Gonçalo Pina

GDP-Linked Bonds in the Portuguese Economy

Public debt crises bring about massive economic and social costs. The use of state-contingent public debt has the potential to avoid these crises. Unlike traditional public debt, state--contingent debt payments reflect the economic conditions of the country issuing the debt, as they are linked to indicators such as GDP. However, the use of explicit contingencies in public debt remains very limited. What is state-contingent public debt, and how has it been applied in Portugal and around the world? How would the generalised use of this type of debt in Portugal affect debt to GDP ratios? This study shows that state-contingent public debt has the potential to produce public debt that is more sustainable and less exposed to crises, but it also highlights some important challenges associated with these debt markets that are relevant for policymakers and market participants.

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Gonçalo Pina

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Contents

Abstract

This project studies GDP-linked bonds in the context of the Portuguese economy. The first chapter provides a brief introduction to state-contingent government debt, of which GDP-linked bonds are an example. The second chapter surveys existing examples of state--contingent debt and presents a new database focused (i) on the design of these types of debt instruments and (ii) on crucial determinants of their performance. Despite the previous experiences with these bonds, the use of state-contingent debt remains very limited. The third chapter reviews some suggestions on how policymakers can design successful state-contingent debt instruments. The fourth chapter applies GDP-linked bonds to the Portuguese economy. In this chapter, a structural model of debt issuance to smooth government expenditure under strategic default is solved and calibrated to the Portuguese economy, using traditional, noncontingent debt. Then, a counterfactual test is run, showing that state-contingent debt would have decreased the debt to GDP ratio by 15 percentage points in 2011. The fifth chapter reviews the Portuguese experience with state--contingent government debt; namely, the "Certificados do Tesouro Poupança Mais – CTPM", introduced in 2013, and the "Certificados do Tesouro Poupança Crescimento – CTPC", introduced in 2017. Finally, the last chapter presents the conclusions and discusses examples of countries that could potentially be instrumental in the broader implementation of state-contingent public debt.

Chapter 1
Introduction to state-contingent government debt

International sovereign borrowing is plagued with costly debt crises (Tomz and Wright, 2013). Recent academic and policy work suggests making debt repayments indexed to real and nominal variables, which are linked to the overall state of the economy, as a potential improvement on current sovereign debt markets (Besley and Powell 1989, Shiller 1993, Obstfeld and Peri 1998, Haldane 1999, Council of Economic Advisors 2004, Borensztein and Mauro 2004, Sandleris and Wright 2013, Barr et al. 2014, Benford et al. 2016; Blanchard et al. 2016, Cabrillac et al. 2017, Cecchetti and Schoenholtz 2017, Benford et al. 2018, and many more.). Current government borrowing is dominated by noncontingent debt, where payments do not depend directly on the state of the economy, apart from highly disruptive events like debt default or debt restructuring. In other words, current debt does not allow borrowers to transfer payments from bad states of the world, when resources are scarce, to good states of the world when resources are plentiful. By linking payments to the state of the economy, state--contingent debt would make sovereign debt markets more stable and less prone to crises, while borrowing economies would experience more sustainable debt levels, particularly during economic downturns.

This debate has recently reached the G20. For example, point 11 of the "Communiqué of the G20 Finance Ministers & Central Bank Governors", from the meeting in Chengdu, China, on July 23 and 24, 2016, states: "We call for further analysis of the technicalities, opportunities, and challenges of state-contingent debt instruments, including GDP-linked bonds". In October 2016, a policy push to establish GDP-linked bonds was made by economists of the Bank of England, together with lawyers and financiers, with the formation of the London-based Ad Hoc Working Group on GDP-Linked Bonds and the publication of an indicative term sheet for a set of standard terms for a GDP-linked bond.[1]

The history of state-contingent government debt, however, is not so recent. In fact, there have been many examples of government debt where payments or maturity depended on economic variables including GDP, other measures of production, commodity prices, wages, revenues, and even natural disasters, some going as far back as the 19th century. Surprisingly, markets for this type of debt remain very limited, and debt crises still have devastating effects on the economy. Therefore, a thorough understanding of the reasons behind market closure is crucial for policymakers and market participants.

This research project contributes to understanding these markets in three dimensions currently missing from the literature: (i) a new database of existing state-contingent debt examples around the world; (ii) a structural model of government borrowing under state--contingent debt, applied to Portugal and; (iii) a theoretical analysis of a novel reason behind the closure of markets for indexed-debt, in particular, the fact that the benefits of this type of debt accrue disproportionately to borrowers.

This report presents parts (i) and (ii) mentioned above, the database, and the structural model of sovereign borrowing. Part (iii) was developed as part of this project, but consists of a separate research paper. The report includes also with a summary of the main lessons for policymakers interested in state-contingent government debt and concludes with a proposal of avenues for future work and developments in these markets.

Chapter 2

State-contingent government debt: a new database

2.1. Introduction

This chapter describes a database that collects existing examples of state-contingent government debt. The database is intended to be exhaustive and will be updated as new debt is issued, or as significant developments occur on previously issued state-contingent instruments. Although much of this information is currently scattered in several academic, policy, and industry publications, this project collects it under a single source and, more importantly, codifies it into a database. The coded information includes technical details related to the contracts issued, an analysis of their market penetration, and the factors that crucially determine the success of these types of instruments.

The main goals of this chapter are to present the key variables collected in the dataset, report stylized facts regarding state-contingent government debt, and review existing experiences with this type of debt. The history of state-contingent debt instruments reaches as far back as 1863 and covers a wide variety of experiences with this type of debt, both regarding their design and their performance.

2.2. Literature review

Several academic and policy papers have collected information on existing state-contingent debt instruments, and this chapter draws from this work. Most of these papers focus on estimating the benefits associated with these debt instruments, or on understanding their potential limitations while analyzing a few examples of existing debt instruments. In this chapter, however, all the available data will be reviewed and described in a systematic way.

The database includes primary and secondary sources for each instrument recorded. In this section, I review the main sources that have covered multiple debt instruments. Until now, the most extensive collection of examples of state-contingent instruments is the project by the IMF (International Monetary Fund, 2017). The annexes to this IMF report provide information on many of the state-contingent debt instruments covered in this database. Compared to the IMF report, this chapter increases the coverage both in the number of state-contingent assets and in the amount of information collected. It also tabulates these characteristics into a dataset. A non-exhaustive list of papers and books with significant descriptions of state-contingent instruments include works by the International Monetary Fund (1995), Atta-Mensah (2004), Borensztein and Mauro (2004), Tabova (2005), Miyajima (2006), International Monetary Fund and World Bank (2011), Park and Samples (2015), Williamson (2017) and Bertinatto et al. (2017).[2]

2.3. Database

The database is divided into three main categories: (i) basic features, (ii) design, and (iii) performance. There are currently 34 entries in the database, as listed in Table 1. The unit of observation is the first issuance of a state-contingent government debt instrument. Some observations will, therefore, include multiple issuances by the same country, for example, in different years or within the same year but with slightly different structures. Others will include multiple issuances of the same instrument by different countries, for example, through official lenders. This approach to the unit of observation intends to avoid double counting of what is essentially the same state-contingent instrument. Disaggregated information regarding these dimensions is included in the database when available.

This section also presents figures with summary statistics for selected variables. These summary statistics, which are not weighted by volume, provide an overview of existing state-contingent government debt instruments.

Table 1: Database entries as of January 2019

Sovereign	Debt instrument and linkage	Type
Algeria	Oil-linked loan	Loan
Argentina	Real GDP growth linked warrants	Warrant
Bolivia	Bond linked to the price of tin	Bond
Bosnia and Herzegovina	GDP Performance Bonds	Warrant
Bulgaria	Additional Interest Paid (AIP) linked to GDP	Warrant
Burkina Faso, Mali, Mozambique, Senegal, Tanzania	AFD countercyclical loans linked to Exports	Loan
Confederate States of America	Cotton Bonds	Bond
Costa Rica	Value Recovery Rights linked to GDP	Warrant
France	Pinay Bond linked to Gold	Bond
France	Pinay Bond linked to Industrial Production	Bond
France	Rentes Giscard Bond linked to Gold	Bond
Greece	GDP-warrant linked to real GDP	Warrant
Grenada	Bond hurricane clause	Bond
Grenada	Citizenship by investment revenues linked bond	Bond
Various countries[3]	Petrocaribe loans linked to oil	Loan
Honduras	GDP-linked bond	Warrant
India	Oil-linked bond	Bond
India	Gold Bond	Bond
Ivory Coast	GDP-linked bond	Warrant
Malaysia	Citibank Loan	Loan
Mexico	Petrobonos linked to oil	Bond
Mexico	Value Recovery Rights linked to oil	Warrant
Mexico	CatMex linked to earthquakes	Bond
Mexico	Multicat linked to earthquakes and hurricanes	Bond

Sovereign	Debt instrument and linkage	Type
Nigeria	Payment Adjustment Warrant linked to oil	Warrant
Papua New Guinea	Metallgesellschaft Loan linked to copper	Loan
Peru, Colombia, Chile, Mexico	IBRD Cat Bonds CAR 116-120 linked to earthquakes	Bond
Portugal	Treasury certificates linked to real GDP growth	Bond
Singapore	New Singapore Shares, Economic Restructuring Shares linked to GDP growth	Share
Turkey	Revenue indexed bond	Bond
Ukraine	Warrants linked to real GDP	Warrant
Uruguay	Value Recovery Rights linked to terms of trade	Warrant
Uruguay	Nominal wage linked bond	Bond
Venezuela	Oil-indexed payment obligations	Warrant

2.3.1. Basic Features

The first contribution of the database is to provide researchers and policymakers with an overview of the history of state-contingent government, which is captured by the following basic features:

- Sovereign
- Name of the debt instrument
- Year first issued
- Type of instrument
- Indexation
- Indexation detail
- Years used

Table 1 collects the database entries, including the sovereign, the name of the debt instrument, and the type of asset. For simplification purposes, the focus is limited to the first issues. In other words, when an instrument is withdrawn or matures and is replaced by a similar one, the reported date only refers to the first issue. For example, Uruguay updated its nominal wage-linked 2014 bond with a new bond in 2017. Portugal's GDP-linked certificates of treasury issued in 2013, called "Tesouro Poupança Mais – CTPM", were withdrawn and replaced in 2017 with the slightly different "Certificados de Tesouro Poupança Crescimento – CTPC". In both cases, the database entry corresponds to the first debt issue, although details were recorded for both issues. The issuance of the same instrument by multiple countries is also counted once. For example, the 2007 AFD counter-cyclical loans were issued to Burkina Faso, Mali, Mozambique, Senegal, and Tanzania, while the 2018 IBRD Cat Bonds were issued to Chile, Colombia, Mexico, and Peru. Again, these are treated as two observations in the dataset, although details were recorded for each country.

Figure 1 shows the frequency of issuance of state-contingent government debt between 1850 and 2018. These data show two main developments, namely the Brady restructurings in the 1990s, which included state-contingent warrants, and the renewed interest in these instruments in the 2000s, which saw the introduction of different types of assets and contingencies.

There are three main types of instruments issued by sovereigns with state-contingent features: bonds, warrants, and loans. Bonds and warrants are traditionally issued to the public, while loans are issued to official or private lenders, usually banks. Warrants have been usually linked to a traditional "plain vanilla bond" but, in some cases, they have been detachable. The main difference between a bond and a warrant is that warrants are designed in a way that may lead to an increase in payments to investors, but never a decrease. In other words, the contingency is only on the upside. Unsurprisingly, warrants are traditionally issued as sweeteners in debt restructuring deals.

Figure 1 Year of the first issuance.

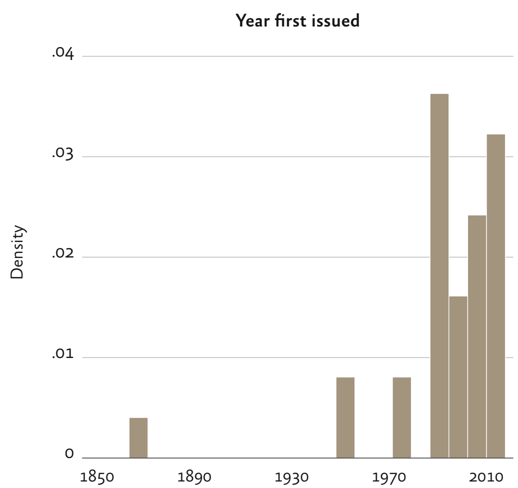
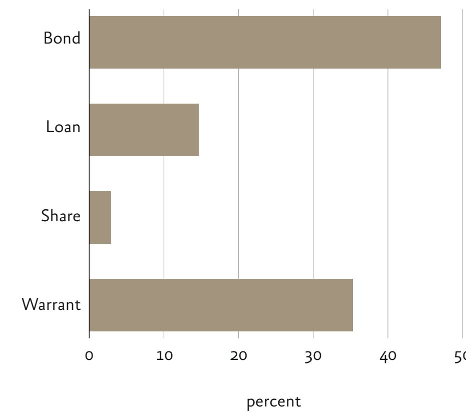


Figure 2 plots the distribution of debt instruments and shows that bonds and warrants account for most of the issuances in this dataset. However, it should be noted that this likely underestimates the number of loans linked to commodities, as several state-owned companies have issued loans where either the repayment or the maturity were linked to the price of an exported commodity.

