

The case for contingent convertible debt for sovereigns

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Abstract

We make the case for sovereigns to issue contingent convertible bonds as a means to forestall debt crises. These instruments contractually stipulate payment standstill, contingent on a sovereign's credit default swap spread breaching a distress threshold. This is a financial innovation solution to the lack of sovereign debt restructuring mechanisms, limiting *ex ante* the likelihood of debt crises and imposing *ex post* risk sharing between creditors and the debtor. The new instruments are contingent contracts addressing neglected risks in sovereign debt. Building on literature for contingent convertible debt for banks we address the design of sovereign contingent debt, including market discipline and sovereign incentives; market manipulation and multiple equilibria; errors of false alarms or missed crises. Then we develop a risk optimization model to incorporate contingent debt in the portfolio of instruments financing a sovereign. Using Greece as a case study we illustrate Pareto improvements in expected cost *vs* tail risk.

Keywords: sovereign debt; debt crisis; contingent contracts; GDP-indexed bonds; puttable bonds; debt restructuring; scenario analysis; portfolio optimization; conditional Value-at-Risk.

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1 Introduction

We make the case for sovereigns to issue a new security with state-contingent payment standstill. This will be of direct benefit to sovereigns, their creditors and the sovereign bond market. A standstill is triggered when the sovereign is in distress and the relief so provided could forestall default. The cost of the standstill is priced *ex ante*. This arrangement provides risk sharing between the debtor and its creditors, with the potential of eliminating lengthy debt restructuring negotiations. Our proposal is no substitute for prudent management of public finances. Nevertheless, by making rare but costly events part of a “contingent contract” it prices the “neglected risk” of sovereign default thereby creating incentives for fiscal discipline.

The proposal is for a class of instruments with design flexibility, and a concise definition follows. Design features (i) – (iii) below are justified as our argument develops and alternatives are given when relevant.

Sovereign contingent convertible debt (S-CoCo): *A sovereign debt instrument with (i) a built-in trigger to allow standstill of payments when an indicator breaches a threshold, (ii) invoking a precautionary credit line from the IMF, and (iii) making the triggered bond senior to subsequently issued debt.*

A major question is what triggers a standstill. We argue for a market based trigger such as credit default swap (CDS) spreads, activated when a distress threshold is breached.

This proposal responds to the evidence of persistent problems with sovereign debt. Debt crises are rare but they have been increasing both in numbers and in magnitude. Up to 55% of the world sovereigns had been in default at some point since 1975 on hundreds of billions USD debt; Figure 1. Totals average 1.8% of global sovereign debt, which is only a small fraction of the market. Brooke et al. (2013) show that over the past two decades IMF lending as a proportion of borrowing country GDP has tended to increase, and Barkbu et al. (2012) report that annual IMF credit commitments during the recent crisis increased ten-fold from the Tequila crisis of 1990s. Pisani-Ferry et al. (2013) illustrate that the average IMF program during 1992–2012 was about 3% of the recipient’s GDP and lasted 1,5 years, the programs for Latin American crisis countries were 6% of GDP for three years, and for the Eurozone crisis it reached 18% of GDP for an average of four years. For eurozone crisis countries the program sizes are staggering: Greece first program was 49% of GDP, second program 85% and third program 40%, for Ireland 60%, Portugal 68%. Cyprus program was for 55% of GDP in addition to 30% of GDP from bailed-in bank deposits.

“Advanced countries have relied far more on [methods that include debt restructuring] than many observers choose to remember” note Reinhart et al. (2015). But the survey in Reinhart and Trebesch (2015) informs us that theory is ambiguous as to whether debt relief is beneficial or not. There are seminal contributions arguing about welfare benefits of forgiving debt in situations of debt overhang, with both creditors and debtors gaining from a partial debt-write-down, while others demonstrate that restructuring can cause reputational damage and trigger sanctions and output losses. Instruments that contractually specify debt restructuring under adverse conditions can bring welfare benefits without triggering sanctions and reputation damage.

The debate on the costs of debt restructuring highlights the fact that there is no universal legal framework for dealing with sovereign defaults –akin to Chapter 11 for corporations and Chapter 9 for municipalities in US insolvency procedures— and coordination between creditors and debtor remains a major challenge in sovereign debt restructuring. When defaults occur it takes on average almost eight years to resolve, and theories explaining the delays are proposed in Benjamin and Wright (2009); Ghosal and Miller (2015). Delays destroy value for both creditors and debtor, and Buchheit (2011) explains that failure to contain debt repayment to manageable levels imposes large costs by further undermining repayment capacity and distributing the burden in an arbitrary manner. Panizza (2013) reaches similar conclusions, make makes a

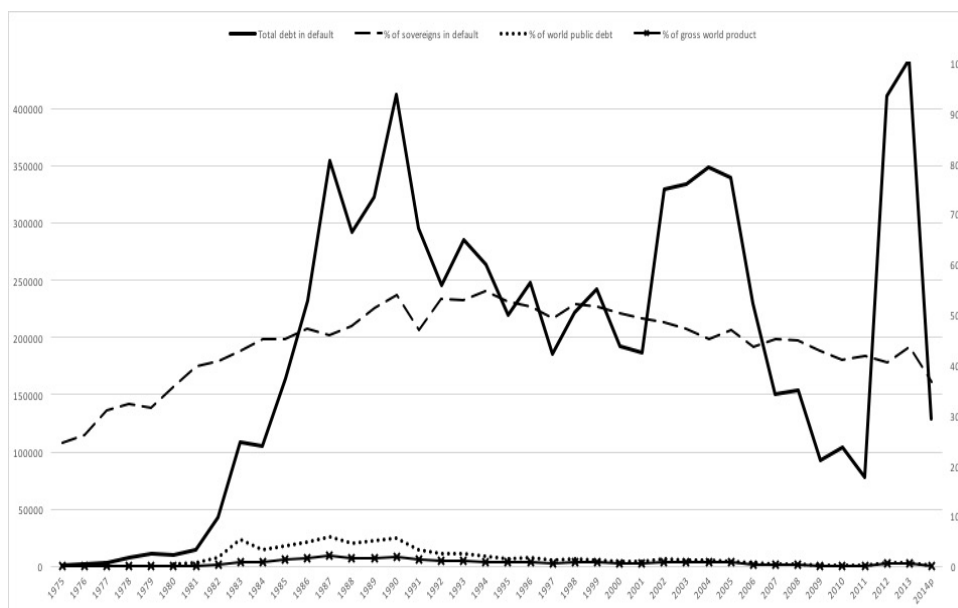


Figure 1: Sovereign debt default worldwide. (Data from Beers and Nadeau (2015).)

