks, we refer to Dvorkin et al. (forthcoming).[14] Column (2) summarizes the model outcome in simulations of the benchmark economy. We consider 1500 series of 400 years, where we discard the first 100 observations. First-order moments are medians. We refer to 'Bad times' as the years with an endowment realization below the trend. The calculation of 10-year spreads follows the yield to maturity definition in Appendix I. All statistics refer to periods in which the economy is not in default.

In line with the sovereign debt literature, e.g. Arellano (2008) and Cuadra et al. (2010), consumption is more volatile than output. However, the volatility of consumption is boosted by the use of large sizes of official loans in the benchmark calibration, such that the ratio of the volatilities of consumption and output exceeds the value found in the data. Note that, for the benchmark calibration, official debt as share of total debt at bailout entry exceeds the value from the data by a large magnitude, while the frequency of bailout entry is too low.

The maturity in the simulations is significantly lower than in the data and the correlation with output has the opposite sign. The reason is the very pronounced use of official loans in case of a bailout in the benchmark calibration. While long-term debt usually serves to hedge against future income risk, official loans can also provide insurance, but are available at more favorable interest rates. Unlike in the data, the median maturity is higher for low endowment. If endowment is high, the government has less incentives to default such that bond spreads are lower and the government is less credit-constrained. Since official loans can be used to serve high debt obligations if the government faces increasing bond interest rates in the next year, short-term debt is more advantageous than long-term debt to increase the amount of additional resources from debt issuance. During bad times, the positive effect of bailout availability on short-term debt issuance is lower since the incentives to enter a bailout and suffer a reduction in consumption due to conditionality decrease such that the government enters bailouts less often. The increased use of short-term debt issuance in good times instead of hedging against future income risk with long-term debt switches the sign of

[14] Our dataset in Section 3.2 does not contain sufficient information to calculate the debt duration which we need as a target.

Table 3.2: Business Cycle Statistics

	(1) Data	(2) Benchmark	(3) λ =0.14	(4) λ =0.15	(5) No Bailout
$\sigma(\log(c))/\sigma(\log(y))$	1.15	1.82	1.92	1.29	1.15
$\sigma(TB/y)/\sigma(log(y))$	1.36	1.42	1.53	0.81	0.65
$\rho(\log(c), \log(y))$	0.90	0.60	0.59	0.76	0.82
$\rho(TB/y, \log(y)$	−0.08	−0.08	−0.09	0.03	0.08
Duration	5.08	2.73	2.57	3.64	3.80
Duration (bad times)	4.55	3.07	2.94	3.67	3.79
Maturity	8.90	4.58	4.24	6.51	6.86
Maturity (bad times)	7.90	5.30	5.03	6.61	6.85
$\rho(m', \log(y))$	0.93	−0.37	−0.42	−0.09	0.01
$\rho(duration', \log(y)$	0.93	−0.37	−0.42	−0.07	0.03
1-y spread	1.34	0.00	0.00	0.00	0.00
1-y spread (bad times)	1.63	0.03	0.03	0.03	0.03
10-y spread	3.26	0.30	0.33	0.18	0.16
10-y spread (bad times)	4.39	0.38	0.40	0.31	0.30
$\rho(1\text{-y}s, \log(y))$	−0.61	−0.28	−0.28	−0.36	−0.38
$\rho(10\text{-y}s, \log(y))$	−0.89	−0.55	−0.55	−0.65	−0.68
$E((b'm' + a'm'_a)/y)$	15.23	21.17	21.06	20.97	21.31
$E(a'M_a/(b'm' + a'm'_a))$	6.75	52.07	51.19	55.25	–
Default frequency (in %)	–	0.26	0.25	0.25	0.25
Bailout probability (in %)	18.18	5.62	7.15	0.87	–
Bailout prob. (bad times)	–	1.48	2.34	0.16	–
Bailout duration	–	2.06	2.02	2.20	–

Notes: The first three blocks of column (1) are based on Dvorkin et al. (forthcoming). The last block refers to IMF and Worldbank data. y and c denote real output and real private consumption, respectively. s denotes the sovereign spread. Shares and probabilities are given in %. Maturity and Duration are given in years. The calculation of the duration follows the Macaulay definition, see Appendix I. Columns (2) to (5) are based on 1500 simulations of 400 years, where we discard the first 100 observations. Column (2) reports the statistics for the benchmark model, columns (3) and (4) consider variations of the bailout conditionality λ. Column (5) refers to the model without access to bailouts. 'Bad times' refers to years with an endowment realization below the trend. First-order moments are medians. $E(a'M_a/(b'm' + a'm'_a))$ denotes the share of official debt on total debt at bailout entry. All statistics refer to periods in which the economy is not in default.

the correlation between maturity of privately held debt and output.