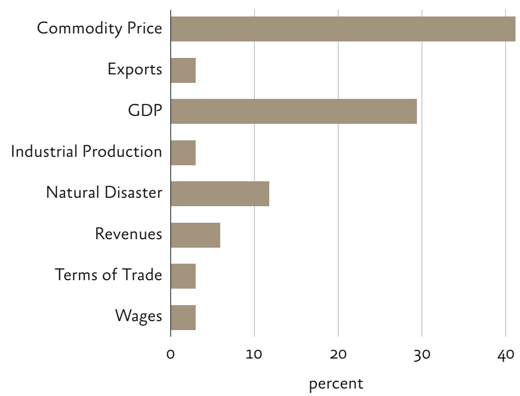
These loans are often guaranteed by the government, either implicitly or explicitly, and therefore are, effectively, state-contingent government debt. Unfortunately, data regarding the details of these contracts are currently limited.[4]

Figure 2 Distribution of type of instrument issued.



State-contingent debt instruments may be indexed to many different variables. These can be related to production and income (level and/or growth), terms of trade, commodity prices, government revenues, or natural disasters. This database collects debt indexed to these different variables as they are all related to the state of the economy. In particular, many of these variables are closely linked to GDP. For example, exogenous increases in commodity prices increase the value of production, while natural disasters will likely reduce it. Figure 3 shows the distribution between these types of indexation. It shows that commodity prices and GDP are the most commonly used variables to implement state-contingent debt.

Figure 3 Variables to which the instrument is indexed.



2.3.2. Design

A crucial issue for policymakers is the design of state-contingent debt, which is very heterogeneous and, with a few exceptions, not yet standardized. This database collects information on the following design features:

- Currency
- Jurisdiction
- Maturity (average for multiple issues)
- Maturity (detail)
- Linked to Plain Vanilla Bonds or Loan (yes/no)
- Linked to Plain Vanilla Bonds or Loan (detail)
- Tradability (yes/no)
- Tradability (detail)
- Contingency type
- Payout/Deferral Mechanism
- Payout/Deferral Details
- Callable, Redeemable, Sinking fund
- Grade period
- Coupon rate, ceiling, and floor
- Payout date and lag relative to data

Figure 4 plots the distribution of issuances across domestic, foreign, and both domestic and foreign currencies. It shows that most of these assets are issued in foreign currency. Some assets are payable in commodities, for example, cotton or oil, and are, therefore, recorded as foreign currencies. Although Eurozone countries are assumed to issue their debt in local currency when issuing in euros, given that they do not have direct control over monetary policy, there is an element of foreign currency in them. A related issue, jurisdiction, is not covered systematically by this database.[5]

Figure 4 Currency of issuance.

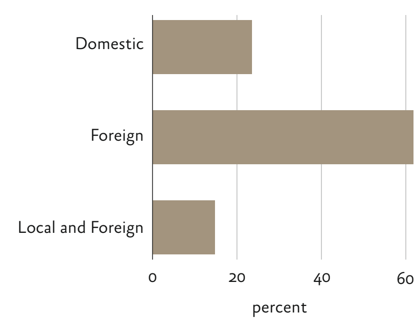


Figure 5 shows the distribution of the maturity of state-contingent debt instruments. When there are multiple debt structures or multiple debt issues with different maturities in one database entry, the data presented here refer to their unweighted average maturity. Details on the maturity of each of these debt issues are recorded under a different variable in the database. The data show that the maturity of these instruments tends to be relatively long, mostly between 10 and 20 years.

Many debt instruments are linked to plain vanilla bonds or regular loans, that is, to other debt instruments that have no indexation. Figure 6 describes whether these assets are linked, detachable, or never linked. It captures the proportion of state-contingent instruments that are connected to other assets in the sense that it is not possible to own one without the other. Another related issue is whether these assets are tradable in secondary markets. Figure 7 summarizes the data in this regard, showing that a large percentage, almost half of the assets, cannot be traded. Note that all contingent assets linked to tradeable bonds are recorded as tradeable. However, detached assets issued to official creditors, or to individuals or corporations under retail agreements, are recorded as non-tradeable.

Figure 5 **Distribution of average maturity by issue, measured in years.**

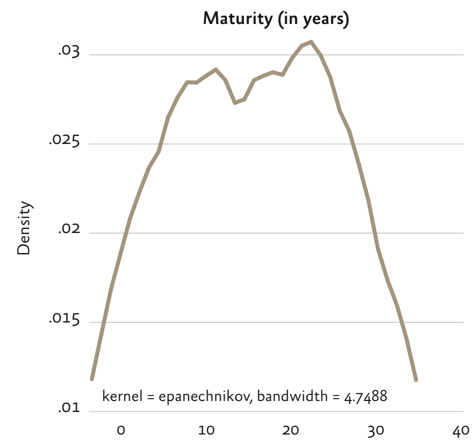


Figure 6 **Proportion of state-contingent assets linked to plain vanilla bonds or loans.**

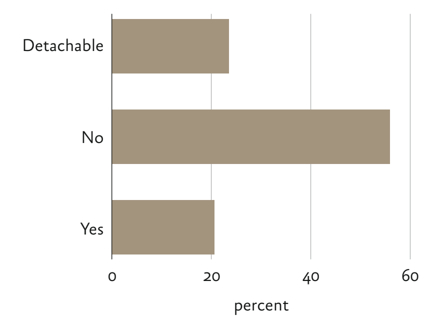
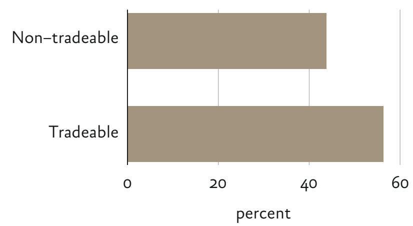


Figure 7 **Tradability of state-contingent government debt.**

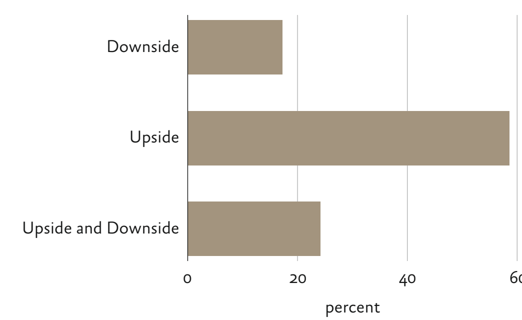


The next characteristic recorded in the dataset refers to the type of contingency provided by the debt instrument: upside, downside, or both. The definition of contingency is based on the economic consequences for the sovereign issuing the asset. If the instrument explicitly pays more or reduces the maturity of the asset only in good times, it is recorded as an upside contingency. If it pays explicitly less or extends the maturity in bad times, it is recorded as a downside contingency. This definition is somewhat arbitrary as thresholds for upside or downside contingencies should be defined relative to fundamental trends. For example, take a bond that is indexed to real GDP growth. It promises a specific payment when real GDP growth is zero and relatively more if real GDP growth is equal to 2%. If trend real GDP growth is 1%, this bond will reflect some level of both downside and upside contingency. However, the database would record it as having only upside contingency. Given that forecasting fundamental trends for these variables is a non-trivial exercise, the database records the contingency that is made explicit in the contract and does not estimate implicit contingencies. This approach results in a stronger requirement to extract the type of contingency in these issuances.

Figure 8 shows the distribution of assets across this dimension. Most assets allow only for explicit upside contingencies.

Finally, the database records several additional characteristics for these assets, namely whether these assets are callable or redeemable, have a sinking fund or grace period, as well as descriptions of the payout mechanism, coupon floors and ceilings, payout dates and lags. These characteristics are harder to summarize using visual evidence and, therefore, are not presented in this report.

Figure 8 **Type of explicit contingency included in the instrument.**



2.3.3. Performance

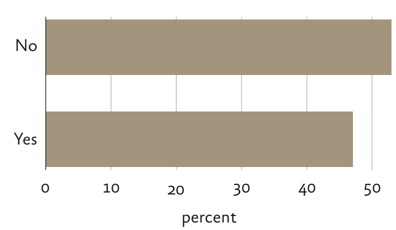
The database collects information on the following performance dimensions of these assets:

- Part of debt restructuring (yes/no)
- Brady Bond (yes/no)
- Volume at issuance

- Volume detail
- Base annual interest rate
- S&P rating
- Indexation activated (yes/no, by June 2019)
- Indexation activation (detail)
- Problems/Benefits
- ISIN codes/URL
- Country-specific sources

Figure 9 records whether an asset is part of a debt restructuring, in other words, whether it was issued in normal times or following a crisis period that led to default and/or debt restructuring. The first big wave of instruments issued with state-contingent features was part of the Brady bond restructurings. Recent large issuances, for example, in Greece and Ukraine, were also part of debt restructurings. The figure below shows a nearly even split of issuances in and out of debt crises. However, this figure is likely to be biased towards non-debt restructurings, as it is based on unweighted averages and does not consider the volume issued for each instrument, which is much larger in debt restructurings.

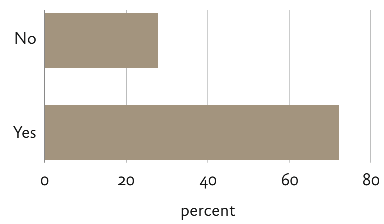
Figure 9 **Issuances that are part of debt restructuring.**



When available, the database also records data on the volume issued, the base interest rate, and the credit rating. Figure 10 summarizes the proportion of instruments whose indexation was activated in December 2018, which, for most instruments, is equivalent to whether the indexation was paid. Payment details are available for a subset of observations. Some of the debt instruments were called or bought back in order to avoid payments to creditors, and these data are also recorded.

Finally, the database collects information on design or performance problems associated with specific instruments. These data are not codified as these issues tend to be country-specific and include unclear contracts, statistical disputes, delays, and lags in payments relative to the state of the economy. For an example of uncertainty regarding the indexation variable, Bulgaria's GDP-linked bond issued in 1994 was initially linked to data published on a periodical that was discontinued. Following the discontinuation of the original data, the Bulgarian government chose a new series based on constant-value local currency units that did not trigger indexation. An example of statistical disputes is a suit filed against Argentina, in January 2019, by a hedge fund over missed payments in 2013 related to a change in the base year used to compute GDP, which took place in 2014 and reduced estimated growth just below the payment threshold. Finally, for an example of delays in the payment of indexations relative to the state of the economy, in January 2005, Standard & Poor's cut Venezuela's rating to selective default, following a delay of the country in calculating and paying its Oil-Indexed Obligations. The obligations were eventually paid with interest in March 2005. Some of these aspects are described in more detail in the next section.

Figure 10 Indexations activated in December 31, 2018.



2.4. Overview of experiences with state-contingent debt

This section reviews the performance of the most important state--contingent debt instruments included in the database. The goal is to identify what types of state-contingent debt worked, what were some of the challenges, and to extract lessons for policymakers and market participants interested in these debt instruments.

2.4.1. Early state-contingent debt

The first instance of government state-contingent debt for which relevant data is available was the 20-year bond issued by the Confederate States of America in 1863, during the American Civil War. These bonds were convertible into a warrant and then into a predetermined amount of cotton at a fixed price of six pence per pound. Prices for cotton in Liverpool were considerably higher at the time, as much as five times the price determined by the bond, making this an attractive asset. Accordingly, 22.4% of the bonds were converted into cotton warrants and, although exact figures are not available, there is some evidence that the indexation was activated (Weidenmier, 2000). However, several logistical and design difficulties likely reduced the number of redemptions into cotton. Firstly, investors had to obtain the warrants from the Confederate European representative in Paris. Secondly, they had to wait up to 60 days to receive the cotton after exercising the warrant. Thirdly, upon receiving the cotton, they would have to run the blockade by the opposing Union government, as the contract specified that cotton would be delivered to a point in Confederate territory within ten miles of ship access. Finally, if the investors decided to wait for the end of the war to convert the bonds, they would have six months following the peace agreement to convert them into cotton under different terms. Otherwise, they would be redeemable only at maturity or until they were retired by the lottery provision (2.5% of the bond issue was paid semiannually). This early state-contingent instrument highlights some of the logistical difficulties with using commodities as a means of payments in a war context. However, it also illustrates the potential benefits for commodity exporters to issue bonds linked to the price of a commodity in order to raise funds in international markets during challenging times. The demand for these bonds, which were traded in secondary markets at positive prices for much of the Civil War, was substantial (Weidenmier, 2000).

The next instances of state-contingent bonds recorded in the dataset pertain to France. The first ones are the Pinay 1952 bonds, worth 429b francs in 1952, which included a clause in the prospectus that linked cash flows to the price of gold. A similar bond was issued in 1958. These bonds were issued following the Breton Woods agreement, at a time when France maintained the franc's exchange rate under bands related to the price of gold. The end of the Breton Woods system in the 1970s lead to an increase in the price of gold, and these bonds, converted in 1973, resulted in substantial payments by the French government. Also, in 1973, and before an even larger increase in the price of gold, the French government issued the Giscard Bond, again with a payment linked to gold. This bond was exchangeable for gold at 32 dollars an ounce. Unfortunately for the French government, by 1978, gold prices had risen to about 200 dollars an ounce. Given the massive increase in the price of gold, this debt ended up being extremely expensive for the French government, which highlights the perils of indexing debt to a commodity that does not directly reflect economic conditions. At this time, gold was not an essential part of France's production, and gold prices changed dramatically following Bretton Woods, as the price of this commodity reflected a new monetary policy regime in the world economy. In other words, the increase in the price of gold reflected a new state of the world, but not one positively related to the state of the French economy. This change made payments on this bond countercyclical, with very high payments in a period of low economic growth. The collapse of Bretton Woods and its effect on gold prices was likely neglected in the bond design, which demonstrates that state-contingent debt may be prone to neglected risks.