suggestion for the role of an international lender of last resort, and suggests that “contingent instruments would be an even better solution”

International legal procedures for dealing with sovereign defaults are missing and a debate is ongoing. Gianviti et al. (2010) suggest a special chamber of the Court of Justice of the European Union to deal with negotiations between a sovereign debtor and its creditors. The International Capital Markets Association suggests reforms in sovereign debt contracts (Gelpern, 2014). Buchheit et al. (2013) suggest modifications to the European Stability Mechanism treaty to make debt restructuring a pre-condition for assistance.

Our proposal provides a financial innovation response to sovereign debt crises through the *ex ante* introduction of distress contingencies into the debt contract. A payment standstill limits debt repayment thus avoiding default with its adverse effects. The proposed instrument does not eliminate litigation, but distress situations are covered by the contract.

Earlier suggestion for using contingent debt with sovereigns were made, independently, by Weber et al. (2011) and Barkbu et al. (2012). The French Aid Agency (AFD) used maturity extension contingent debt for some African countries in 2009 (Brooke et al., 2013). Mody (2013) argued that sovereign debt should be recognized as equity (a residual claim on the sovereign), operationalized by automatic lowering the debt burden upon the breach of contractually specified thresholds. Brooke et al. (2013) provide extensive discussion. *Ex post* maturity extension is not uncommon, and well-known instances are 1997 Korea, 2000 Turkey and the Vienna Initiative for post Soviet Union central european countries.

Our proposal draws on ideas of convertible debt for banks (B-CoCo) with a significant difference. B-CoCo convert from debt to equity, whereas S-CoCo convert to more favorable repayment schedule. Contingent debt for banks was first suggested in a 2002 working paper published as Flannery (2005). He argues that “reverse convertible debentures” would bring market discipline to the recapitalization of large banks under stress. Flannery (2014) provides a survey. However, criticisms have been voiced. Sundaresan and Wang (2015) raised the possibility of multiple equilibria, and Bond et al. (2010) discuss difficulties in using market data to signal contingencies when the signal provokes policy responses priced by the market. Successful deployment of these instruments hinges on overcoming the shortcomings pointed by their critics, and suggestions have been made by Calomiris and Herring (2013); McDonald

(2013). Dealing with multiple equilibria was also addressed in Avdjiev et al. (2015); Flannery (2014). The market of coco capital for banks is small but sizeable and rapidly growing. Avdjiev et al. (2013) report \$70bn for banks between 2009 and 2013. Issuance increased significantly in 2014, with 187 instruments for \$208bn by 68 banks (Avdjiev et al., 2015).

Contingent capital has not been restricted to banks. It is used by insurance and re-insurance firms to supplement reserves for protection against catastrophic events, in manufacturing as source of capital during downturns of the business cycle, by rated firms as part of capital management to satisfy rating agencies with their leverage ratios, and as supplementary liability insurance by service firms. Culp (2002) discusses uses by French tyres company Michelin, Swiss Re and US mono-line insurer MBIA. These firms benefit from contingent capital that combines capital raising with risk management.

Our paper adds to these contributions by suggesting and analyzing a fully specified type of contingent debt. To the best of our knowledge what we suggest is new, and the paper makes two distinct contributions. First (Sections 2 and 3), it justifies the use of sovereign state-contingent convertible debt as “contingent contracts” to address “neglected risks” in sovereign debt, and briefly compares with alternative proposals. Building on banking literature we give a comprehensive discussion of the issues relating to the design of S-CoCo: which triggers, market discipline and sovereign incentives, standstill schedules, potential for market manipulation and multiple equilibria, and errors of false alarms or missed crises. The discussion is supported by numerical results from a pricing model. Second (Section 4), it develops a risk management optimization model to incorporate contingent debt in funding a sovereign. Using Greece as a case study we present (Section 5) two examples with improvements in the risk profile of the country’s debt when using S-CoCo, and discuss the issue of risk endogeneity. Section 6 concludes with some thoughts on the potential adoption of S-CoCo.

2 Why contingent debt for sovereigns

Sovereign contingent debt makes distress (i.e., “near default”) contingencies part of the legal contract, and the ensuing payment standstill avoids right out default. Two arguments from the literature on contingent contracts (Bazerman and Gillespie, 1999) support making default contingency part of a sovereign debt contract: (i) avoiding biases, and (ii) sharing risks between debtor and creditors. The risk sharing arguments are obvious and Section 4 develops a relevant risk management model. Avoiding biases needs elaboration. The sovereign’s bias is the over-confidence that their debts can be fully repaid, or —when its ill-placed confidence is proven unfounded— “gambling for redemption” (Conesa and Kehoe, 2014). The creditors’ blind spot is in providing credit expecting full repayment. For instance, Bank of Cyprus and Cyprus Popular Bank exhibited blind spots in carry trade of Greek government bonds with ECB financing (Acharya and Steffen, 2015) on the working hypothesis that “there will be no stop of payments for the public debt of a eurozone country” (Zenios, 2015). Eventually almost 25% of Cyprus GDP was lost with the Greek PSI (private sector involvement with nominal value haircuts). Instead of being over-confident on their views, debtor and creditors should make the contingency part of the contract.