While the government defaults at a low frequency, the short-term spreads are close to zero and only marginally increase during bad times. While mean values reflect the default rate in bond prices, the use of medians shows that default risk is typically very low, but can increase strongly. Such dynamics can also be observed in our analysis on bailout entries in Section 3.4.3. The default rate is lower than the value of 3% in the dataset of Tomz and Wright (2013), p. 257, and the ratio of 3 defaults in Colombia over the past 120 years.[15]

In columns (3) and (4), we consider the statistics for a weaker ($\lambda = 0.14$) and a stronger conditionality parameter choice ($\lambda = 0.15$), respectively. With stricter conditionality, the government enters bailouts less often. The decline in the ability to finance consumption with new private or official debt reduces the volatility of consumption. Since the government loses the insurance provided by official debt at times of low endowment realizations, the correlation between consumption and output increases. The government uses more long-term debt to hedge against future income risk such that the average maturity increases. The increase is proportionally higher for high endowment realizations. The economy lacks the insurance properties of bailouts such that bond spreads are more negatively correlated with output. As the government becomes more credit-constrained with stricter conditionality, indebtedness decreases and the government defaults less frequently. The default risk expressed by the long-term bond spreads declines. The effects on the debt level, the share of official debt on total debt, and the bailout duration are, however, weak as the statistics show little variation in the bailout participation rates for the chosen conditionality variations.

Finally, in column (5), we compare the benchmark model with the model in which the availability of official loans is absent. In line with the quantitative literature, e.g. Fink and Scholl (2016), the default risk increases when bailouts exist, reflected in rising long-term bond spreads. At a given debt level, the insurance through the availability of official loans below the market rate reduces the government's incentives to default and international private creditors charge a lower premium. Thus, the government faces lower borrowing costs and accumulates more debt. With a higher debt stock and higher debt service, the probability increases that an endowment shock realizes for which the government defaults. While the increase in indebtedness is not present in the median debt statistics of Table 3.2, mean total debt over output increases from 20.63% in the model in which bailouts are absent to 21.75% and 21.99% in the benchmark economy and the model with $\lambda = 0.14$, respectively. The maturity and duration are higher for high endowment. The maturity choice follows from the bond yields. For high

[15] After the independence in 1819, Columbia has defaulted 7 times on government debt obligations in 1826, 1850, 1873, 1880, 1900, 1932, and 1935 (Reinhart, 2010).

endowment, bond spreads are low and the government uses long-term debt as insurance against future income risk. At low endowments, bond spreads increase and short-term issuance becomes relatively more favorable such that the government chooses lower portfolio maturities. If bailouts are available, the incentives from the yield curve are dominated by the incentives from the availability of official loans.

3.4.3 Bailout Dynamics

To study the dynamics around a bailout entry, we choose episodes of bailout entries out of our simulations of 1500 series of 400 observations, where we discard the first 100 observations. The bailout entries are preceded by at least 4 years without bailout participation, default, or periods in exclusion from international financial markets after a default. We consider episodes of two consecutive bailout years, in line with the mean bailout duration in simulations, which are followed by at least 3 years of repayment without official financial assistance. Figure 3.2 shows the log output, the trade balance to output, the sudden stop frequency, the bond maturity, the face value of privately held debt to output, total debt over output, the share of official debt obligations on total debt obligations, and the spreads for annual interest rates of 1-year and 10-year bonds.