Another French bond, issued in 1956, was the first precursor of GDP-linked bonds. This bond included an additional payment linked to industrial production. The indexation mechanism was a base interest rate of 5% per annum, plus 0.05% for every point industrial production index exceeds the 1955 level. This indexation was activated. Another bond issued in 1956 had a fixed interest rate, but its' redemption value was linked to the annual change in the average value of the price indices of French securities with fixed and variable interest rates. Finally, the larger Ramadier Loan, in 1956/57, worth 320b francs, had interest payments and redemption values linked to the average price of shares on the Paris Bourse. These three instruments are noteworthy in that they represent the closest to the GDP-linked bonds that are proposed today, with the caveat that industrial production is only a fraction of the economic activity and the stock market may fluctuate due to non-fundamental reasons. They were also much more successful than the gold-linked bonds, although such success was overshadowed by the negative impact of gold state--contingent debt on the government's finances.

In 1977, Mexico issued $50b of Petrobonos, the largest ever issue of bonds linked to the state of the economy ($78b in 2018 prices). These bonds had a 3-year maturity and were linked to the local price of oil. At maturity, they could be redeemed for the maximum between the bond face value and the market value of oil, with a 1000-peso bond linked to 1.95354 barrels of oil. Oil prices increased by 43%, but foreign investors still made a loss on these bonds. Even though the inflation rate in Mexico from mid-1978 to mid-1980 was about 20 percent per year, the nominal exchange rate between pesos and dollars was kept constant, and investors were forced to use the official exchange rate when converting pesos to dollars.

2.4.2. The Brady Plan

The first major multinational push for state-contingent government debt came with the Brady Plan of sovereign debt restructuring in the late 1980s and early 1990s. Some state-contingent debts included warrants, often called value recovery rights, which were initially attached to bonds and promised additional payments depending on the state of the economy. Although they shared their main characteristics, for example, they were initially attached to plain-vanilla bonds but later detachable, and included only upside contingencies, these sweeteners were indexed to the variables that best described the state of each economy. They depended on GDP (in Bulgaria, Costa Rica, Ivory Coast), on commodity prices (in Mexico, Nigeria, Venezuela), or on terms of trade (in Uruguay, defined as the ratio of the country's main exports price – wool, beef and rice; and the price of the country's main imports – crude petroleum). Several warrants that were not part of the Brady Plan, but shared some of its features, were issued in debt restructurings.

Although the design of these warrants had some innovative features, and many contingent payments were activated, they were plagued by several issues. For oil producers, the surge in oil prices in 2000 led to higher payments than anticipated, and many attempted to buy back the warrants. There is anecdotal evidence that lenders were not taking these warrants into account when pricing the bonds. Initially, many of these options were well out of the money while still attached to the bonds. The payments were triggered following detachment and the rise of oil prices in the 2000s. However, a large backlog of unreconciled trading positions, taking Nigeria and Venezuela as an example, meant that it was often unclear whom to pay them to.[6] Furthermore, there were some payment delays justified by the fact that they were confusing to calculate. The fact that some of these payments were quite substantial did not make it more palatable for sovereigns.

Warrants linked to GDP were even more problematic. For example, in Bulgaria's case, the GDP statistic to which the warrant was linked was poorly defined. It was initially based on a periodical that had moved online and was, thus, more frequently updated. The Bulgarian government then decided to use a constant-value local currency unit as a measure of GDP, and the warrant payments were never triggered. Bosnia and Herzegovina issued a GDP-linked bond in 1997 that was poorly designed, with issues related to low-quality statistical data and unclear treatment of data revisions. The bonds were eventually activated in 2007 and 2008, although some lenders disagreed and calculated that the activation period would be 2006 and 2007.

2.4.3. The Singapore experiments

An interesting experiment took place in Singapore in the 2000s, with the New Singapore Shares (NSS, issued in 2001) and the Economic Restructuring Shares (ERS, issued in 2003). These shares were given out by the government to lower-income groups in order to compensate them for structural changes, particularly the increase in sales taxes. Crucially, these shares earned annual dividends of, at least, 3% plus the real GDP growth rate of the preceding calendar year. The real GDP growth was greater than zero for all years covered by these shares, fluctuating between 4.2% in 2002 and 9.5% in 2004. They were discontinued in 2007.

2.4.4. Argentina, Greece and Ukraine's GDP-linked warrants

In 2005, Argentina issued GDP-linked warrants as part of a debt restructuring, which would pay if real GDP rose above a specific threshold. The annual growth rates of real GDP exceeded 4.3% in 2005, and then started to decline slowly to 3% from 2014 onwards. Economic conditions improved in Argentina in the mid-2000s, and the warrants, which had limits on cumulative payments, paid for most years up to 2011. However, lags in payments meant that some payments were due while Argentina was experiencing a recession, which created public pressure not to pay. An important issue was that the base year to compute GDP was changed in March 2014, from 1993 to 2004, which reduced the estimated growth in 2013 to 3 percent, almost half of what was initially forecasted, and just below the trigger for warrant payment. Aurelius, a hedge fund, filed a suit in January 2019, New York, for missed payments in 2013, arguing that there had been a statistical manipulation in the change of the base year. Although the case is still in court, this litigation risk appears to have shunned interest in the Argentine GDP-warrants and poses an important challenge for these assets elsewhere. Greece and Ukraine have also issued GDP-warrants as part of debt restructurings recently. In the Ukrainian case, payouts are capped between 2021 and 2025 at 1 percent of the overall nominal GDP, but not afterward, until 2040. Recent economic performance suggests that the cap will be hit, raising the question of whether these bonds represent a looming fiscal risk once the cap is withdrawn. Greece's warrants include a cap on payments for all years.

2.4.5. Portuguese experience with GDP-linked treasury certificates

Portugal created two GDP-linked treasury certificates. Initially, in 2013, with a maturity of 5 years (the CTPM) then, in 2017, with a maturity of 7 years (the CTPC), both certificates being redeemable after one year. Contrary to the Brady bonds or the recent GDP-warrants, they were not issued as part of a debt restructuring. These retail certificates target domestic savers, are non-tradeable, and can be subscribed continuously. They include a fixed base interest rate, which raises over time, and additional payments linked to real GDP growth. Payments are not updated due to revisions of GDP statistics.

Section 5 studies these certificates in detail and discusses the indexation to real GDP growth, the level of subscriptions and the forecasted interest payments for the government under alternative scenarios for real GDP growth.

These certificates were innovative and did not experience major issues. They represented 6.7% of total government debt in May 2019, about €17 billion. The indexation was always activated, and additional payments linked to GDP have been sizable as real GDP growth has exceeded expectations since 2014, and the Portuguese economy is yet to suffer an economic downturn.

2.4.6. Catastrophe bonds

A growing example of state-contingent debt is the market for catastrophe bonds, or cat bonds, which are securities indexed to natural events. These are examples of state-contingent debt where the exogeneity is guaranteed, and where there are no concerns regarding moral hazard from policymakers. Contrary to GDP or other macroeconomic variables, policymakers have no influence on the occurrence of natural catastrophes. Because these events are potentially very costly for the economy, they represent an almost ideal setting for state-contingent government debt.

In 2006 Mexico issued a $160 million non-tradeable cat bond that included a decrease in payment in case an earthquake with a certain magnitude and depth occurred in any of three pre-defined geographical zones in Mexico. It followed up with a similar tradable issue in

2009 worth $290 million. The 2009 issue saw the indexation activated. Investors in the $100m tranche of MultiCat Mexico Ltd. (Series 2012-1) Class C catastrophe bond notes faced a 50% loss of principal in 2016. Both the 2006 and the 2009 issues were rated by S&P above BB- and as high as BB+. The 2009 issue was oversubscribed and very successful, but there were some problems with the trigger design and with investors' losses. It took around three and a half months following the event to determine the exact indexation, and there was uncertainty about whether the size of investors' losses was 50% or 100%. Finally, there was a problem with the measurement of landfall pressure from storm chasers, which differed from the official measurement.[7] These instruments show that the correct and timely measurement of the relevant state of the economy, which was so prevalent under debt relying on GDP statistics, is also present in catastrophe bonds.

Grenada issued a bond with a hurricane clause in 2015. If the indexation was activated, Grenada would see deferred payments for up to two payment periods, but no nominal principal or interest rate reduction. This indexation can be triggered a maximum of 3 times. With losses between $15m and $30m, there would be a 6-month deferral, and with losses greater than $30m, there would be a 12-month deferral. A one-off trigger of the hurricane clause could also provide a cash flow relief. In 2018, Peru, Colombia, Chile, and Mexico issued cat bonds that involve a decrease in payment in case of a natural disaster above a specific threshold. The amounts were modest. Peru issued $200m, Colombia $400m, Chile $500m and Mexico $260m. The database includes details of the indexation mechanism.

Catastrophe bonds are not limited to natural disasters. In 2017, following the Ebola crisis, the World Bank issued bonds linked to disease outbreaks through the Pandemic Emergency Financing Facility (PEF). Contingencies will be applied if an outbreak takes at least 20 lives in a minimum of two countries.

2.5. Conclusion

This chapter presents a database that provides researchers and policymakers with an overview of existing state-contingent government debt. It shows that the design of state-contingent government debt around the world is extremely varied, both regarding the variable to which debt is indexed and the different payout mechanisms that are used. It also documents the activation of several state-contingencies in government debt. Although the database suggests that these debt instruments can be successful, it also documents several issues and challenges. By reviewing existing examples of state-contingent government debt and codifying the available information, this database is a useful resource for researchers interested in investigating the design and performance of these debt instruments. Therefore, this database contributes to our understanding of why many of these markets are still relatively limited.

Chapter 3
Some Lessons for Policymakers

In this chapter, I draw a few lessons from past experiences with state-contingent debt that may be relevant for policymakers and market participants. Some of the perspectives presented in this chapter are relatively speculative in the sense that although they are guided by the narratives presented before, they are not drawn from data analysis. This chapter also presents some avenues for future research work on state-contingent government debt.

3.1. Clarity

Given the complexity of these debt instruments, it is crucial to limit any ambiguity regarding the computation of state-contingent payments and the potential to default on previously established commitments. The prospectus of the debt instrument should clearly define which statistic determines the state contingency and what happens if there are changes to the way this statistic is computed. This is harder to accomplish for longer maturity assets, but it is crucial that policymakers minimize any confusion on this matter and mitigate potential litigation risk. Argentina's GDP-warrant is a case in point. In 2019, the Argentine government was back in court, after years of litigation over defaulted bonds, due to a lawsuit regarding a change in the base year it used to compute the GDP statistics that determined the coupon payments on GDP-warrants.

The database highlights several countries where statistical ambiguity and short-run opportunism played a significant role in making these debt instruments less effective in the long-run. Furthermore, there is an externality every time a sovereign uses a loophole or manipulates statistics. Other countries wishing to issue this type of instrument will likely experience a chilling effect on the demand for their state-contingent assets. Because individual sovereigns do not take into account the external effects of their actions, this externality may limit the markets for state-contingent debt.

3.2. Contingent debt may be expensive

Besides the risks that are already present in traditional debt, contingent debt is likely to expose lenders to several additional risks and their associated premia. These may further interact and make contingent debt more expensive. Empirical work has shown that some of these risks matter. For example, there are novelty premia associated with first-mover costs related to the writing of new contracts, marketing, and pricing. Looking at Argentina's GDP-linked warrants, Ricci et al. (2008) document significant novelty premia. Liquidity premia would also play a role, although they are common in small issuances of noncontingent bonds.

State-contingency will likely include additional premia related to indexation. For example, if the contingency is established in terms of commodities, it will matter how easily these assets can be converted into commodities or their equivalent international value. This was an issue with the Cotton bonds in 1863 or the Petrobonos in 1977.

If the contingency is related to GDP, and even if the terms of the asset clearly state which statistical series is the relevant one, there is a reputational effect that makes debt costlier at the start. Even before any manipulation occurs, fears of statistical manipulation will play a role.

Regarding bonds that are linked to natural disasters, uncertainty about the measurement of an event may lead to uncertainty regarding payments after the event takes place. For instance, in the Mexican 2012 catastrophe bond, there was uncertainty after the event as to whether it would yield a 100% or 50% loss for the bondholders. This uncertainty may interact with statistical manipulation risk as the measurement of the disaster is not exogenous.

State-contingent debt may interact with other risks, such as for example, currency risk or capital controls. It is, thus, crucial to estimate the covariance of these risks in order to price the assets correctly. For example, in good states of the world, where payments for the sovereign are expected to be large, the government may impose unfavorable payment conditions for investors. This happened in 1980, when the Mexican government forced investors to convert pesos to dollars at the official rate, which was overvalued relative to the market rate. The overvaluation was such that even though the price of oil increased dramatically, foreign investors still experienced losses from the oil-linked bonds.