Justification for S-CoCo is also provided by the literature on “neglected risks” of Gennaioli et al. (2012). They argue that investors neglect certain unlikely risks, financial intermediaries provide securities exposed to these neglected risks, and because the risks are neglected, security issuance is excessive. When (if) these neglected risks are realized investors run away and markets become fragile, even without leverage, precisely because the volume of new claims is excessive. Mody (2013) used this argument in explaining the eurozone crisis. Sovereign debt was regarded as virtually risk-free, a notion fostered by zero risk weighting of sovereign assets held by banks. Hence, euro area banks had excessive sovereign exposure. The Deauville agreement between Chancellor Merkel and President Sarkozy on 19 October 2010, put the neglected risk

of sovereign debt restructuring on the table, resulting in sovereign distress and escalating into financial panic. With the use of S-CoCo neglected risks are not so neglected any more. There is risk sharing between creditors and the debtor in adverse states of the world, and restructuring risk is priced.

Hence, S-CoCo is a contingent contract and a financial innovation to price neglected risks.

2.1 Goals of contingent debt

We now turn to the literature on contingent debt for banks to discuss the implications of S-CoCo (Flannery, 2014). The banking literature does not apply *mutadis mutandis* to sovereigns: in B-CoCo conversion is from debt to equity, whereas in S-CoCo conversion is from one type of debt to another with favorable repayment schedule. Some of the arguments we provide here have been made in Barkbu et al. (2012); Brooke et al. (2013), and some are new. They are provided here in a comprehensive discussion of the goals of sovereign contingent debt.

Fore stall default during a crisis. A payment standstill gives the sovereign space to put public finances in order. In B-CoCo the design goal is to forestall default during systemic crises but allow institutions to fail for idiosyncratic problems. This is achieved through a dual trigger, McDonald (2013). One trigger is institution-specific (e.g., stock price), while the other is market-specific (e.g., a financial institutions index). This structure protects financial firms during systemic crises, but lets them go bankrupt if they perform badly during normal times. Allowing for failure of financial institutions is healthy for market efficiency. However, sovereigns do not fail and the standstill should be triggered by a unique idiosyncratic indicator. We do not see any arguments in favor of a dual trigger for sovereign contingent debt, although an additional market-specific indicator could be introduced in design feature (i) to allow for potential default. For bank coco, there is conversion to equity when the threshold is breached during systemic crises, but the bank is allowed to go bankrupt during idiosyncratic crises. Similarly, if the sovereign CDS threshold is breached during a systemic crisis the standstill could be triggered, but for idiosyncratic crises there would be no payment standstill and the sovereign will be cut off the market and require a debt renegotiation (which is akin to a bankruptcy).

Reduce the probability of default. A sovereign funded by S-CoCo does not default in the sense of unexpectedly ceasing payments. The payment schedule is altered with a contractually specified standstill and this is not a default event. Reducing default probability is questionable in the case of banks where good designs of contingent debt allow bad institutions to fail. For sovereigns the goal is *a priori* provision for burden sharing in case a sovereign enters the default zone. Hence, we are aligned with the B-CoCo literature that failures are allowed, but whereas a banking failure means bankruptcy, a sovereign “failure” means losses to creditors. But what, then, are the incentives for the debtor not to provoke the standstill? The answer is found, in part, in market discipline.

Provide market discipline to the debtor. One reason why sovereigns get into debt crises is the fact that benefits from borrowing come immediately, whereas the risk of default is borne in the future. This encourages governments with a finite (and short) horizon towards excessive debt. S-CoCo price the risk of future payment standstills thus making the costs immediately visible. With risk sharing between creditors and debtor, the interest charged on a sovereign coco will increase as a crisis zone is approached, and because triggered bonds are senior —design feature (iii)— the increased rate is transmitted to standard bonds, disciplining the sovereign. For Brooke et al. (2013) market discipline is the primary goal of contingent debt.

With simple bonds, markets also give disciplining warnings with yield increases. However, warnings from S-CoCo lead warnings from straight bonds as standstill precedes defaults

and evidence from corporate CDS markets show that they lead in price discovery (Blanco et al., 2005). Hence, contingent debt does not encourage more risk taking than current instruments. The discipline by the market is in the right direction but this is not sufficient, as we have also seen with market discipline from plain bond yields. Discussions on this issue for banks is given by Calomiris and Kahn (1991) and (McDonald, 2013, p. 233).

Solve creditor moral hazard. Brooke et al. (2013) make a distinction between creditor and debtor moral hazard, and S-CoCo address two important issues of the former.

First, we have the propensity of creditors to buy short term debt from crisis countries. This is based on the assumption that, in the short term, a country in crisis is likely to pay its debts due to an international official assistance program, but the long term prospects are unclear. In the short-run the country is treated as having a liquidity problem that will be solved with assistance from the official sector, but in the long-term the country may be facing a solvency problem that requires private creditors to contribute. S-CoCo embeds the uncertainty about liquidity *vs* solvency in the contract. Short-term creditors could see the threshold crossed and the standstill triggered in the same way that long-term creditors may witness a default. Hence, flight to short term debt —with its adverse effect on long-term yields— is arrested.

Second, we have the burden on taxpayers from sovereign bail-out. The standstill reduces the size of an assistance program and creditors can not count on taxpayers to carry all the cost. This point is emphasized in both Brooke et al. (2013) and Weber et al. (2011).

Provide automatic stabilisers and countercyclical fiscal policy. Once a country is in the crisis zone fiscal solvency requires a combination of concessional financing and austerity to create primary surplus and limit public debt ratios. As several authors pointed out, in the eurozone crisis this strategy left very limited scope for countercyclical fiscal support. A standstill on debt payment lowers primary surplus needs and creates space for fiscal intervention.