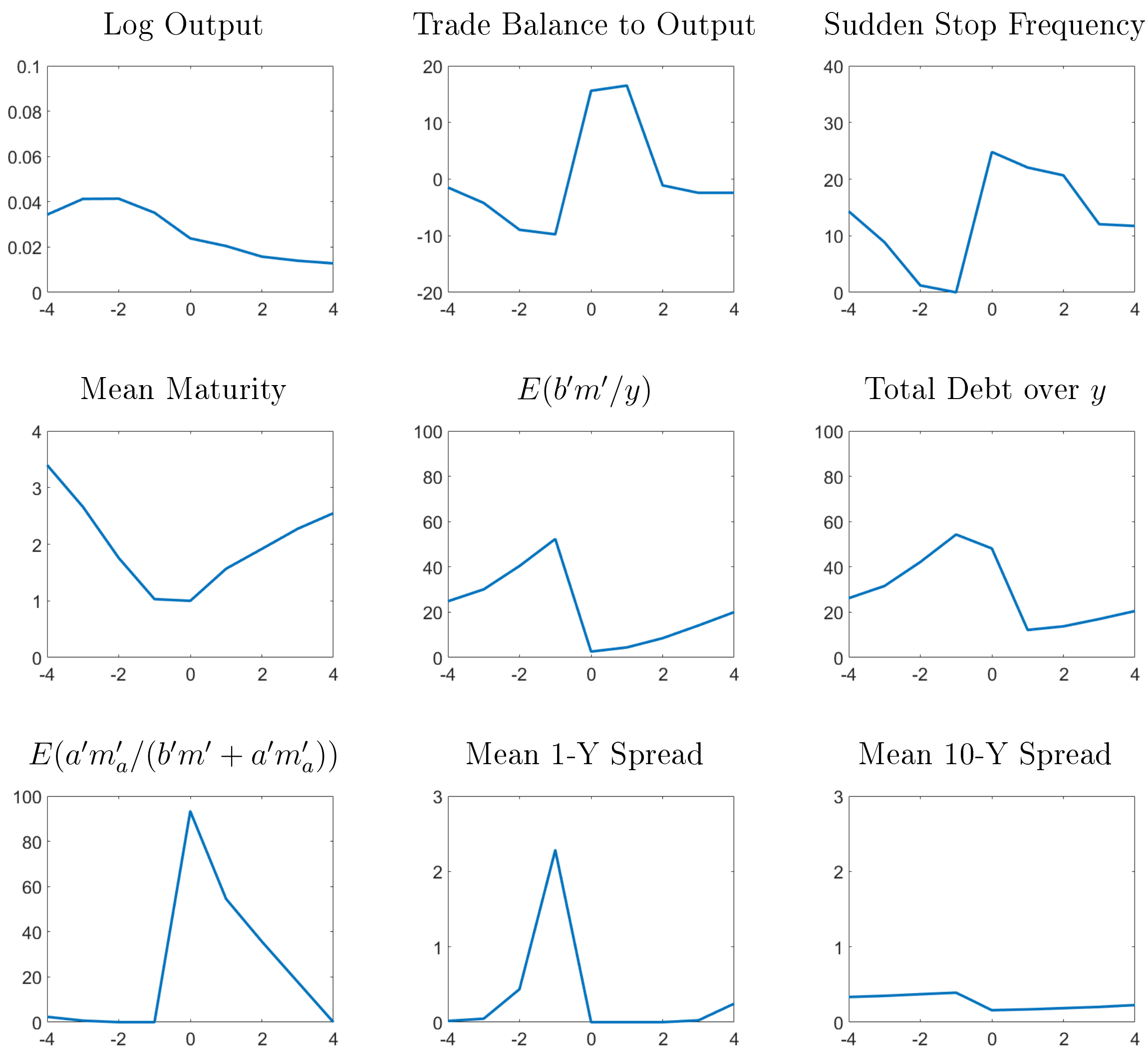
Bailout entries are preceded by high output, increasing indebtedness, and increasing bond spreads, reflecting an increased default risk. Bond interest rates for short-term debt increase by a higher margin that the rates for long-term debt, implying a reversal of the yield spread curve.[16] The increase in the annual bond interest rates makes long-term debt particularly more expensive such that the government issues more short-term debt and the portfolio maturity declines. There is only a minor number of observations for which the government has ongoing debt obligations and thus has participated in a bailout program immediately before the years considered in the event analysis.

In the year of bailout entry, output drops and large shares of existing privately held debt are replaced by official debt. Note that, while we set a lower bound on the choice of privately held debt during bailouts, the replacement of a major share of bonds with official loans is possible because of the maturity reduction in the previous years. The interest rate spreads drop with the use of official financial assistance. The conditionality constraint implies a switch in the trade balance to a positive value. Around 30% of the bailout entries is related to a sudden stop, which is above the long-term sudden stop probability of 14.3%.

In the second bailout year ($t = 1$), the government reduces on average total debt by more than implied by the conditionality constraint. In particular, the amount of official

[16] Sánchez et al. (2018) find a similar reversal of the yield spread curve before defaults.

Figure 3.2: Event Study: Bailout Entry



Notes: The figures show the mean of log output, trade balance to output, maturity, private debt to output, total debt to output, official debt to total debt, 1-year spread and 10-year spread as well as the sudden stop frequency for episodes of bailout entry at $t = 0$ out of simulations of 1500 series of 400 observations, where we discard the first 100 observations. The bailout entries are preceded by at least 4 years without another bailout or exclusion from financial markets after a default. The entries are followed by another year in bailout and at least 3 years in repayment without financial assistance. Shares and spreads are denoted in percentage values. The maturity is given in years.

loans drops. The reason is that in a third of observations, the government reacts to the decline in bond spreads with reducing official loans to zero and replacing these credits by privately held debt at interest rates below the rates for official debt. While the first bailout year is not characterized by increased maturities for private debt as in our statistics from Section 3.2, the maturity increases during the follow-up bailout program.

In the years following the bailout years, the maturity of bonds further increases compared to the pre-bailout year, which is in accordance with our empirical evidence in Section 3.2. The sudden stop frequency converges to the long-term probability, determined by ρ_s. Following from a positive trade balance, indebtedness declines and remains below the pre-bailout level, confirming the empirical findings by Balima and Sy (2019).

If we relax our restrictions on the number of consecutive programs, we observe a significant number of follow-up bailout programs, in line with empirical evidence by Conway (2007) and Bird et al. (2004). While allowing for bailout entries followed immediately by 4 periods of repayment would increase the number of episodes by 5.66%, adding bailout entries with two immediately following programs would result in an increase of 41.74% of cases. These numbers are in line with the median bailout duration above 2 years in our simulations.

3.4.4 The Quantitative Effect of the Maturity of Official Loans

In this section, we analyze the impact of the pre-determined maturity of official loans on the model outcomes. Columns (2) and (3) of Table 3.3 show variations of the official debt maturity $\mathcal{M}_a$.