Whether these costs are prohibitive is ultimately an empirical question. Pouzo and Presno (2016) show that uncertainty premia are sizable in the context of sovereign borrowing with default. Moreover, the experiences reviewed in Chapter 2 suggest that accounting for all these costs is still an ongoing exercise for market participants. Getting to the right price and debt terms is a learning process. Some examples of successful state-contingent government debt have been described as overly generous ex-post. This may prove problematic at a time when noncontingent debt is being issued with historical minimum interest rates, making contingent debt relatively more expensive. Note, however, that many of the potential risk and associated premia described above were also present in inflation-indexed bonds, which have managed to thrive in recent years, and are undoubtedly present in equities and derivatives, which are currently much larger asset classes.[8]

3.3. What is the relevant state variable?

The goal of successful contingency is to index payments to a variable that reflects the state of the economy and the government's finances in an accurate and timely manner. However, if the indexed variable diverges from the state of the economy, then contingencies may induce very high payments, which can either be unexpected or occur at the wrong time. This problem becomes compounded when maturities are very large, as it becomes harder to gauge the relevant risks or what variables will be relevant in the future. For example, France linked long-term debt to the price of gold, but a change in global monetary arrangements after the end of Bretton Woods increased the price of gold dramatically compared to other prices and output, which made the French gold-linked bonds extremely expensive for the French government. A commodity-rich country may index debt to the price of a commodity. However, the depletion of commodity stocks in the country, or temporary shocks that determine the production of the commodity, for example, weather shocks or political instability, may turn the international price of oil into an irrelevant variable to capture the state of the economy. By combining prices and quantities, export revenues, for example, would better summarize the state of that economy. More generally, long-term state-contingent debt is particularly prone to neglected risks.

Finally, linking debt payments to GDP-growth is the most common way to issue GDP-linked bonds. However, following a sizeable negative output shock, GDP-growth may be very high while the economy recovers. This would induce large payments on debt while the level of GDP would remain substantially below trend. In other words, even though the economy is in a bad state, with low private consumption and government revenues, this sovereign would have to pay a large sum due to contingencies. Indexing payments to the level of GDP or an index of consumption would avoid this problem. However, this seems to be unpopular among market participants. One alternative is to introduce caps and floors on debt payments, but these further increase the complexity of the assets and will likely translate into higher premia. Recent GDP-linked debt in Argentina, Greece, and Portugal includes caps in the payments associated with GDP growth. There are exceptions, however. For example, Ukraine's GDP warrant, issued in 2015, caps payments until 2025 but only matures in 2040, exposing the government of Ukraine to potentially large payments in case of good economic performance.

Should state-contingent debt link the principal or the coupon to the state of the economy? Linking the coupon makes state-contingent debt closer to a claim on an equity dividend. Linking the principal makes state-contingent debt closer to an equity asset. Although linking the coupon to the growth of GDP appears to be an easier option to sell these types of assets to investors, it should be noted that linking the coupon to the state of the economy would have a smaller effect on debt sustainability following crises, compared to linking the principal, as the latter directly affects the total level of debt.

Publication lags may also play a role in the determination of the relevant state variable. Payments on debt often lag the relevant state variable by a few quarters, sometimes a year. This backward-looking property may be problematic if payments referring to a good state of the world occur during a recession or a crisis, as it was the case in Argentina in the 2000s.

3.4. Attached bonds and neglect

Many state-contingent bonds are attached to other bonds, either directly, or through cross-default covenants, and they cannot be traded or defaulted on independently. This attachment was one of the novel issues developed by the Brady Plan, where the warrants issued as sweeteners for the restructuring deal were initially attached to the "plain vanilla" traditional bonds. There is anecdotal evidence that these warrants were not used to price these assets and were largely ignored during the 1990s. Initially, this was not a big issue because the contingency was not activated. However, once they were activated in the 2000s — for example, the oil-warrants issued by Nigeria and Venezuela, which had been detached by then — confusion reigned about how the payments would work. Furthermore, unreconciled trading positions meant that there was uncertainty regarding who owned the warrants. This neglect may decrease trust in these types of assets and reduce their usage by borrowing countries. These issues were not present in non-tradeable or detached debts. Therefore, not attaching state-contingent debt to other assets will likely facilitate the pricing of these assets and the development of these markets.

3.5. Moral hazard

State-contingent debt is subject to moral hazard. The literature usually discusses one moral hazard related to the fact that state-contingent debt discourages governments from developing the economy as, for example, higher GDP translates to higher debt payments. This is usually discarded with the argument that the incentives to increase GDP are simply too large for this moral hazard problem to be a concern. However, there is potential for statistical manipulation, particularly when the payments are based on the latest figures, and not on revised data. Therefore, the ideal candidates for state-contingencies are exogenous variables over which the government has zero or little control but that still matter to the overall economy. Examples include natural catastrophes, but also variables like exports, or even tourism revenues, which are arguably exogenous in the short run for small open economies like Portugal.

There is an additional moral hazard problem in debt issuance. State-contingent debt may lead to risk-taking in poor states of the world, which increases the total amount of debt. If debt is indexed to the state of the economy, then everything else equal, it will likely be in a bad state in the future and payments will be reduced. Therefore, the government will want to borrow more. This may increase the total amount of debt and precipitate a debt crisis should the state of the economy be worse than expected. On the other hand, in a good state, the opposite would likely occur. Given that the state of the economy would probably be favorable in the future, and the government would have to pay more in interest, issuing debt would be more expensive, and, therefore, less debt issuance would be observed. These risk-taking considerations play a more important role in shorter maturity debt.

3.6. Identifying the demand for these assets

There is a big debate in the academic and policy world regarding the natural buyers of large state-contingent government debt issuances. This is important as policymakers need to market this debt and target the correct demand. Traditional buyers of government bonds are more interested in their safe asset characteristics and liquidity. This debt is neither safe nor, at least initially, very liquid. Where is the demand for these assets likely coming from?

One option is to target pension funds or private pension savings. A recent proposal by Merton et al. (2019), suggests consumption-linked bonds as a savings vehicle for retirees wishing to sustain a level of consumption that is indexed to future average consumption in the country in which they retire. This could be interesting for a country like Portugal, where some foreigners choose to retire. Domestic pensions are implicitly indexed to the state of the economy, for example, they may be revised downwards if the economy is doing poorly, as was the case in Portugal during the Eurozone debt crisis, or they can be revised upwards, like in the 2019 debate in Germany. However, the same is not true for foreign pensions, which will likely reflect foreign conditions. This asset may allow retirees to have state-contingent income in the country of retirement.

Targeting pension funds may be harder due to regulatory constraints or, in the case of non-eurozone funds, high currency-hedging costs. Hedge funds, asset managers, and corporate savings may provide better alternatives as targets. Cash holdings by corporations have seen a sustained increase in the last 20 years, and there is an active search for yield by investors. However, corporations may be looking for countercyclical debt payments, which are larger in bad times.[9] Another option for sovereigns could be to issue both types of state-contingent debt and implicitly act as an intermediary, although this would introduce several additional risks.

Hedge funds and asset managers are likely the natural holders of these assets. State-contingent debt is risky, and it should be marketed as such. However, it is risky debt without debt crises, and that is the comparative advantage of these assets. Importantly, an additional paper developed as part of this research project shows that risk-averse lenders may be willing to pay more for this debt when upside risk is high (Pina, 2019). In other words, risky environments allow both borrowers and lenders to benefit from the introduction of state-contingent debt. This result is consistent with the evidence in Section 2, showing that many of these issuances were part of debt restructurings in emerging economies, which have high growth potential but also high risk.

Finally, institutional lenders, like the International Monetary Fund or the European Stability Mechanism, will likely play a crucial role in helping these markets achieve the necessary levels of liquidity. For example, they can include substantial state-contingency in debt restructurings. However, in order to allow for a market-based development of state-contingent government debt, they must distort neither the prices of these assets nor the regular functioning of state-contingent payments.

Chapter 4
GDP-linked debt in Portugal: a theoretical approach and a counterfactual analysis

4.1. Introduction

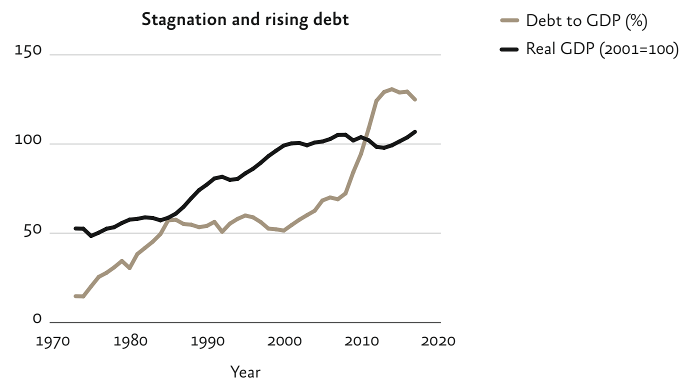
Between 1970 and 2017, the general government debt to GDP ratio in Portugal increased from 14% to 125%, reaching a maximum of 130% in 2014, at the peak of the Eurozone debt crisis. In June 2011, the Portuguese government, faced with debt equal to 110% of GDP and effectively shut out of debt markets, obtained financial assistance amounting to €78 billion, or about 45% of GDP, in the form of a bailout program complemented with austerity measures and reforms.

Figure 11 plots the evolution of the debt to GDP ratio for the Portuguese government, together with the value of annual economic output corrected for inflation, or real GDP, between 1973 and 2017. The debt to GDP ratio is represented in percentage points, while real GDP is indexed to take on the value of 100 in 2001. It is possible to identify four different periods. The first period, between 1974 and 1985, saw slow economic growth and rising debt levels. The second period, between 1985 and 2000, saw fast economic growth and a slight decrease in debt to GDP. The third period, as of the 2000s until the global financial crisis, which started in 2007, saw a much slower increase in real GDP and a slow increase in debt to GDP. Finally, in the fourth period, after 2007, real GDP decreased and remained below its 2007 level for a full decade, with the debt to GDP ratio increasing rapidly to its maximum in 2014 before stabilizing. All this debt was noncontingent.[10] In other words, neither the level of the debt nor the payments associated with the debt depended on the state of the economy except for an outright debt default.

Would the Portuguese economy have benefitted if the government had borrowed using state-contingent debt, for example, GDP-linked debt, instead of traditional debt? As a small open economy, Portugal was strongly hit by the global financial crisis and global economic downturn. As of 2008, both exports and output decreased substantially, and the Portuguese government soon faced payments and financing difficulties that eventually led to the debt crisis and bailout in 2011.

GDP-linked debt ties the debt-payments or the principal to economic activity, in other words, it prescribes higher payments or higher debt principal when the economy is performing well and lower payments or lower debt principal when the economy is performing poorly. This chapter studies how the debt to GDP ratio in Portugal would have evolved under different levels of state-contingency.

Figure 11 **Debt to GDP: General government gross debt for Portugal from Marinheiro (2006), complemented with data from Eurostat after 2012; Real Gross Domestic Product for Portugal, 2010 U.S. Dollars, indexed to 100 in 2001 (data from the World Bank)**



To answer this question, I estimate a structural model of government borrowing under different types of debt. Then, I calibrate the model to the Portuguese economy and provide counterfactual debt to GDP ratios for different degrees of state-contingency. The benefits of state-contingency include the reduction in interest payments in bad times, which may reduce total debt levels as lower amounts of interest payments need to be rolled over. However, by making debt crises less likely, state-contingent debt may lead to an increase in total borrowing, particularly in the run-up to a crisis. Indexation completes the market and removes the effect of shocks on the debt path. The calibration exercise carried out in this chapter allows computing which effects would likely dominate in the Portuguese economy and in estimating the benefits of this type of debt. In the baseline scenario, I show that under debt indexed to GDP, debt to GDP ratios would be 15 percentage points smaller by 2011.

The theoretical framework used in this chapter is the canonical strategic default model developed by Eaton and Gersovitz (1981), which has been estimated quantitatively in a large body of work, starting with Aguiar and Gopinath (2006) and Arellano (2008). Panizza et al. (2009) provide a survey of this literature. In these models, the government cannot commit to repay its otherwise noncontingent debt, and every period decides whether the debt is repaid or not. Default occurs when a country misses debt payments. It comes with both output costs and a temporary exclusion from international borrowing. I perform an analysis with transitory shocks to output around a deterministic trend, as in Arellano (2008), and with permanent shocks, or trend shocks, as in Aguiar and Gopinath (2006). Considering shocks to the growth rate, often called trend shocks, it seems crucial to account for the Portuguese experience. Looking at Figure 11, we can see that Portugal has experienced shocks to the growth rate of real GDP in the last 30 years, with high growth in the 1990s, low growth in the 2000s, and no growth between 2007 and 2017. After solving the model for noncontingent debt and calibrating it to the Portuguese economy, I then run counterfactuals for different levels of indexation.

I have chosen a well-studied model to investigate the role of state--contingency in order to identify the effects of debt-indexation more clearly. However, state-contingency is linked to a different strand of the debt default literature that assumes that the government always pays up to a fiscal limit. If debt payments are above the limit, then default occurs but is excusable, as in Grossman and Van Huyck (1988), and comes with no exclusion or cost. Examples of this literature include Collard, Habib, and Rochet (2015), who have used the concept of excusable default to compute the maximum level of debt a government can sustain, and Collard, Habib and Rochet (2016), who showed that the optimal amount of debt for a self-interested government with excusable default is very close to the maximum sustainable debt level. Because the fiscal limit may depend on the state of the economy, this chapter is related to this body of work.