Reinhart et al. (2003) attribute the inability of debt intolerant countries to stay within safe debt levels to, among other reasons, the pro-cyclical nature of capital markets that lend in boom times only to retrench when there is a shock. The standstill is an automatic stabiliser: if inflows stop so does the outflow for debt payments.

Privatisation of state-owned-enterprises is also used by countries in crisis to raise funds to reduce debt levels. Fire sales generate less income than the worth of the divested assets and may have a detrimental effect on macro-financial stability. The standstill provided by S-CoCo buys time for the sovereign's privatisation plans, and avoiding fire sales is one of the arguments of Flannery (2014) in favor of B-CoCo.

Speedy response to crises. Flannery (2014) emphasizes that contingent capital bonds replace supervisory discretion with rules for maintaining bank stability. This could avoid problems of “regulatory forbearance” that, for many reasons, play a significant role in banking crises. The equivalent malaise in sovereign crises is the “pathological procrastination” (Buchheit, 2011) exhibited both by the sovereigns in trouble and the international organizations that come to the rescue, see, e.g., Rhodes and Stelter (August 2011). S-CoCo force creditors and debtor to act as soon an objective criterion is satisfied.

Improve financial stability. This was one of the major motivations for Weber et al. (2011) in making their proposal. Both they and Mody (2013) discuss this attractive property of contingent debt. They each give different reasons and we do not repeat them here.

2.2 Brief comparison with other proposals

Other proposals have been made for sovereign debt instruments to achieve some (combination) of the above goals. Most notable are the suggestions for GDP-linked bonds (Borensztein and Mauro, 2004; Hatchondo and Martinez, 2012; Kamstra and Shiller, 2009) or inflation indexed bonds (Mercurio, 2005), and, more recently and less discussed, for puttable bonds (Bögli and Fattinger, 2015; Neftei and Santos, 2003).

These proposals are quite distinct from ours in the nature of instruments they suggest. We do not discuss in detail how they meet the goals of sovereign contingent debt, but briefly highlight the differences with S-CoCo.

The fundamental distinction with GDP-linked bonds or inflation indexed bonds is that these instruments are equity-like and investors buy a stake in the country's economy. S-CoCo is debt and only under conditions of sovereign stress the buyer has a stake in the country's economy, and even then the risks are well defined and limited. There are also concerns that the index (GDP growth or inflation) is known with delays, about pricing models using both financial (interest rates and spreads) and economic (GDP, inflation) random variables, and about manipulation of the index by the sovereign.

Puttable bonds allow investors to return the bond to the sovereign at a predetermined strike price, thereby reducing investor risk and lowering sovereign borrowing interest. However, when (if) a crisis develops the sovereign is not in a position to honor the put option which must be guaranteed by an intergovernmental organization, such as the European Stability Mechanism. Hence, risks are transferred (for a price, of course) from the sovereign and its creditors to an intergovernmental agency. S-CoCo aims at risk sharing between creditors and the sovereign.

Emphasizing the differences of these proposals from ours, and highlighting some of the problems, is not to claim that they fail to achieve some of the goals required of contingent debt. Their merits are articulated in the literature that suggested them.

3 Sovereign contingent debt designs

We now go into the details of the design, obtaining guidance from the B-CoCo literature and Barkbu et al. (2012); Brooke et al. (2013).

3.1 Which trigger(s)

An appropriate trigger must be accurate, timely, and comprehensive in its valuation of the issuing entity, Calomiris and Kahn (1991). It should be defined so that it can be implemented in a predictable way. Barkbu et al. (2012) suggest debt-to-GDP ratio as trigger for sovereign contingent debt and Brooke et al. (2013) left open the choice of trigger. Mody (2014) suggested payment deferral when “the 100-day average risk premium on [the debtor's debt] (the excess interest rate above US treasuries or German bunds) rises above a pre-agreed threshold”.

Market data indicating a sovereign's probability of default are CDS spreads. CDS spreads are timely and comprehensive as they aggregate the views of multiple market participants, and incorporate information about a sovereign's contingent liabilities. For instance, debt-to-GDP ratio of Cyprus at the start of the crisis was 71% which, by itself, is not alarming. This single number ignored the implied guarantees for a banking sector with assets 700% the country's GDP, and the fact that debt was short-term and therefore fragile. CDS spreads were increasing rapidly (Figure 2).

Eurozone data illustrate how a CDS spread trigger would have provided early responses to the crises, see Figure 2 with illustrative threshold 400bp. This threshold corresponds to probability of default about 5%¹, therefore default risks at the 5% confidence level are not

¹Calculated from Deutsche Bank Research data with 60% recovery rate, see <http://www.dbresearch>.