An increase in the maturity of official loans, ceteris paribus, strongly amplifies the government's preference to enter a bailout program and to draw larger official credits. While the conditionality constraint restricts the draw of official debt, longer maturities reduce the debt service in the following periods and thus make bailouts more attractive. Bailout participation at states with higher initial indebtedness reduces the default risk and allows the government to increase the issuance of privately held bonds. Overall, the default risk declines such that bond spreads become lower. As official debt at longer maturities provides a better opportunity to hedge against future income risk, the government reduces issuance of long-term bonds. The portfolio maturity drops to 1 year. The low portfolio maturity implies a larger per-period debt service such that the government can replace more privately held debt by official debt, resulting in a larger total amount of drawn official loans. The bailout probability and the bailout duration imply that the government frequently switches between years of repayment and years of bailout to access additional financial resources.

3.4.5 The Impact of Grace Periods for Official Loans

Columns (4) and (5) of Table 3.3 present the statistics for 2 alternative specifications in which repayment of official debt is still over 3 years, but begins with a delay of $\Omega = 1$ and $\Omega = 2$ grace periods, respectively. The levels of private and official debt, and the bailout probability are increasing in the amount of grace periods. The maturity drops to 1 year. More grace periods reduce the debt service in the following periods and thus increase the incentives to enter a bailout program and to draw larger amounts

Table 3.3: The Maturity and Grace Periods of Official Loans

	(1) Benchmark	(2) $\mathcal{M}_a = 1$	(3) $\mathcal{M}_a = 5$ $\Omega = 0$	(4) $\mathcal{M}_a = 4$ $\Omega = 1$	(5) $\mathcal{M}_a = 5$ $\Omega = 2$
$\sigma(\log(c))/\sigma(\log(y))$	1.82	1.16	5.51	6.98	7.94
$\sigma(TB/y)/\sigma(log(y))$	1.42	0.65	5.77	7.72	8.94
$\rho(\log(c), \log(y))$	0.60	0.82	0.17	0.13	0.11
$\rho(TB/y, \log(y)$	−0.08	0.07	0.02	0.02	0.02
Duration	2.73	3.70	1.00	1.00	1.00
Duration (bad times)	3.07	3.69	1.00	1.00	1.00
Maturity	4.58	6.65	1.00	1.00	1.00
Maturity (bad times)	5.30	6.65	1.00	1.00	1.00
$\rho(m', \log(y))$	−0.37	0.00	0.03	−0.00	0.05
$\rho(duration, \log(y)$	−0.37	0.02	0.03	−0.00	0.05
1-y spread	0.00	0.00	0.00	0.00	0.00
1-y spread (bad times)	0.03	0.03	0.00	0.00	0.00
10-y spread	0.30	0.31	0.10	0.03	0.00
10-y spread (bad times)	0.38	0.47	0.13	0.03	0.00
$\rho(1\text{-y}s, \log(y))$	−0.28	−0.39	−0.16	–	–
$\rho(10\text{-y}s, \log(y))$	−0.55	−0.69	−0.49	−0.53	−0.97
$E((b'm' + a'm'_a)/y)$	21.17	19.84	72.98	113.24	140.33
$E(a'M_a/(b'm' + a'm'_a))$	52.07	0.00	71.64	94.97	98.17
Default probability (in %)	0.26	0.23	0.07	0.00	0.00
Bailout probability (in %)	5.62	0.00	50.44	54.06	47.39
Bailout prob. (bad times)	1.48	0.00	51.12	54.19	47.48
Bailout duration	2.06	–	1.00	1.00	1.00

Notes: The statistics are based on 1500 simulations of 400 years, where we discard the first 100 observations. y and c denote real output and real private consumption, respectively. s denotes the sovereign spread. Shares and probabilities are given in %. Maturity and Duration are given in years. The calculation of the duration follows the Macaulay definition, see Appendix I. Columns (2) and (3) presents variations of the maturity of official debt $\mathcal{M}_a$. Column (4) and (5) additionally introduce a number Ω of grace periods. 'Bad times' refers to years with an endowment realization below the trend. First-order moments are medians. $E(a'M_a/(b'm' + a'm'_a))$ denotes the share of official debt on total debt at bailout entry.

of official debt. The increase of drawn official debt is dampened, but not eliminated, by increasing interest rates on official loans. Additional official debt provides more resources to hedge income risk such that the government can avoid the issuance of long-term debt at higher interest rates. With more financial resources, the default probability and the spreads on short-term and long-term debt drop. With the high bailout participation rate, the transition from periods with reduced debt issuance due to bailout conditionality to repayment periods with increased issuance of short-term bonds and vice versa occurs more frequently and increases the volatility of consumption and the volatility of the trade balance over output.

3.4.6 Robustness

In this section, we study how the parameters for the extreme value distribution of the additive preference shocks affect our results. Table 3.4 provides the results for variations of the standard deviation and the autocorrelation, σ_ϵ and ρ_ϵ. For smaller standard deviations, the government draws less official debt and increases issuance of bonds at lower maturities. As Dvorkin et al. (forthcoming) elaborate, the probability of default and thus the bond price functions become smoother with higher standard deviations. With smoother bond prices, the government adjusts bond issuance less strongly to changes in the endowment and indebtedness becomes less volatile. Technically, the probability of choosing a certain portfolio is less pronounced and the set of portfolios with a choice probability significantly larger than zero increases. Similar to the standard deviation parameter σ_ϵ, a higher autocorrelation ρ_ϵ increases the volatility of the additive preference shocks and smooths both the default probability and the bond price function. The pattern is similar as for variations of σ_ϵ.