This chapter is related to the vast literature on indexed debt in quantitative sovereign default models, for example, Borensztein and Mauro (2004), Alfaro and Kanczuk (2005), Ruban et al. (2008), Durdu (2009), Foley-Fisher (2011), Hatchondo and Martinez (2012), Brooke et al. 2013, Barr et al. 2014 Benford et al. 2016, Cabrillac et al. 2017 and Cecchetti and Schoenholtz 2017. The closest work is by Bertinatto et al. 2017, who studied a quantitative model of strategic default under transitory shocks with GDP-linked debt and calibrated it to Argentina. In this paper, I study the role of trend shocks and apply GDP-linked debt to Portugal.

The focus on the debt to GDP ratio is related to the work of Blanchard et al. (2016), who compared debt dynamics under the two scenarios in which the government finances itself through ordinary nominal bonds or growth-indexed bonds. The study shows that indexation can decrease the worrisome upper tail of the distribution of the debt ratio, but also how sensitive this is to the premia associated with indexed bonds. Acalin (2018) shows that benefits from GDP-linked bonds may be too small on the upper tail of the debt distribution. Ostry and Kim (2018) study the impact of indexation on fiscal space.

Regarding interest savings, this paper is related to the work of Pereira and Bonfim (2018), who perform an analysis of the benefits of GDP-linked bonds for Euro area countries using the methodology developed by Borensztein and Mauro (2004). They show that by changing only interest payments, aggregate savings on interest paid would amount to 0.13% of GDP. These would be larger for countries more directly affected by the debt crisis, such as Greece, Ireland, Italy, Portugal, and Spain, about 0.3% of GDP, but would decrease under risk aversion. These estimates are relatively low. However, they are obtained under the assumption that no other variables, except interest payments, would change with the introduction of indexed debt. In other words, government borrowing is taken as given. Additionally, the effects on the probability of default, debt restructuring and/or bailouts with conditionality are also not studied.

State-contingent debt changes the trade-offs associated with public debt management. This chapter is, therefore, related to the literature on optimal fiscal policy following Barro (1974, 1979), and Lucas and Stokey (1983).[11] In particular, GDP-linked bonds reduce payments for the government in bad times and increase them in good times, acting as an automatic stabilizer of the financing needs of the government following exogenous shocks. Compared to traditional noncontingent debt, the government does not need to change taxes as much as following shocks under state-contingent debt, which also has an impact on optimal government spending and debt accumulation. These smoothing benefits may allow the government to avoid some of the distortions associated with taxation and government expenditure fluctuations, which, for taxes, as shown by Cardoso-Costa and Lewis (2017), may be particularly relevant for countries in a monetary union.

4.2. Model

The model used is the traditional Eaton and Gersovitz (1981) model of strategic sovereign default. The endowment process follows the work by Aguiar and Gopinath (2006) closely to account for both transitory and trend shocks. However, unlike Aguiar and Gopinath (2006), the maximization problem is defined for a government that collects a fraction of output as taxes, then decides on default, debt issuance and government consumption.

Consider a small open economy that receives an exogenous and stochastic endowment each year, which is assumed to depend on both a stochastic trend and a transitory shock. Define the process governing this endowment income as:

$$\ln y_t = \ln Trend_t + Transitory_t,$$

where $Trend_t = g_t Trend_{t-1}$, and $\ln g_t = (1-\rho_g)(\ln(\mu_g) - k) + \rho_g \ln(g_{t-1}) + \varepsilon_t^g$.

Assume that $|\rho_g| < 1, \varepsilon_t^g \sim N(0, \sigma_g^2)$, and $k = \frac{1}{2}\frac{\sigma_g^2}{1-\rho_g^2}$.

The growth rate of trend income is given by g_t with long-run mean μ_g. Log growth follows an AR(1) process and shocks ε_t^g have permanent effects. The transitory component also follows an AR(1) process with long-run mean μ_z, and is given by $Transitory_t = z_t = \mu_z(1-\rho_z) + \rho_z Transitory_{t-1} + \varepsilon_t^z$, where $|\rho_z| < 1, \varepsilon_t^z \sim N(0, \sigma_z^2)$.

The government maximizes the expected present value of the utility of government expenditure, and government expenditure is given by:

$$e_t = \gamma y_t - q_t d_t + \varphi(y_t) d_{t-1},$$

where $\gamma<1$ corresponds to the share of government revenues from the output y_t, and $-q_t d_t$ are the revenues obtained from issuing debt $-d_t$ at price q_t. I follow the literature on strategic sovereign default and formulate the problem as government savings, where a negative number for d_t represents government borrowing. Accordingly, $-d_{t-1}$ is the outstanding debt that is due at t, and $\varphi(y_t)$ summarizes the possible indexation of debt payments to output, which will be discussed below. For simplicity purposes, I will consider only one-period zero-coupon bonds.[12]

This government is assumed to be self-interested and have no commitment. At the beginning of every period t the government decides first whether to repay outstanding debt and, then, issue new debt. If the government defaults, it is excluded from borrowing that period and returns to financial markets next period with exogenous probability π. Let V_E represent the value function of the government when it decides to repay debt. Let V_D represent the value function of the government when it decides to default. For simplicity, assume that if the government defaults, then it does so on all outstanding debt. Then, at every t, the value function of the government is given by:

$$V(d_{t-1}, g_t, z_t) = max(V_E(d_{t-1}, g_t, z_t), V_D(0, g_t, z_t)).$$

The value function when the government repays is given by:

$$V_E(d_{t-1}, g_t, z_t) = \max_{d_t} u(\gamma y_t - q_t d_t + \varphi(y_t) d_{t-1}) + \beta(E[V(d_t, g_{t+1}, z_{t+1})]),$$

where β is the government's discount factor, e is the expectation operator over the next period's output, the utility takes the CRRA form with the coefficient of relative risk aversion σ, and the value function when the government defaults is given by:

$$V_D(0, g_t, z_t) = u((1-\alpha)\gamma y_t) + \beta E[\pi V(0, g_{t+1}, z_{t+1}) + (1-\pi) V_D(0, g_{t+1}, z_{t+1})],$$

where captures the cost of default in terms of output.

In the baseline model, lenders are risk-neutral and willing to lend at the expected return of the world interest rate r, which is assumed to be constant. They have complete information regarding the state of the economy and price bonds at fair value. Thus, the bond price satisfies the following condition under no debt-indexation:

$$q(d_t, g_t, z_t) = (1-\lambda(d_t, g_t, z_t))/(1+r),$$

where $\lambda(d_t, g_t, z_t)$ represents the probability of default next period, such that expected payment per unit of debt is given by $(1-\lambda(d_t, g_t, z_t))$. The higher the probability of default, the lower the expected repayment and the lower the price at which the government can sell bonds.

Under indexation, debt payments will depend on the state of the economy also according to $\varphi(y_t)$. Expected debt payments are then given by $E(\varphi(y_t))(1-\lambda(d_t, g_t, z_t))$, where $E(\varphi(y_t))$ is the expected indexation factor next period. It is equal to one under noncontingent debt but different from one under indexed debt. Indexation is taken as given by both lenders and the government, with higher values of output prescribing larger values for $\varphi(y_t)$. Note that I assume that if the government defaults on debt payments, then the indexation part is also defaulted on. The specification for this function will be described in the results section in more detail. In the calibration exercise, I assume that the government will not be interested in saving, instead only in borrowing.

This model does not allow for a closed-form solution and needs to be solved computationally. In the next section, I calibrate it to Portugal and solve for the case under traditional, non-indexed debt. Then, the following section explores different counterfactuals with indexation.

4.3. Calibration and Model solution for noncontingent debt

Each period refers to one year. The calibration strategy consists in using data for Portugal, when possible, for observable parameters. Unobservable parameters are then set to match debt levels at crucial dates. Given that Portugal joined the Eurozone on January 1st, 1999, I allow for different output costs of default before and after accession. All other parameters are the same throughout. The coefficient of relative risk aversion σ is set equal to 2, a standard value. I calibrate tax revenues as a share of GDP equal to Portugal's average between 1973 and 2012; 34% (Marinheiro, 2006). The risk-free rate is calibrated using the average yearly value of the German ten-year bond rate, net of inflation, between 1973 and 2018, and is set to r=2.8%.

The state-space for government savings is capped at zero from below, to capture the fact that the government does not ever save, but only borrows. This is potentially important because, unlike the traditional model of strategic default, I opt to use a plausible value for the impatience parameter beta, which I set equal to 0.94 and keep constant across periods. Models of strategic default require either a high level of impatience or high default costs to induce enough borrowing.[13] I opt to use the latter, as high impatience translates to extremely fast dynamics towards the maximum level of debt sustained by default costs. In a sense, this approach mirrors that of excusable default models where very high default costs, often left unmodelled, sustain the state-contingent payments. However, the model is too simple to match the level and the dynamics of debt. Other factors that would likely matter, but are not addressed by the model, include adjustment costs in the level of debt, learning about spreads and feedback effects between private banks and the government. Also, note that different combinations of parameters regarding default costs or impatience would effectively deliver the same experiment station for alternative debt structures.

The two parameters related to the output cost of default are unobservable for Portugal. The probability of returning to financial markets following default is set at 0.125, implying exclusion on an average of eight years. This value is substantially larger than the empirical estimates for developing economies, for example, Gelos et al. (2011) report estimates between 2 to 4.5 years. However, it took Greece almost nine years, from April 2010 to January 2019, to regain access to debt markets. The cost of default in terms of output before the Euro is set to 15% of GDP, which is within the 90% confidence interval for hard defaults reported by Trebesch and Zabel (2016), who mostly cover developing economies. The cost of default after joining the Euro is set at 25% of GDP, which is much larger than estimates in other papers. However, this value is consistent with the reduction in real GDP for Greece between 2008 and 2011-2018. Crucially, I assume that, in case of default in 2011, Portugal would have remained within the Euro. The absence of exchange rate adjustments, capital controls and independent monetary policy justifies why these costs may be higher when compared to estimates for developing economies.

Finally, parameters related to the process for the endowment require the estimation of a large time-series and are also kept constant throughout. The mean percentage yearly real GDP growth rate is set to 1.7% to match the average yearly growth for Portugal between 1973 and 2017. The rest of the parameters are obtained using Bayesian methods, as described in Miyamoto and Nguyen (2017). Reproducing their analysis for Portugal between 1950 and 2013, I set ρ_g=0.52, σ_g=1.04% ρ_z=0.76 *and* σ_z=1.46%.[14] These continuous processes are approximated using a discrete Markov chain, which is then integrated to obtain the Markov transition matrix. Finally, the mean of log output is set such that the average detrended income is equal to one.

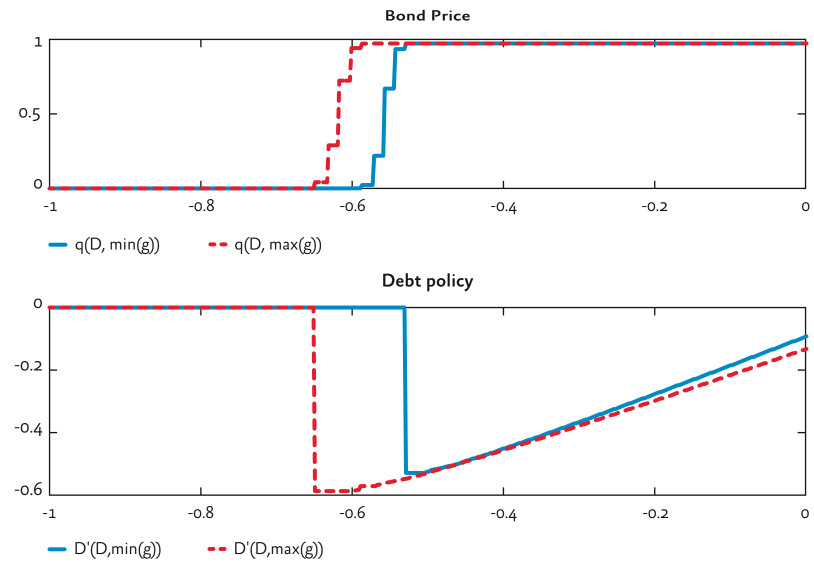
The model is solved using value function iteration in detrended form, as shown in Aguiar and Gopinath (2006). The computational algorithm consists of four main steps:

- Set the values of parameters and determine a grid for d (debt) and y (income).
- Given initial guess for the bond price schedule $q0 = 1/(1+r)$ solve the optimal policy function for optimal debt issuance d_t via value function iteration of functions V_E, V_D and V until convergence.
- Given the solution for value functions, calculate the default and repayment sets.
- Given the default sets, compute the new bond price schedule subject to the expected break-even constraint of lenders. Update the bond price schedule, repeat step 2, and iterate until the difference between bond prices satisfies the convergence criterion.

4.4. Model fit under noncontingent debt

Before presenting the results from the simulation, Figures 12 and 13 show the results from the solution of the model for the two calibrations. I solve the model for 500 grid points, nine states for trend GDP, and nine states for transitory shocks. To facilitate exposition, I plot results for two states for the endowment, which are each defined by one value for the trend and one realization of the transitory shock. In these figures, I report results for the lowest and the highest possible values of trend growth, and a zero transitory shock. Figure 12 shows results for the pre-Euro calibration, while Figure 13 collects results for the post-Euro calibration.