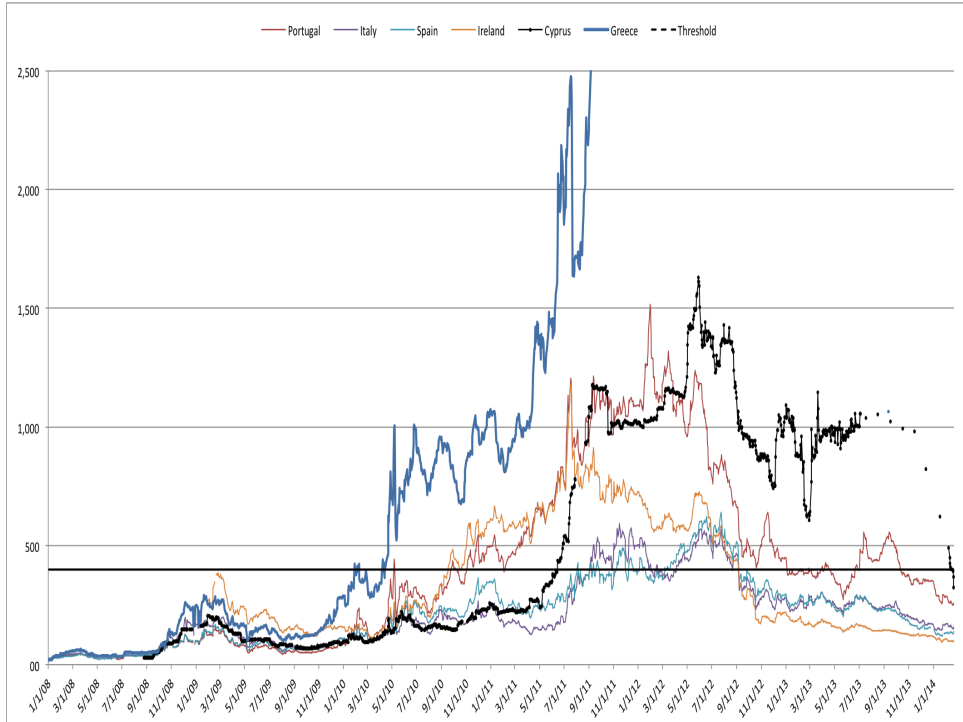


Figure 2: The 5-year CDS spread on eurozone crisis countries and the trigger threshold.

Country	Triggered standstill	Program signed	Early response
Greece	24 April 2010	5 Sept. 2010	4 months
Portugal	16 Nov. 2010	20 May 2011	6 months
Ireland	1 Oct. 2010	16 Dec. 2010	2,5 months
Spain	27 March 2012	Dec. 2012	9 months
Cyprus	11 July 2011	15 May 2013	21 months

Table 1: Date of example S-CoCo trigger for eurozone crisis countries and of signing an agreement with the IMF (ESM for Spain).

neglected. We use a 30-day moving average as the trigger. Table 1 shows the timing of a standstill together with the time of signing an international assistance program. We observe that for Greece, Portugal and Spain almost half year passed from an S-CoCo warning to the signing of an agreement. With S-CoCo the response would have been swift. Greece would have received relief through payment standstill in spring 2010 and not with the PSI haircut at the end of 2011, that was “too little and too late” according to IMF. Cyprus was an extreme case of government procrastination for 21 months that created a “perfect crisis” and resulted in depositor bail-in (Zenios, 2015). Only Ireland was decisive in dealing with its troubles within 2.5 months.

We do not favor triggers based on accounting data or institution based triggers such as sovereign debt ratings. Such measures are either not timely or not comprehensive (or both).

A significant issue needs to be addressed in choosing a trigger. As Bond et al. (2010) point out, the markets eventually will price the action taken based on the trigger, and the market based trigger will not be informative. For as long there are simple (non-contingent) bonds for a

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sovereign and CDS on these bonds, there is no feedback from the action (i.e., payment standstill) and the value of the CDS spread trigger. If, however, S-CoCo are widely accepted and become the only (or predominant) instrument for sovereign financing then CDS spreads on S-CoCo could become less informative as a trigger: they will encompass both the fundamentals of the sovereign and the effect of the action to be taken. We elaborate on this point in Section 5.3.

There are several solutions to this eventuality. Sovereigns could be required to issue sufficient volume of simple debt to act as an indicator. (Regulators require banks to issue subordinated debt to provide an alternative indicator of a bank’s health in addition to stock prices.) Or, following Bond et al. (2010), we could introduce triggers based on the prices of multiple traded securities, bringing more transparency of the sovereign’s information in triggering a standstill, or introduce a security that pays off in the event that the sovereign takes a corrective action (a prediction market). Of course the models would need to be calibrated on the new data and concerns about liquidity of the prediction market will arise.

Prescott (2012) comments that a prediction security does not exist for B-CoCo triggers, but he points out that “credit default swaps are very close in that they are essentially insurance contracts that pay out in the event of a default. If a credit default swap was designed so that conversion was the triggering default event, then the swap could be used as the prediction security”. In the case of sovereign debt, CDS do exist and the introduction of CDS for S-CoCo will provide both a hedging instrument for investors in S-CoCo and a prediction security.

We also comment on the potential choice of a market index to activate a trigger, thus accounting for systematic risk. We explained already that although McDonald (2013) advocates this for banks, and we subscribe to his arguments, we do not find that they apply to sovereigns. However, should a dual trigger be considered necessary this could be an indicator that measures overall investor sentiment with increased risk aversion and reduced liquidity. Such a systemic market index is the CBOE volatility index VIX, or, for eurozone countries, the CDS spreads on the German bunds, or, for emerging markets, the EMBI index. If the sovereign CDS threshold is breached during a systemic crisis measured by a market index, then the standstill could be triggered, but for idiosyncratic crises there would be no payment standstill and the sovereign will be cut off the market.

3.1.1 A simple example

A simple example illustrates the difference between S-CoCo and plain bonds. Plain bonds are subject to rare extreme losses due to default. S-CoCo have higher probabilities for smaller losses from a standstill.

To simulate CDS spread dynamics we fit to the log-returns of the spread an Orstein-Uhlenbeck process with jumps, as extended by O’Donoghue et al. (2014) to account for long-term mean reversion. The model ensures that spreads and their variance are bounded, non-negative, and exhibit the empirically-observed properties of stationarity and autocorrelations. The same model is used for plain bond returns (although jumps are virtually non-existent in the calibration). The model is calibrated on Greece CDS spreads for the period 17 Dec. 2007 to 28 Feb. 2012. Bai-Perron regime switching identification is used to calibrate the model for different regimes during the crisis. In our simulations we use the tranquil regime up to April 2010. Details of the calibration and S-CoCo pricing simulations are given in Consiglio et al. (2016).