3.5 Conclusions

In this paper, we have developed a quantitative sovereign debt model to study the effects of bailouts with different predetermined repayment schedules for official debt, i.e. different maturities and grace periods, on macroeconomic outcomes. The model features endogenous default risk, endogenous bailout participation, endogenous maturity choice on private debt, and long-term institutional debt.

Our model implies that the availability of bailout credits reduces the maturity of government bonds held by private creditors. The government uses official loans instead of long-term debt as insurance against future income risk. Stricter conditionality reduces the access to official loans and the government issues more bonds at long maturities such that the portfolio maturity increases.

Table 3.4: Robustness: Extreme Value Distribution Parameters

	(1) Benchmark	(2) $0.2 \times \sigma_\epsilon$	(3) $2 \times \sigma_\epsilon$	(4) $0.5 \times \rho_\epsilon$	(5) $2 \times \rho_\epsilon$
$\sigma(\log(c))/\sigma(\log(y))$	1.82	1.96	1.47	1.88	1.45
$\sigma(TB/y)/\sigma(log(y))$	1.42	1.55	1.07	1.47	1.04
$\rho(\log(c), \log(y))$	0.60	0.58	0.68	0.60	0.69
$\rho(TB/y, \log(y)$	−0.08	−0.11	−0.00	−0.10	0.00
Duration	2.73	2.66	3.08	2.73	3.33
Duration (bad times)	3.07	3.20	3.16	3.17	3.40
Maturity	4.58	4.44	5.32	4.57	5.86
Maturity (bad times)	5.30	5.58	5.51	5.53	6.02
$\rho(m', \log(y))$	−0.37	−0.61	−0.12	−0.52	−0.10
$\rho(duration, \log(y)$	−0.37	−0.61	−0.11	−0.52	−0.10
$\sigma(m')$	2.11	2.03	1.96	2.11	2.08
$\sigma(duration)$	1.00	0.96	0.92	1.00	0.98
1-y spread	0.00	0.00	0.00	0.00	0.00
1-y spread (bad times)	0.03	0.06	0.01	0.05	0.02
10-y spread	0.30	0.24	0.48	0.20	0.15
10-y spread (bad times)	0.38	0.35	0.57	0.30	0.25
$\rho(\text{1-y}s, \log(y))$	−0.28	−0.34	−0.32	−0.34	−0.32
$\rho(\text{10-y}s, \log(y))$	−0.55	−0.66	−0.59	−0.62	−0.59
$E((b'm' + a'm'_a)/y)$	21.17	23.31	18.41	22.97	20.24
$E(a'M_a/(b'm' + a'm'_a))$	52.07	44.68	60.36	45.24	57.43
σ(total debt/y)	11.28	11.12	8.64	11.09	8.71
Default probability (in %)	0.26	0.30	0.20	0.31	0.23
Bailout probability (in %)	5.62	8.19	1.52	6.98	1.41
Bailout prob. (bad times)	1.48	2.02	0.32	1.65	0.31
Bailout duration	2.06	2.01	2.08	2.01	2.10

Notes: The statistics are based on 1500 simulations of 400 years, where we discard the first 100 observations. y and c denote real output and real private consumption, respectively. s denotes the sovereign spread. Shares and probabilities are given in %. Maturity and Duration are given in years. The calculation of the duration follows the Macaulay definition, see Appendix I. Columns (2) and (3) as well as columns (4) and (5) vary the standard deviation and the autocorrelation of the extreme value distributed shocks, respectively. 'Bad times' refers to years with an endowment realization below the trend. First-order moments are medians. $E(a'M_a/(b'm'+a'm'_a))$ denotes the share of official debt on total debt at bailout entry.

Bailout entries are preceded by high output, increasing indebtedness, increasing bond spreads, and decreasing portfolio maturities. During a bailout, the government replaces large shares of privately held debt by official debt. After a bailout, there is a high probability of a follow-up bailout program. Compared to the pre-bailout years, the debt level is lower after a bailout and the portfolio maturity increases.

Longer maturities and grace periods for official loans make bailouts more attractive and the government requests larger sums of official debt. The bailout frequency and indebtedness increase, whereas the maturity for privately held debt drops. There is a repeated transition between periods of bailouts, in which conditionality reduces consumption, and repayment periods with the issuance of high amounts of short-term debt, which increases consumption. These transitions increase the volatility of consumption relative to output.

In this study, we have focused on the impact of bailout programs with predetermined maturities and grace periods for official debt. The 'case-by-case' approach chosen by the ESM allows for further questions, such as what the optimal maturity choice to international financial institutions is, given the intention to avoid sovereign debt crises, but also to keep the dependence of governments on official financial assistance low. It follows the question how the determinants of bailout packages are defined, e.g. during negotiations betwenn the government and the institution. These questions are left for future research.