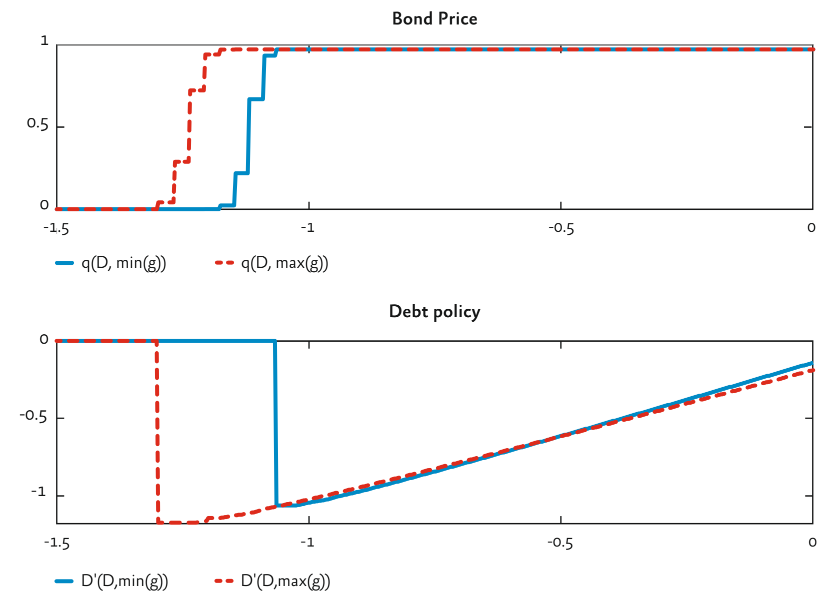
Figure 12 Pre-Euro calibration with noncontingent debt



The top panel in each figure plots the bond price schedule as a function of the debt due for payment. When the level of debt is such that default probability is zero, this price is determined by the risk-free rate and is the same in both states. When the level of debt is such that the government would default with certainty, then the price of debt is zero, as lenders would not hold debt. Finally, for positive but smaller than 1 default probabilities, it is possible to see how bond prices depend on the level of debt and the state of the world. A higher level of debt leads to lower bond prices at issuance, while a better state of the world leads to higher bond prices.

The lower panel in each figure plots the policy function of the government, which corresponds to optimal debt issuance today as a function of debt due. Again, it is possible to see that default occurs in equilibrium when the debt due today is too large, or the state of the world is too negative. As the policy function flattens, the government reaches a debt limit for a specific combination of trend and transitory shocks. However, a negative shock to trend output may induce default for a high enough debt level.

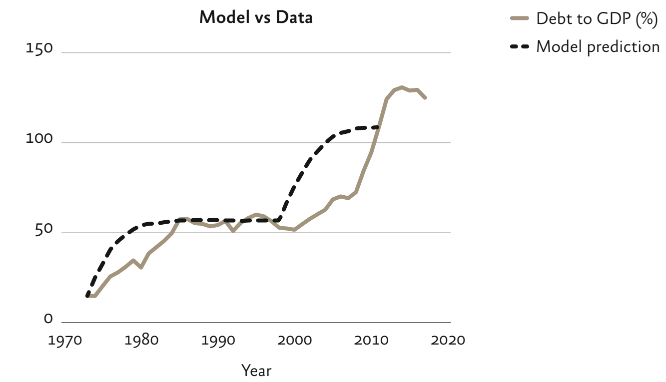
Figure 13 Post-euro calibration with noncontingent debt



Using these results, I simulate the path of the Portuguese economy, implied by the model, and compare it to the data. To do so, I match each observation for real GDP in Portugal with the closest combination of trend and transitory shocks. First, I determine the relevant trend by looking for structural breaks in trend real GDP. Then, I match deviations from the trend to the grid of transitory shocks. The calibration exercise was designed to match debt to GDP ratios in the late 1990s and in 2011. I stop the exercise in 2011, as this represents the onset of the debt crisis in Portugal and the beginning of institutional lending for which this model is not appropriate.

Figure 14 plots the model prediction with data between 1973 and 2011. As can be seen, the model matches the overall pattern of debt in Portugal much better than it matches the dynamics of debt accumulation. Although the optimal policy approaches the debt limit too quickly, it should be noted that considerations related to the Stability Growth Pact, which includes a ceiling on debt to GDP ratio equal to 60%, may have distorted debt accumulation for Portugal in the early 2000s. In addition, this chapter focuses more on the debt levels and less on the dynamics. If one would like to match the dynamics as well, an option would be to introduce adjustment costs in the change of debt, such that the actual debt issuance is a function of the difference between the desired debt level and the current debt level.

Figure 14 Comparison of simulation results with noncontingent debt and the data



4.5. Model solution and counterfactuals under contingent debt

In this section, I perform a counterfactual analysis under contingent debt. First, I discuss the function that determines the indexation and the solution of the model. In this exercise, I focus on indexation that includes both upside and downside contingencies. Consider an indexation scheme that merely transfers payments from bad states to good states of the world. In other words, $\varphi(y_t)=1+k(y_t-Trend)$, where k>0 is a constant governing the strength of indexation. When the output is larger than the trend, which I normalize to 1 here, the debt payments increase. When the output is lower than the trend, the debt payments decrease. Lenders break-even in expectation but now face two sources of risk, the same default risk as before, plus the risk in payment fluctuations when state-contingent payouts occur.[15]

Figure 15 plots the indexation $\varphi(y_t)$ embedded in these bonds for each state of the economy. The state is defined by a trend, which is represented in the Y axis as a gross growth rate, and a transitory shock, which is represented in the X axis as a net growth rate. The actual output level y will depend on both the trend growth and the deviation from the trend during that period. The factor $\varphi(y_t)$ is the largest for high levels of both the trend and transitory shocks, as represented, for example, by the yellow squares. This factor is above one, meaning that the government pays back more than initially promised. The opposite happens in the purple square, or for low levels of trend growth and negative values of the transitory shock. In this case, the indexation factor is smaller than one, and the amount of debt paid back is less than what was initially promised. This graph is plotted for $k=0.25$. Higher values of k would translate to stronger contingencies. Before showing the impact of the path of debt accumulation, what are the effects of introducing these types of contingencies on borrowing and bond prices?

Figure 16 plots the solution to the GDP-linked model for the post-euro calibration (left panels) and the solution under noncontingent debt (right panels). Again, two values are presented for the trend, the largest and the smallest, and the transitory shock is set to zero. Comparing the two sets of graphs, it is possible to see that bond prices in the bad state of the world are lower, everything else being equal, as contingencies are more likely to reduce payments on debt. However, they are higher when they reduce lower default risk. As for the good state of the world, bond prices are higher, which indicates that contingencies will likely increase payments in the next period. It is possible to see that indexation increases the fiscal space for the government in a bad state. The borrowing limit becomes larger as contingencies reduce default risk.

It is not clear that the government will borrow more with additional fiscal space. How much debt the government issues depends on bond prices. For the states where bond prices were already high to begin with, the effect on borrowing will be minimal. However, the government will issue less debt in the states of the world where the default probability went down due to indexation. Lower default probabilities translate into higher bond prices which, in turn, reflect lower interest rates on debt. In other words, lower interest rates require the government to issue less debt to obtain the same amount of financing. Note that, for the worst and the best states, the differences between bond prices and policy functions for output trend are much smaller in the left panels than in the right panels. Indexation removes part of the effect of being on a different state by transferring resources across states of the world. In that sense, it completes the market and allows market participants to better deal with uncertainty.

One important unresolved issue is how to calibrate the parameter k, which determines the strength of indexation. Previous works, for example, Bonfim and Pereira (2016), add the difference in real GDP growth relative to a benchmark to the baseline coupon rate, capping this modified coupon at zero. In this exercise, I set $k=0.25$ in the expression above. As per the process for output calibrated in this chapter, this translates into a maximum additional debt payment related to indexation close to 5% of GDP, and a maximum reduction in debt payments close to 5% of GDP. Finally, to account for additional premia associated with contingencies, in the simulations, I increase the base interest rate by 100 basis points as in Blanchard et al. (2016).

Figure 15 Indexation term as a function of trend and transitory shocks

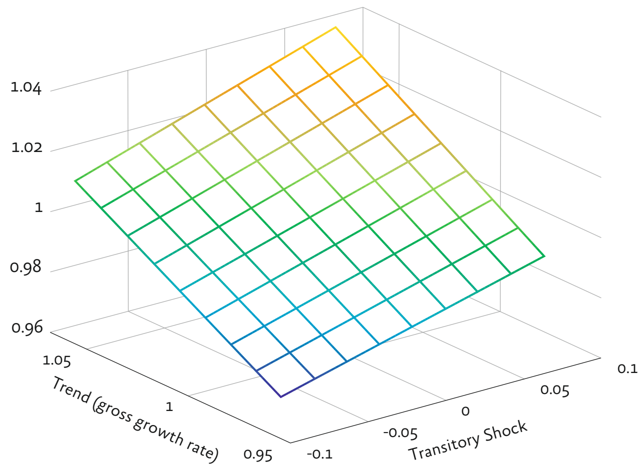
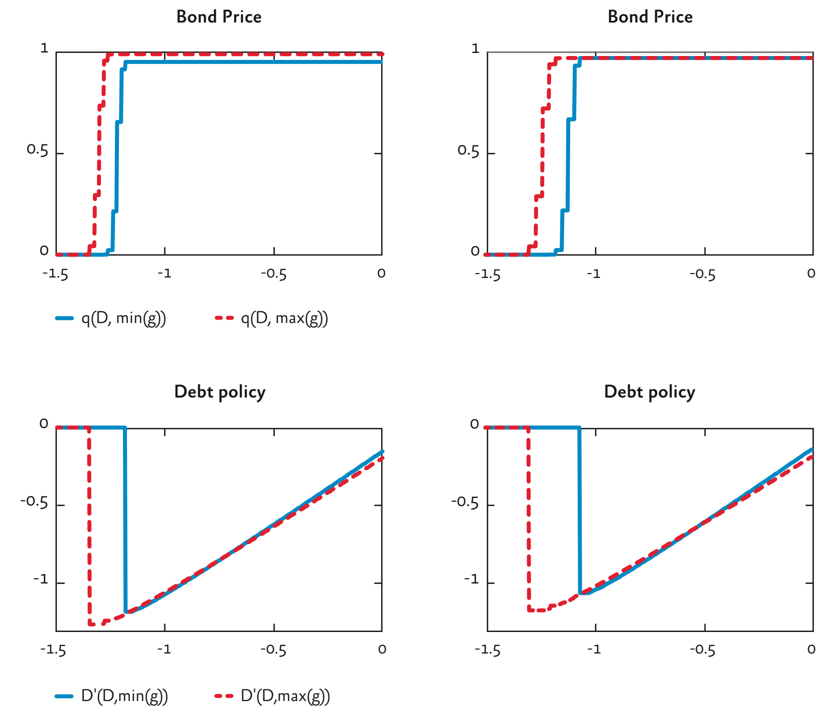


Figure 16 Post-euro solution with GDP-linked debt (left panels), and noncontingent debt (right panels).



After solving the model with indexation, I simulate it using Portuguese data. To focus on the recent debt crisis and capture the subsequent accumulation of debt, I present the results of the simulation starting in 1999. The strategy is the same as before, except that the policy function used to determine the next period's debt now considers that debt is contingent on the state of the economy. Figure 17 plots the results, showing that if Portugal had issued debt indexed to real GDP according to the specification presented above, it would have significantly reduced the accumulation of debt in the run-up to the crisis. In 2011, the date of the bailout, debt to GDP would be equal to 93.5%, which is 15 percentage points lower than what was observed in the data.

What would have happened if Portugal had issued contingent debt without having to pay the indexation premia of 100 basis points? Let us suppose that there were no premia related to first-mover costs or risk aversion and that the base interest rate was the same in both types of debt. We can use the model to simulate the debt path for Portugal in 2011 with $k=0.25$, in this scenario. Figure 18 shows that without premia debt would be higher in Portugal under indexation, about 111% of GDP, which is consistent with the results in Figure 16, which shows that indexation relaxes the borrowing constraint in the bad state of the world. Crucially, this debt would now be more sustainable because of the indexation. Because the state of the economy was low at the time, the decrease in payments in bad times associated with contingent debt, together with the prospective improvement of the economic situation, would have allowed Portugal to borrow more. In other words, by using contingent debt, Portugal would not only borrow against future income but also against the possibility of paying more in states where future income would be higher than today.

Figure 17 Comparison of data and models with and without contingent debt.