For the plain bond we assume that spreads of 500bp signal default with nominal value haircut 50%. (This is roughly what happened with Greek bonds between spring 2010 and end of 2011.) For S-CoCo there is a 3-year standstill when spreads reach 200bp but without risk of nominal value haircuts. (The risk of default is not eliminated but the probability is reduced, and we elaborate on this point in Section 5.3). The plain bond is priced at par for a coupon rate 6.5% on our simulated data. S-CoCo with the same coupon is priced at 25% discount. We measure losses as deviations of the present value of cashflows under each scenario from the expected present value. Figure 3 compares the distribution of losses for the plain bond and the

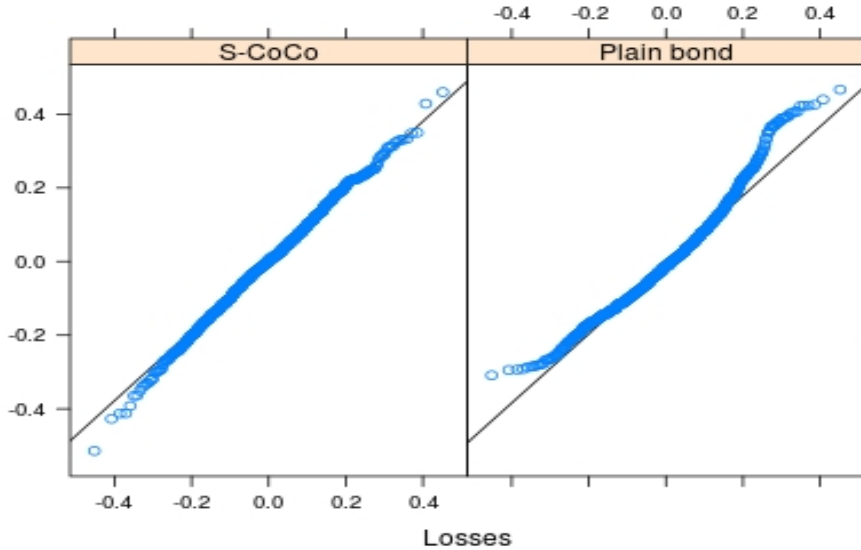


Figure 3: S-CoCo losses have lower tail risk than plain bonds.

S-CoCo against the normal distribution. We observe that the S-CoCo has significantly reduced tail risk but higher average (expected) losses, as evidenced from the price discount.

3.2 Incentives

The incentives from B-CoCo on bank management are discussed by Himmelberg and Tsyplakov (2014) where they explain a very intuitive behavior: if conversion terms are dilutive for existing shareholders, banks have incentive to reduce the likelihood of triggering, leading to less defaults and lower borrowing costs. Conversely, if at conversion bond principal is written down without diluting shareholders, then banks have perverse incentives to pursue higher leverage and destroy capital. Similarly, Calomiris and Herring (2013) argue that B-CoCo is a poison pill for the bank management that triggers it, as both diluted shareholders and converted B-CoCo owners hold bank management responsible.

What are the incentives on a sovereign? Payment standstill is helpful—more money is left to finance government programs—and the sovereign may like to see it triggered. However, the design of S-CoCo creates both financial and political disincentives.

Let us understand first the financial disincentives. We use the S-CoCo pricing model to price S-CoCo with 3-year standstill triggered at different thresholds. We observe in Figure 4 a nonlinear increase of S-CoCo discounts—implying increased coupon rates for par pricing—over plain bonds as the threshold decreases. The nonlinear increase is explained from the bell-shaped distribution of (30-day averaged) CDS spreads, since the number of scenarios exceeding a threshold increases nonlinearly with lower thresholds. The heavy tail further increases convexity. Since S-CoCo with a triggered standstill are senior to subsequently issued debt (design feature *iv*) the increase in S-CoCo rates is transmitted to new plain bonds. This is a disincentive to provoking a standstill. A sovereign that needs market access to finance its debt—or to pay salaries and pensions—can not trigger the standstill with impunity. The market expects a discount for the risk of a potential standstill and as the threshold is approached the discount increases nonlinearly with a commensurate increase of borrowing costs for the sovereign.

What about a sovereign running primary surplus? There is extensive literature explaining why sovereigns pay even if they have immunity, the main argument hinging on reputation risks from a default. While we subscribe to this argument, it does not necessarily apply to the case

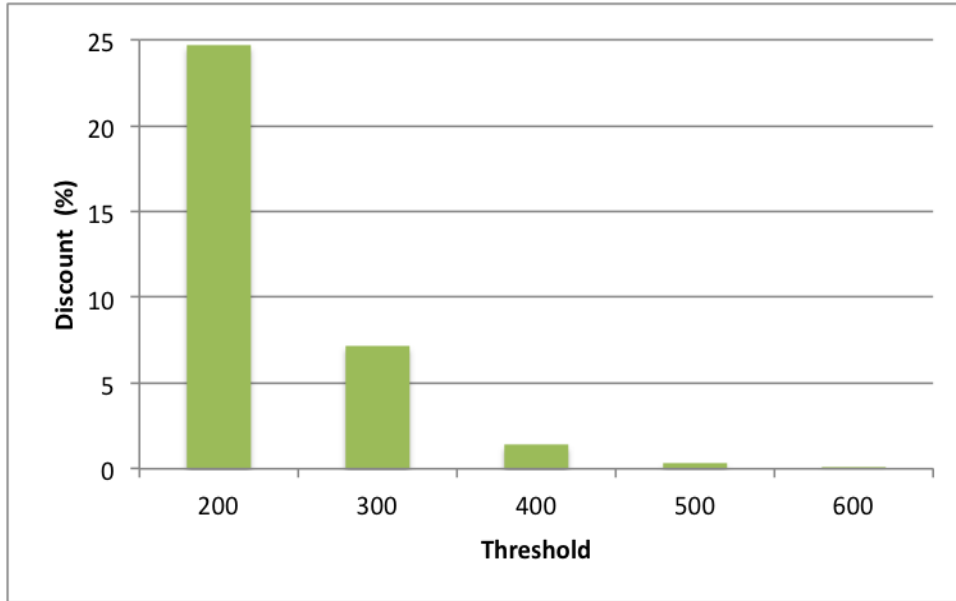


Figure 4: Discounts on S-CoCo increase non-linearly as the threshold is approached. (Illustrated here for 3-year payment standstill when the threshold is breached.)