G Appendix: Empirical Analysis

Table 3.5 lists the IMF programs included in the empirical analysis of Section 3.2.

Table 3.5: IMF Programs

Country	**Program Type**	**Year**
Brazil	SBA	1988, 1992
Ecuador	SBA	1994, 2003
Mexico	SBA	1995, 1999
Russia	SBA	1999
Venezuela	SBA	1996

Program Types: Stand-by Arrangement (SBA), Supplemental Reserve Facility (SRF), Extended Fund Facility (EFF), Extended Credit Facility (ECF)

H Appendix: Application of Preference Shocks

Following Dvorkin et al. (forthcoming), the additive preference shocks $\boldsymbol{\epsilon}$ are i.i.d. Generalized Extreme value distributed with joint cumulative density function

$$F(\boldsymbol{x}) = \exp\left[-\left(\sum_{j=1}^{\mathcal{J}} \exp\left(-\frac{x_j-\mu}{\rho_\epsilon \sigma_\epsilon}\right)\right)^{\rho_\epsilon} - \exp\left(-\frac{x_{\mathcal{J}+1}-\mu}{\rho_\epsilon \sigma_\epsilon}\right)\right],$$

where the parameters μ, ρ_ϵ, and σ_ϵ imply a zero mean for the shocks, relate to the correlation between the shocks attached to the different choice combinations of debt and maturity, and scale the shock variance, respectively. For this distribution, the decision problem takes the form of a Nested Logit. The first nest is given by the default decision, the second nest by the choice on bond issuance and portfolio as well as bailout participation with choice on the amount of official loans.

The use of additive preference shocks and the possibility to consider the policy option implied by the discrete grid as finite and mutually exclusive events, allows us to rewrite the bond price function (3.1), $q(y, b_j, a_j, m_j, m_{a,j}; n)$, as

$$\frac{E_{y',s'|y}}{1+r}\Bigg[(1-D(y',s',b_j,a_j,m_j,m_{a,j})) \\ \left(1+\sum_{k=1}^{\mathcal{J}} q(y',s',b_k,a_k,m_k,m_{a,k};n-1) G_{y',s',b_j,a_j,m_j,m_{a,j}}(b_k,a_k,m_k,m_{a,k})\right)\Bigg],$$

where expectational values are represented by the sum of the products of the probability and the realization of each event. The function $D(y', s', b_j, a_j, m_j, m_{a,j})$ denotes the probability that the vector $\boldsymbol{\epsilon}$ takes a value such that the government prefers to default. The probability that the realization of $\boldsymbol{\epsilon}$ implies the choice of a specific combination of debt and maturity, b_k, a_k, m_k, and $m_{a,k}$, where $m_{a,k} \in \{\max(m_{a,j}-1,1), M_a\}$, is given by $G_{y',s',b_j,a_j,m_j,m_{a,j}}(b_k, a_k, m_k, m_{a,k})$.

Let the value for policy option j and initial state i be given by

$$X_{i,j} = \begin{cases} \frac{(c_{ij}(y))^{1-\gamma}}{1-\gamma} + \beta E_{y',s'|y} V(y', s', b_j, m_j, a_j, m_{a,j}) \quad \text{for } j = 1, ..., \mathcal{J} \\ \frac{(f(y)+a_i)^{1-\gamma}}{1-\gamma} + \beta E_{y',s'|y} \left[(1-\theta)V^D(y', a_j, m_{a,j}) + \theta V(y', s', 0, 1, a_j, m_{a,j})\right] \\ \qquad \text{for } j = \mathcal{J}+1. \end{cases}$$

Then the probability of default D_i, the probability that the government chooses policy option $j \in \{1, ..., \mathcal{J}\}$ conditional on not defaulting $G_{i,j}$, and the value function V_i for initial state i can be written as

$$D_i = \frac{1}{1 + \left[\sum_{j=1}^{\mathcal{J}} \exp\left(-\frac{X_{i,\mathcal{J}+1} - X_{i,j}}{\rho_\epsilon \sigma_\epsilon}\right)\right]^{\rho_\epsilon}},$$

$$G_{i,j} = \frac{1}{\sum_{k=1}^{\mathcal{J}} \exp\left(\frac{X_{i,k} - X_{i,j}}{\rho_\epsilon \sigma_\epsilon}\right)},$$

$$V_i = X_{i,\mathcal{J}+1} + \sigma_\epsilon \log\left[1 + \left(\sum_{k=1}^{\mathcal{J}} \exp\left(-\frac{X_{i,\mathcal{J}+1} - X_{i,j}}{\rho_\epsilon \sigma_\epsilon}\right)\right)^{\rho_\epsilon}\right].$$

I Appendix: Definitions of Duration and Yield to Maturity

We follow Dvorkin et al. (forthcoming), Hatchondo et al. (2009), and Sánchez et al. (2018) and apply the Macaulay definition to compute the duration of a bond. The duration is defined as the weighted sum of future promised payments

$$\frac{q(\cdot;1) + 2 \times (q(\cdot;2) - q(\cdot;1)) + ... + m_j \times (q(\cdot;m_j) - q(\cdot;m_j-1))}{q(\cdot;m_j)},$$

where $(\cdot)$ represents the states $(y, b_j, a_j, m_j, m_{a,j})$.