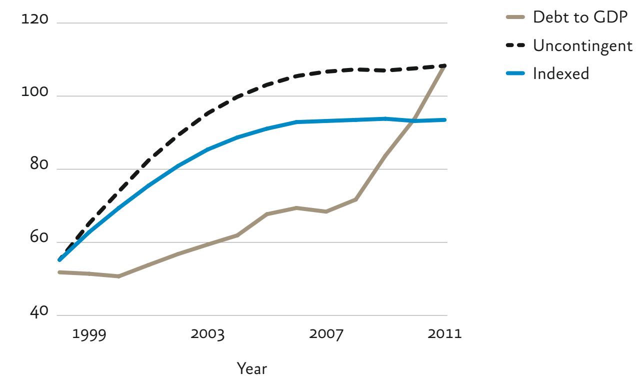
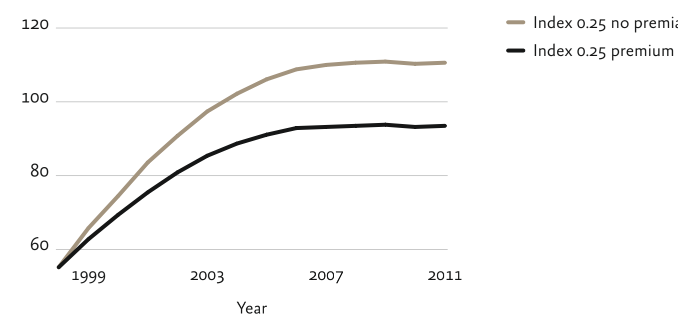
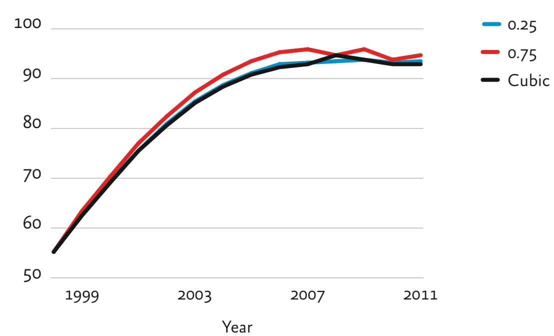


Figure 18 Comparison of debt to GDP path under contingencies with and without interest rate premia.



Next, I increase the level of contingencies and set $k=0.75$. I also study a specification where the difference between output and trend is raised to the power of 3, then standardized to match the scale of the previous indexations. The first alternative indexation mechanism increases the impact of indexation. This makes debt cheaper in bad times, on the accumulation path, which increases debt levels in the 2000s. It also reduces debt service when the crisis hits, leading to a sharper decrease in the debt to GDP ratio after 2007. The second alternative mechanism is almost indistinguishable from the original indexation on the accumulation path. However, it exhibits a higher variance and a higher decrease in the debt to GDP ratio after 2007. These results are presented in Figure 19.

Figure 19 **Comparison between alternative indexation mechanisms.**



4.6. Conclusion

This chapter presents a framework to study the introduction of GDP-linked borrowing when borrowing is endogenous. First, it calibrates a model of strategic default to match the Portuguese economy. Then, it studies the effects of introducing indexed debt to GDP. This chapter shows that indexation helps complete the market, reduces the effect of the state of the economy on both bond prices and borrowing decisions, and reduces the level of debt issued.

These results are the outcome of three effects. Firstly, borrowing limits are eased following the introduction of indexed debt, which allows the government to borrow more. Secondly, bond prices are higher under indexed debt, which requires the government to issue less debt in order to obtain the same revenues. The latter represent interest savings and are particularly important around explosive debt dynamics driven by high interest rates and significant rollover of borrowing needs. Thirdly, the additional risk associated with indexation increases the base interest rate and leads the government to borrow less. When I apply this framework to Portugal, I find that debt indexed to real GDP would reduce the predicted level of the debt to GDP ratio by 15 percentage points in 2011.

Future work should study the robustness to different degrees and types of indexation, for example, considering only upside or only downside contingencies, and calibrate the parameter governing indexation to match existing debt issuances. In this chapter, I set this parameter such that additional debt payments, or reduction in payments, are about 5% of GDP. However, this raises questions regarding the optimal degree of indexation or, more immediately, the sensitivity of the results against different levels of indexation.

Chapter 5
Portuguese experience with GDP-linked treasury certificates

5.1. Overview

The Portuguese government created two GDP-linked treasury certificates. Initially, in 2013, with a maturity of 5 years (CTPM), and then, in 2017, with a maturity of 7 years (CTPC). Both are redeemable after one year. In the 2013 edition, the coupon in the final two years was linked to 80% of the average real GDP growth in the last four quarters known in the month before the date of interest payment. The government announced a reduction in base interest rates in mid-January 2015, taking effect at the end of that month, without specifying the details on the new rates. This prospective decrease in interest rates led to a surge in subscriptions in January 2015. The 2017 edition further decreased base rates and, starting in year two, included variable payments indexed to 40% of the average real GDP growth in the last four quarters known in the month before the date of interest payment. Both instruments include a coupon floor equal to zero. The 2017 edition also includes a cap of 1.2 percentage points on additional interest payments related to real GDP growth. Payments are not corrected due to statistical revisions.

Figure 20 **Gross subscription of Treasury Certificates**

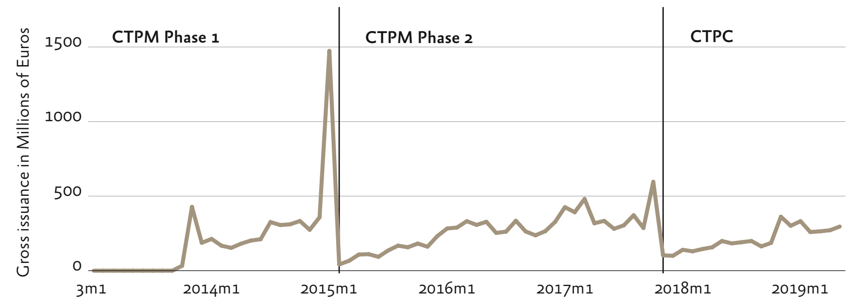
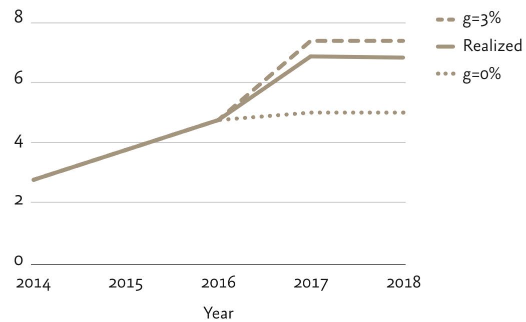


Figure 20 plots the gross subscription of treasury certificates, that is, without considering redemptions. The graph also plots the three different phases of the assets described above, which are represented by the vertical lines. The first phase of the CTPM, between October 2013 and January 2015, the second phase of the CTPM, between February 2015 and October 2017, and the CTPC, issued starting November 2017.

Figure 21 **Gross interest rates by year for Portugal's CTPM subscribed on October 31, 2013. Average real GDP growth represented by g.**



To get a sense of the level of indexation in the Portuguese instruments, Figures 21 to 23 plot realized and forecasted gross interest rates for the different instruments described above.[16] For simplicity, I plot gross rates of return at specific years instead of yield to maturities. Income earned from these certificates is subject to a 28% income tax in Portugal. In order to compare them to other assets, one would need to compute the internal rates of return associated with these bonds and compare them to yield to maturity.[17] However, to understand the role of indexation, gross rates of return provide a clear picture of the GDP premium.

5.2. The CTPM

Figure 21 shows the data for a CTPM subscribed when it was initially introduced, on October 31, 2013. Given the 5-year maturity of this subscription, it has now been fully redeemed. The bold line shows the realized gross returns for a holder that kept the asset until maturity. The dashed lines show the hypothetical payments for constant growth rates in real GDP equal to 0% and 3%. The line showing rates for GDP growth equal to 0% also plots the base real interest rate. This instrument used high benchmark interest rates, as Portuguese government bonds were trading historically high yields in capital markets, and ended up providing generous basic terms for investors ex-post, which turned out to be better when the indexation kicked in. As of 2014, the Portuguese economy recovered, and the interest rates of all other assets decreased. This resulted in a high return for this asset in 2017 and 2018, with indexation premia of about two percentage points adding to a close to 7% gross return in the last two years, which was higher than other instruments issued by Portugal at the time.[18]

The base rates were updated in January 2015. As can be seen in Figure 22, the new interest rates were much lower. This figure plots the realized returns and the hypothetical returns under 0 and 3% growth from a subscription that occurred immediately before the rates changed, and from another one that took place immediately afterward. The data after 2019 are based on official forecasts, and we can see that the payment profile is substantially reduced.

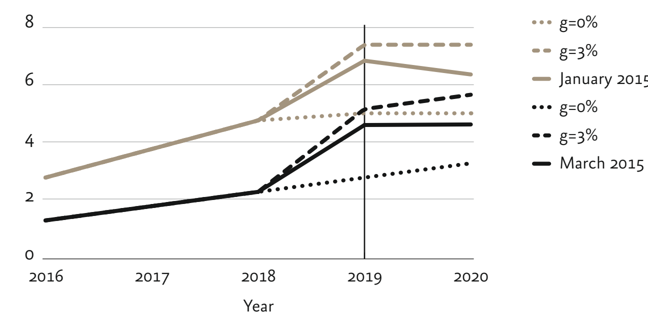
Due to a prospective decrease in benchmark rates, there was a massive increase in subscriptions of the CTPM in January 2015. As can be seen in Figure 20, during December 2014, and before the announcement of interest rate changes, subscriptions of Treasury Certificates amounted to €358 million. During January 2015, before the rate change, but after the announcement, this amount was €1474 million. Whereas in February 2015, after the interest rate change, subscriptions of Treasury Certificates amounted only to €42 million.

This event in Portugal highlights one challenge regarding subscription-based debt emissions. Because the government does not directly determine the amount it is borrowing, it can face a high opportunistic demand depending on the state of the economy. In this case, the generous conditions of the CTPM and the prospective decrease in interest rates led to a much larger subscription than usual of these instruments in January 2015, about half of all subscriptions in 2014 or 2015. This effect was also observed in the subscription of the "Certificados de Aforro", an instrument which also saw its interest rates revised. One possibility to overcome these issues is for the government to issue GDP-linked bonds that also index their base rate to a floating market-benchmark.

This borrowing was likely expensive when compared to alternative options. However, counterfactuals regarding potential interest savings are difficult to construct. Could the government have borrowed the same amount using alternative instruments? How would additional non-retail borrowing affect total debt premia? If these had to be retail certificates, would it have been possible for the government to refrain from announcing the decrease in rates before implementing them, thus avoiding the surge in subscriptions and saving some interest payments without allowing the exploitation of insider information? Was there a need for extra borrowing determining the timing of the actions taken by the government and leading it to announce the reduced rates in order to induce additional subscriptions in January 2015?

These are hard questions to tackle. However, given that we have the realization of real GDP for the first quarter of 2019, and a forecast for 2020, it is possible to compute the expected additional cost in interest from this surge in subscriptions. First, I assume that the change in interest rates did not generate additional demand for certificates, but only anticipated the demand for the month of January. This assumption is consistent with the lower issuance in the rest of 2015. Second, I assume that there were no redemptions. This assumption is consistent with the generous base rates relative to other assets. Under these two assumptions, the only difference is that €1.474 billion worth of subscriptions received a higher return in 2019, in fact, 1.62 percentage points higher. This additional interest cost amounted to €24 million in 2019 and is forecasted to be €19 million in 2020, when these certificates mature.[19]

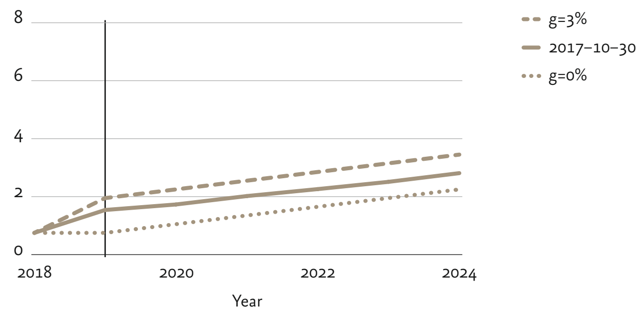
Figure 22 **Gross interest rates by year for Portugal's CTPM subscribed in January and March 2015. Average real GDP growth represented by g.**



5.3. The CTPC

Figure 23 plots the gross interest rate scenarios for a CTPC certificate subscribed on October 30, 2017. The CTPC series was the latest product issued with GDP-linked coupons. It featured lower base interest rates and a different indexation mechanism, as described above.[20] The forecasted return is represented by the full line, while the dashed lines represent the two growth scenarios. It is possible to see that there is a substantial level of indexation. In case of a recession, where real GDP growth is smaller or equal to zero, payments would go down to the dark blue dashed line and would be approximately halved.

Figure 23 **Gross interest rate scenarios for Portugal's CTPC subscribed on October 30, 2017. Average real GDP growth represented by g.**



In May 2019, there were about €17 billion of CTPM and CTPC outstanding, corresponding to 6.7% of the total debt. To find out how much indexation is embedded in these issuances and the maximum amount of interest saved by these assets, I perform three different exercises.

5.4. A steady-state recession

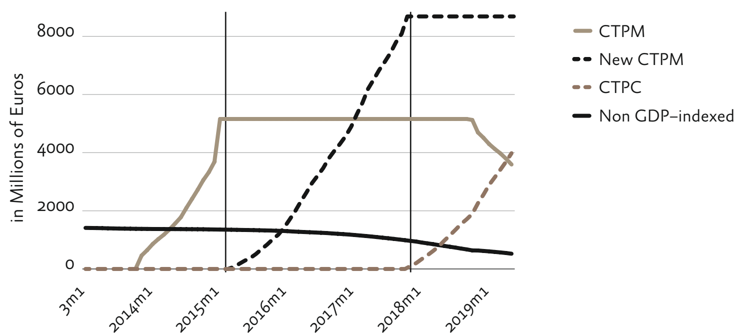
First, let us consider that the €17 billion represent the steady state for this type of certificates and that, as CTPM mature, investors merely replace them with CTPC. At a steady state, the CTPM have matured and all certificates are now CTPC. These certificates are only indexed to GDP after the first year, so 6 out of 7 are paying indexed interest. Using the World Economic Outlook long term projections for real GDP growth in Portugal, which is at 1.4%, and assuming that the 28% tax rate on interest does not change, the maximum interest saved by the Portuguese government in a given year, where the economy grows 0% instead of the projected 1.4%, amounts to $6/7 \times 1.4\% \times 0.4 \times$ €17b $\times$ (1-0.28), or €58.7 million.