when a sovereign activates a contractually prescribed standstill. This is why design feature (ii) stipulates a precautionary credit line from the IMF with its associated conditionality when a standstill is activated. This deters sovereigns from triggering a standstill. One could think of other pre-designed conditionality, such as ear-marking tax revenues for resuming payments, or, for eurozone countries, budget approval by the Commission during a standstill. These are unattractive options, and a government that brings public finances to the point of activating a trigger dilutes its political capital, even as it may reap economic benefits from a standstill. The government runs a risk of being voted out in a way similar to financial institutions ousting the Board if B-CoCo is activated (Flannery, 2014). Borensztein and Panizza (2008) report that, on average, governments in defaulting countries observed 16% decrease in electoral support, and of the 19 countries for which they have data the ruling coalitions lost votes in 18 cases.

3.3 How long standstill

There are essentially two ways to set the standstill (design feature *i*): either for a pre-specified fixed period $\Delta\tau$, or for as long the threshold is breached.

In the previous section we illustrated with a 3-year standstill, chosen as the typical duration of IMF programs. Longer standstills increase the discount of the CoCo (Figure 5). Choosing a very long standstill is akin to overpaying for insurance, as the sovereign offers debt at a discount for the option of a potential standstill that may be too long for its needs. There are many variations of the fixed standstill —such as extending principal maturity, single standstill for the first trigger event etc— but we do not discuss all the alternatives. Suffice it to say that they can be priced with a model such as that of Consiglio et al. (2016).

An alternative approach is to have payment standstill for as long the trigger exceeds the threshold. This makes $\Delta\tau$ a random variable. This standstill is more effective in forestalling crises but it may be less attractive for buyers. Even with random $\Delta\tau$ the simulation pricing model applies with marginal increase in computational complexity, and Figure 6 illustrates. With the stochastic process calibrated for the tranquil regime we observe that S-CoCo with stochastic standstill is priced close to the 1-year fixed standstill instrument.

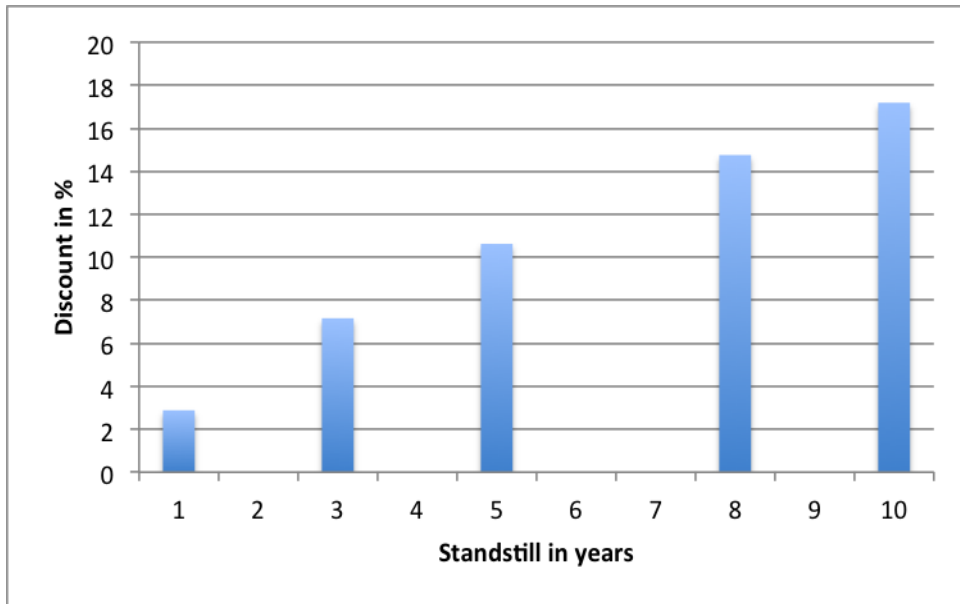


Figure 5: Discounts on S-CoCo increase for longer standstills. (Illustrative threshold 300bp.)

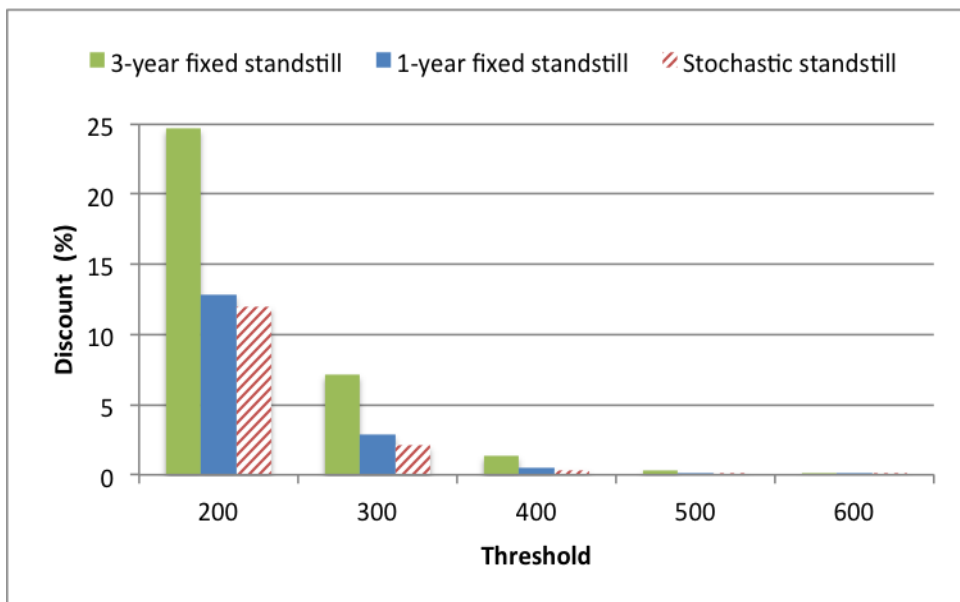


Figure 6: Discounts on S-CoCo when the payment standstill is effective for as long the trigger value exceeds the threshold.