The yield to maturity of a bond with maturity n, $YTM(y, b_j, a_j, m_j, m_{a,j}; n)$, is given by

$$YTM(\cdot;n) \equiv \left(\frac{1}{q(y, b_j, a_j, m_j, m_{a,j}; n) - q(y, b_j, a_j, m_j, m_{a,j}; n-1)} \right)^{\frac{1}{n}} - 1.$$

J Appendix: Numerical Algorithm

We closely follow Dvorkin et al. (forthcoming) and solve the model using value function iteration with discretized grids for external debt $b \in [\underline{b}, \overline{b}]$, official debt $a \in [\underline{a}, \overline{a}]$, and the endowment $y \in [\underline{y}, \overline{y}]$. The debt grid changes across different maturities m_i. We use 31 grid points that are evenly spaced between 0 and $0.7q^*(m_i, r)$, where q^* denotes the risk-free bond choice given the maturity m_i. For official debt, we use 15 evenly spaced grid points. For the endowment, we consider 17 grid points. We use a finer grid for realizations below the median endowment, which is the region in which the bond price function becomes steeper and the default probability becomes non-zero. The 12 (5) grid points below (above) the median endowment are evenly distributed. We use the Tauchen algorithm to discretize the endowment process.

Like Dvorkin et al. (forthcoming), we use the absolute change in the bond price function between two iterations relative to the level of the bond price as convergence criterion. We iterate until the bond price function has converged.

Gesamtzusammenfassung

Die drei Kapitel dieser Dissertation beschäftigen sich alle mit den Effekten von Fiskalpolitik und den ökonomischen Dynamiken im Zusammenhang mit Staatssschuldenkrisen. Im ersten Kapitel integriere ich Humankapitalverlust während Phasen von Arbeitslosigkeit in ein quantitatives Staatsschuldenmodell, um das Zusammenwirken von langfristiger Arbeitslosigkeit und fiskalpolitischen Entscheidungen zu untersuchen. Das Kapitel orientiert sich an den Ereignissen nach 2008, als die südeuropäischen Länder einen starken und dauerhaften Arbeitslosigkeitsanstieg erlitten. Steigende Risikoaufschläge auf Staatsschuldtitel machten die Umsetzung von Sparpolitiken notwendig. Sparpolitik allerdings kann zu einem weiteren Anstieg der Arbeitslosigkeit führen. Wenn Arbeiter Humankapital während Zeiten der Arbeitslosigkeit verlieren, verringert sich das zukünftige Produktionspotenzial der Volkswirtschaft und damit die Ressourcen, um staatlichen Zahlungsverpflichtungen nachzukommen zu können, wodurch sich eine Staatsschuldenkrise weiter verschärft. Neuverhandlungen von Staatsschulden bieten eine Möglichkeit die Kosten der Sparpolitik zu vermeiden. Ich entwickele ein dynamisches stochastisches Staatsschuldenmodell mit langfristigen Schuldverpflichtungen, endogen bestimmten Schuldenschnitten und Humankapitalverlust während der Dauer der Arbeitslosigkeit, um die optimale Fiskalpolitik während Staatsschuldenkrisen zu untersuchen. Das Model impliziert, dass eine höherer Intensität des Humankapitalverlusts ex ante eine geringere Staatsverschuldung und einen Rückgang der Prozyklizität der Fiskalpolitik zur Folge hat. Für Portugal sagt das Modell Schuldenverhandlungen als optimale fiskalpolitische Reaktion im Jahr 2011 voraus, gefolgt von einer mittelfristigen Reduzierung der Arbeitslosenquote um bis zu 3.5 Prozentpunkte.

Im zweiten Kapitel, einer Gemeinschaftsarbeit mit Almuth Scholl (Universität Konstanz), entwickeln wir ein stochastisches, dynamisches, politik-ökonomisches Staatsschuldenmodell, um den Einfluss von Bailouts auf die Wahrscheinlichkeit eines Regierungswechsels und des Staatsausfallrisikos zu analysieren. Wir betrachten eine kleine offene Volkswirtschaft, in der die Regierung Zugang zu Krediten von internationalen Institutionen hat, bedingt auf die Umsetzung von Sparpolitiken. Es gibt ein Zweiparteiensystem, in dem beide Parteien den Nutzen der Bevölkerung maximieren möchten, sich aber in der Wahrnehmung von exogenen Nutzenkosten im Falle eines Staatsausfalls unterscheiden. Ein Regierungswechsel erfolgt endogen durch individuelles Wahlverhalten. In einer quantitativen Analyse wenden wir das Modell auf die Volkswirtschaft

Griechenlands an. Das Modell zeigt, dass Bailouts die Wahrscheinlichkeit für einen Regierungswechsel erhöhen, wodurch sich wiederum die Risikoaufschläge auf Staatsschuldtitel erhöhen. Striktere Sparauflagen erhöhen die Wahrscheinlichkeit für einen Regierungswechsel und einen Staatsausfall kurzfristig, können in der langen Frist aber beide Risiken verringern. Die Häufigkeit für einen Regierungswechsel verläuft U-förmig in der Strenge der Sparauflagen.