5.5. A 2019 recession

Now, let us suppose a downturn had hit the Portuguese economy in 2019, and all of 2019 saw 0% real GDP growth or lower. Computing the amount of interest saved this year is harder because certificates are now composed of CTPM and CTPC. The CTPM are maturing at different times, and the CTPC, which pay indexation after the first year, are slowly starting to enter the indexed payment stage. Unfortunately, the Portuguese Treasury and Debt Management Agency does not publish the composition of redemptions by type of certificate or over different vintages, only the total amount of redemptions. However, because only one type of certificate was issued at a specific time, it is possible to estimate the composition of the certificates under the assumption that all certificates were kept until maturity, except for the older, non-indexed ones. In other words, I am assuming that all redemptions either come from the new certificates, which are maturing, or from old 10-year maturity certificates issued until 2012. Under this assumption, in January 2019, I obtain €13024 million worth of CTPM, from phases 1 and 2, and €2891 million worth of CTPC, although not all CTPC were eligible for GDP-bonification in 2019. The remainder €524 million pertain to older non-indexed treasury certificates.[21]

Figure 24 plots the results of the composition of Treasury Certificates in this simulation, where the vertical lines represent transitions from one type of certificate to another. Let us focus, for example, on the CTPM line. It initially increases until January 2015 and, then, it remains flat until the first CTPM certificates hit maturity and are automatically redeemed after 5 years. Subscriptions of the new CTPM follow a similar pattern, increasing until the CTPC replace them.

Figure 24 Results from the simulation of the composition of Treasury Certificates



Now, I compute the savings should the Portuguese economy be hit by a downturn that saw zero growth instead of the realized and projected growth rates for 2019. Again, I consider the 28% tax on interest earnings. Performing this computation, I obtain potential interest savings in 2019 equal to €95.7 million, or about 0.05% of 2018's GDP. This amount is higher than the steady state exercise, which is justified by the fact that the CTPM, which are excluded from the steady state calculations, included a higher level of indexation to real GDP, 80% of real GDP growth in the CTPM compared to 40% in the CTPC. According to my model, the last payment on a CTPM certificate will occur in 2022.

5.6. What if all Portuguese debt was linked like the CTPC?

The amounts computed before are relatively small, which reflects the fact that the retail, non-tradeable debt market is small for Portugal. However, indexation is quite substantial. To see this, suppose that all of Portugal's direct government debt, about €252 billion in May 2019, was issued with a mechanism like the CTPC, that is, a 40% premium based on real GDP growth. Interest savings would then be much larger. In an economic downturn, where real GDP growth is 0% or less, instead of 1.4%, debt payments would be reduced, at most, by €1187 million in one year, or 0.59% of 2018's GDP.[22]

5.7. Discussion of the Portuguese experience

The recent experience in Portugal with debt linked to real GDP growth shows that it is possible to implement state-contingent government debt in an advanced economy. These certificates saw substantial demand, and there have not been any issues regarding their payment. Ex-post, they may have been more expensive for the Portuguese government compared to alternative financing options, but they insured the government against shocks to real GDP growth and increased the domestic market for public debt.

From the buyers' point of view, the relatively generous base interest rates and the substantial GDP growth numbers have contributed to the popularity and substantial demand for these debt instruments.

What could be some of the sources of uncertainty regarding this demand? One question is whether an economic downturn, which would reduce payments on these debt instruments, would negatively affect demand. Another one is whether the revision of GDP numbers, which do not affect payments retroactively but affect future payments, would matter. If revisions are too large, this may lead to higher variations in payments than anticipated. For example, in September 2019, GDP numbers in Portugal were revised upwards. On the one hand, as this represents lower payments than the actual state of the economy, it may lead to a chilling effect on the demand. On the other hand, this positive news may bring attention to assets linked to GDP and contribute to higher demand. Further research should assess the impact of statistical shocks on these types of assets.

The Portuguese certificates were subscription-based. In other words, the government posted the terms and savers decided how much of the asset to buy. However, because the state of the economy may change faster than the indexation embedded in the asset, the sovereign should retain control of the amount of debt issued, or it may experience a surge in subscriptions until overly generous terms are updated. This happened with the surge in subscriptions of the Portuguese CTPM in January 2015. Although the increase in subscriptions was limited and ultimately unrelated to the indexation itself, there is a risk in subscription-based debt when debt terms are less frequently updated than the state of the economy. One option to manage subscription-based debt would be to index not only the variable payments to the state of the economy but also the base interest rates at issuance to benchmark market rates.

Overall, the Portuguese experience with state-contingent government debt was innovative and ultimately successful. If policymakers are interested in developing these markets further, the next steps would be to issue GDP-growth linked debt that is tradeable in secondary markets and open to foreign investors. In other words, to issue fully-fledged GDP-linked bonds in primary markets which, as shown in Chapter 4, have the potential to make the portfolio of debt more sustainable and resilient to economic shocks.

Chapter 6
Conclusion

This study makes four major contributions. Firstly, it carefully reviews the data on the design and performance of state-contingent government debt, codifies the existing information and makes it available in a dataset. Secondly, it draws valuable lessons for policymakers regarding the design and implementation of state-contingent government debt. Thirdly, it estimates a model of debt issuance for Portugal and runs counterfactuals under state-contingent debt. Finally, it reviews the Portuguese experience with GDP-linked certificates.

An additional paper, which was written as part of this project but is not included in this study, investigates theoretically whether risk-averse lenders are one of the reasons for the limited use of this type of debt. The paper shows that even though state-contingent debt increases economic activity through investment and reduces the probability of a debt crisis, it may reduce the share of output obtained by lenders. In other words, the gains associated with this type of debt accrue disproportionately to borrowers. Finally, the paper concludes by highlighting conditions under which these markets could benefit both types of agents.

State-contingent debt has the potential to make government borrowing more sustainable and less prone to debt crises. However, new risks are present, as is common with financial innovation, and the correct design of these instruments will prove crucial to determining whether the objectives of this type of debt can be materialized.

There have been several small and heterogenous issuances of state-contingent debt that resemble pilot runs in this new asset class. The Portuguese GDP-linked certificates are examples of such experiences. A recent debate suggests that a large developed country should issue a significant amount of state-contingent debt and provide a big push to this market. However, given that current interest rates are low, and demand for developed countries' traditional debt is still sizeable, it is not in the interest of these countries to do so. Furthermore, investors may be more interested in the safe characteristics provided by developed countries' debt and less interested in being exposed to the inherent risks of state-contingent debt.

Having said that, one can still speculate where such a big push could come from, and what type of indexation would likely work. An example of a large country with a highly developed debt market, which is subject to substantial risks and could potentially benefit from state-contingent debt, is the United Kingdom, which is currently in the process of leaving the European Union. This shock will have an uncertain effect on output and consumption. In case these effects are rather negative, lower interest payments could provide much-needed relief to the United Kingdom's Treasury. Finally, there is evidence that the uncertainty surrounding Brexit is already costly to the economy (Born et al., 2019), such that the treasury could already be benefiting from issuing state-contingent debt. Indexing debt payments, or the debt principal, to GDP or exports, would allow the United Kingdom to smooth the effects of these shocks.

Another example of a large economy that could potentially implement a form of state-contingent debt is Canada, a country that features a substantial share of commodities in its export portfolio and a relatively stable output of these commodities. Given that commodity prices fluctuate with international demand, the Canadian Treasury could stabilize the effects of price fluctuations using state-contingent debt. At the same time, this would deepen the market for commodity--linked debt, which could prove crucial for emerging economies that are commodity exporters.

Finally, concerning natural disaster debt, Japan and Chile are two examples of developed countries where this debt could be successful. However, one challenge would be to standardize the measurement and fine-tune the mechanism connecting the event to the debt contingencies. Overall, these big pushes may prove crucial to the development of the state-contingent debt market and to making international borrowing more sustainable and less prone to crises, and they can significantly affect economic welfare around the world.

Chapter 7
Acknowledgments

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Notes

< **1.** See link.

< **2.** Some sovereigns, or state-owned companies, have used options to hedge fluctuations in commodity prices. These have included put options, for example, Mexico and Panama (oil exports), Ghana (cocoa exports), and Sri Lanka's (oil imports) and call options, for example, Ghana, Panama and Sri Lanka (oil imports) and Malawai (maize imports). These types of instruments are not discussed in this paper or database. For more details see International Monetary Fund and World Bank (2011), annex III.

< **3.** Guyana, Nicaragua, Haiti, Belize, Jamaica, Antigua, Dominica, Grenada, St. Kitts & Nevis, St. Vincent & the Grenadines, and the Dominican Republic.

< **4.** Two important exceptions are the China Africa Research Initiative (link) and the China-Latin America Finance Database (link). Work by Adam et al (forthcoming) reviews resource-backed lending by sovereigns and state-owned companies based on these data and on additional data.

< **5.** Data on jurisdiction, as well as the distribution across currencies, is available for some bonds.

< **6.** Joanna Chung and Dino Mahtani (2007) "Nigeria escapes debtors prison", *Financial Times*, 1 February. Available, link.

< **7.** See: link.

< **8.** See Chamon and Mauro (2006), Schinckus (2013) and Consiglio and Zenios (2018) for examples of papers pricing state-contingent government debt.

< **9.** See Gomez-Gonzalez (2019) for a paper on state-contingent assets where the state is defined over the liquidity needs of firms.

< **10.** Hereinafter, I will refer to traditional debt as noncontingent, and to alternative debt instruments as either contingent, linked, or indexed to a specific variable, for example, real GDP.

< **11.** More recent examples include Bohn (1990), Chari, Christiano and Kehoe (1991), Aiyagari, Marcet, Sargent and Seppala (2002), Angeletos (2002), Buera and Nicolini (2004).

< **12.** With one period bonds, linking debt through the principal or the coupon is equivalent. One interesting avenue for future research is to increase the maturity of debt and see how the results change when coupon or principal are linked. One important point is that these may be cash-flow equivalent for rational agents, but the psychological effects may also play a role.

< **13.** This is something that has been noted in the literature, and that is frequently justified by political economy considerations It is less of an issue for the literature on willingness to pay, or in Bocola and Dovis (2017), who introduce a minimum government consumption requirement that effectively transforms a strategic default model into a willingness to pay model.

< **14.** Estimation based on more recent data, for example, after 1980, provides smaller but more unstable estimates for these parameters.

< **15.** Note, however, that with one-period debt, the indexation of the coupon or the principal is equivalent. Furthermore, GDP-linked mechanisms that depend on GDP growth may be less effective. For example, following a bad realization of output, the economy may be growing again but still below its potential. An indexation mechanism prescribing increasing payments as a function of growth may, in fact, increase the burden on the government and, in a model with sticky prices, even prolong the slump.

< **16.** The projections used the Ecofin for 2019 and 2020 (dated May 2019), Bank of Portugal for 2021 (dated March 2019) and the World Economic Outlook for 2022-24 (dated April 2019).

< **17.** See, for example link.

< **18.** For example, the "Certificados de Aforro", Series C, which were issued starting 2012, cap the maximum gross rate of return at 5%, including the non-withdrawal premium until 2017. They are uncapped afterwards. However, given the low levels of Euribor to which they are indexed, payments are substantially below the previous cap. The next iteration, Series D, which was issued starting February 2015, caps the maximum gross rate of return at 4.5%. Treasury bonds paid much lower rates in 2017. However, in October 2013, the 5-year bonds were trading at 5.2% and the 10-year bonds at 6.2%, which was closer to the ex-post returns on CTPMs. Furthermore, the internal rate of return for the CTPMs, which considers the step-up structure, was somewhat lower than the 7% realized in the last two years.

< **19.** This computation does not consider the potential external benefit on other debt instruments from having larger domestic government borrowing. On the one hand, this may put less pressure on other sources of financing by the government, from foreign investors or in the bond market. On the other hand, the larger interest rates ex-post may increase funding needs and lead to higher market rates.

< **20.** A smaller surge in subscriptions of CTPM, amounting €596 million, took place in October 2017, before the new instrument CTPC was implemented.

< **21.** Note that the indexed certificates pay once a year and have different vintages, that is, they are subscribed in different months, and the payment depends on the available data for the 4 quarters of real GDP growth at the anniversary of the subscription. My calculations take this into account by keeping track of how much of both assets was issued, each month, from 2013 to 2018, and by considering the date when the interest is due. I also compute month-specific 4-quarter average real GDP growth rates, and use projections from the EcoFin when not available, to compute the relevant interest bonus.

< 22. This number was obtained by computing 100*((1.4% × 0.4 × (1-0.28) × 252257)/201530) for the 57% of domestic debt holders, which are taxed at 28%, and by adding a similar expression for 43% of foreign debt holders, who are not taxed in Portugal, under the assumption of an existing tax treaty (there are exceptions for two small debt instruments, “Certificados de Aforro” and “Certificados do Tesouro”, and some categories of foreign investors). I assume that the composition of debt holders does not change. For simplicity, the Bank of Portugal is included as part of the domestic debt holders, and transfers to the government by the Central Bank are not considered.

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