Im letzten Kapitel, einer Gemeinschaftsarbeit mit Jan Mellert (TU Dortmund), untersuchen wir die makroökonomischen Auswirkungen von Bailouts mit unterschiedlichen vorgegebenen Rückzahlungsplänen für Hilfskredite. Insbesondere betrachten wir den Einfluss von Hilfskrediten auf die Laufzeit von Schulden gegenüber privaten Kreditgebern. Wir entwickeln ein dynamisches, stochastisches Staatsschuldenmodell mit endogenem Staatsausfallrisiko, endogener Teilnahme an Bailoutprogrammen, endogener Wahl der Laufzeit von Schulden gegenüber privaten Kreditgebern und Bailoutkrediten mit langen Laufzeiten. Das Modell impliziert, dass vor Bailouts die Staatsverschuldung ansteigt und die Portfoliolaufzeit sinkt. Mit dem Eintritt in ein Bailoutprogramm ersetzt die Regierung große Anteile privat gehaltener Schulden durch Hilfskredite. Nach dem Bailout kommt es mit hoher Wahrscheinlichkeit zu einem Folgeprogramm. Die Verschuldung sinkt unter das Niveau vor dem Bailout und die Laufzeit privat gehaltener Schulden steigt. Längere Laufzeiten und Zahlungsfristen für Hilfskredite machen Bailouts attraktiver und führen zu höheren Schulden, wohingegen die Laufzeit von privat gehaltenen Staatsschuldtiteln fällt.

Conclusion

All three chapters of this dissertation focus on the effects of fiscal policy and the economic dynamics in the context of sovereign debt crises. In the first chapter, I introduce skill loss during unemployment in a quantitative sovereign debt model to study the interactions between persistent unemployment and fiscal policy decisions. The chapter is motivated by the events after 2008, when the Southern European economies suffered a strong and persistent increase in unemployment. Rising government bond spreads necessitated the implementation of austerity policies. Austerity however, may increase unemployment. If workers lose human capital during unemployment spells, the economy's future production potential and thus the fiscal capacities to serve public debt will decline, aggravating a sovereign debt crisis. Debt renegotiations can help to avoid the costs of austerity. I develop a dynamic stochastic model of sovereign debt with long-term debt, endogenous haircuts and skill loss during unemployment to study optimal fiscal policy in sovereign debt crises. The model implies that with higher intensity of the skill loss, ex ante, the government issues less debt and the pro-cyclicality of fiscal policy declines. For Portugal, the model predicts debt renegotiations as optimal fiscal response in 2011 with a medium-run unemployment reduction of up to 3.5 percentage points.

In the second chapter, jointly with Almuth Scholl (University of Konstanz), we develop a stochastic dynamic politico-economic model of sovereign debt to analyze the impact of bailouts on political turnover and sovereign default risk. We consider a small open economy in which the government has access to official loans conditional on the implementation of austerity policies. There is a two-party system in which both parties care about the population's welfare but differ in an exogenous utility cost of default. Political turnover is the endogenous outcome of the individual voting behavior. In a quantitative application to the Greek economy, we find that bailouts amplify political turnover risk, which, in turn, elevates sovereign interest spreads. While conditionality fosters the probability of political turnover and sovereign default in the short run, it may mitigate political turnover and default risk in the long run. The frequency of political turnover is U-shaped in the strength of conditionality.

In the final chapter, jointly with Jan Mellert (TU Dortmund) we study the impact of bailouts with different predetermined repayment schedules for official debt on macroeconomic outcomes. In particular, we consider the effect of institutional debt on the maturity of public debt held by private creditors. We develop a dynamic stochastic model of sovereign debt with endogenous default risk, endogenous bailout participation, endogenous maturity choice on privately held bonds, and bailout credits with long maturities. The model implies that bailouts are preceded by increasing indebtedness and decreasing portfolio maturity. At bailout entry, the government replaces large shares of privately held debt by official debt. After the bailout, there is a high probability of a follow-up bailout program. Indebtedness is below its pre-bailout level and the maturity on privately held bonds increases. Longer maturities and grace periods for official debt make bailouts more attractive and increase indebtedness, whereas the bond maturity drops.

Abgrenzung

Ich versichere hiermit, dass ich die Studie im ersten Kapitel "Persistent Unemployment, Sovereign Debt Crises, and the Impact of Haircuts" eigenständig und ohne Hilfe Dritter verfasst habe.

Das zweite Kapitel "The Impact of Bailouts on Political Turnover and Sovereign Default Risk" stellt eine gemeinsame Forschungsarbeit mit Prof. Dr. Almuth Scholl (Universität Konstanz) dar. Mein Anteil bei der Erstellung dieser Arbeit beträgt 50%.

Das dritte Kapitel "Bailouts and the Maturity of Sovereign Debt" ist in Zusammenarbeit mit Dr. Jan Mellert (TU Dortmund) entstanden. Mein Anteil bei der Erstellung dieser Arbeit beträgt 80%.

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