3.4 Market manipulations and multiple equilibria

The existence of multiple equilibria —and the related problem of market manipulation— has been a major criticism of B-CoCo. Although there is no empirical evidence, the arguments of Sundaresan and Wang (2015) are compelling. Several authors responded to the challenge posed by Sundaresan–Wang, see Avdjjeiv et al. (2015); Calomiris and Herring (2013); McDonald (2013); Prescott (2012).

S-CoCo are different from B-CoCo in a fundamental way that avoids multiple equilibria problems. In B-CoCo multiple equilibria arise because the conversion creates equity, and the dilution of equity changes the price of equity that triggered the conversion in the first place. Unless the conversion ratio is carefully calibrated this feedback mechanism gives rise to multiple equilibria or, even worse, no equilibrium at all. In the case of S-CoCo the price of one type of instrument (CDS spreads) is used to trigger the event but the event is not a conversion to CDS but a change of payment schedule.

Market manipulation remains a real possibility. We have already seen that the sovereign’s incentives are not aligned towards manipulation. Investors, on the other hand, may prefer that the standstill is triggered if short-term interest rates shift downwards, but that’s when the sovereign would prefer to retire current debt and refinance its needs at the lower rates. A well known case of sovereign market manipulation was registered in December 1994, when hedge funds tried to trigger a knock-out of a barrier option on Venezuelan Brady bonds. Merrill Lynch, that had sold the option, used its financial muscle to keep prices below the threshold and on a single day (Dec. 9) some \$1.5bn worth of the almost \$7bn market were traded. We suggest a trigger averaged over a long period (30 days) to make market manipulation difficult.

3.5 False alarms and missed crises

Can S-CoCo fail? Of course they can, and McDonald (2013) suggests that the language of statistical hypothesis testing provides the terminology for discussing failures. The case when a standstill is triggered when the sovereign does not need it is a type I error, i.e., a false positive. If S-CoCo fails to trigger when the sovereign needs it we have type II error, i.e., a false negative. In the context of bank contingent capital, McDonald (2013) argues that type II errors are much more serious than type I errors, and the same is true with S-CoCo.

Type I error. If a standstill is triggered when the sovereign can still properly service its debt, the situation can be easily reversed by resuming timely payments. Transaction costs are minimal in this case, as opposed to B-CoCo type I errors when the bank has to buy back the newly issued shares.

Type II error. In this type of error the S-CoCo fails to do its job. The sovereign does not benefit from the standstill and suffers the consequences of a prolonged crisis. Even worse, the sovereign paid a price for issuing S-CoCo but does not benefit from risk sharing with its creditors.

What could cause a type II error? The fact that the standstill is effective only after the sovereign enters a program with the IMF introduces political and legal risks in the process. Four of the five countries reported in Table 1 reached an agreement with the IMF within a month of starting negotiations and hence type II error would have been avoided. However, Cyprus did not sign an agreement for more than 8 months and the country would have suffered type II error. Agreeing on the terms of precautionary credit line before issuing S-CoCo eliminates Type II error.

The S-CoCo could also fail if the threshold is too high. Given that type I errors are less costly and easily corrected, the threshold would rather be on the low side. In the

eurozone crisis all countries (except Cyprus) applied for assistance at CDS spreads circa 600bp. Thresholds of 300–400bp, used for illustration, avoid type II errors.

It is also possible to have a failure of the trigger mechanism. For instance, in Figure 2 we observe a big drop of Cyprus spreads in Oct.-Nov. 2011 as a result of a bi-lateral loan from Russia that eased the pressure on the sovereign without addressing the underlying imbalances. If Cyprus had negotiated this loan around May 2011 it would have kept its CDS spread below the threshold and avoid triggering the S-CoCo. This is fine if the country uses the bi-lateral loan to address imbalances, but in this case the government was “gambling for redemption” and the S-CoCo conversion would have been simply delayed.

Hence, unlike B-CoCo, type II errors depend on government action or, more precisely, inaction. S-CoCo can not protect a sovereign from itself.

4 A risk management model with sovereign contingent debt

We develop now a risk management model to incorporate S-CoCo in sovereign debt. The objective is to optimize the term structure of instruments used to finance debt over a long horizon and study debt financing with S-CoCo. The model determines a portfolio of debt instruments by maturity, with or without contingent standstill provisions. Portfolio choices are evaluated for their expected cost and a risk measure of the cost distribution. Cheaper debt financing is possible —usually with short term borrowing or with plain bonds— but with higher risk. The model traces a frontier that trades off expected cost with tail risk for the sovereign. This is the *risk profile* for a given debt structure and a set of debt instruments, and we use it as “proof of concept” of the gains from contingent debt on sovereign financing.

The model extends earlier work by Consiglio and Zenios (2015b) to include S-CoCo. In the previous paper we use the model to reschedule or restructure debt so that it becomes sustainable. In this paper we model the risk profiles of portfolios of S-CoCo and show that S-CoCo financing improves the risk profiles. The improvements are anticipated from optimization theory, as the model with S-CoCo has larger feasible region than the model with plain debt instruments, and hence the solutions are at least as good. The significance of the model is that it allows us to quantify improvements with alternative S-CoCo designs.

The model is a discrete state-space, discrete time-space multi-period stochastic program, see, e.g., (Zenios, 2007, chap. 5). Decisions are made *here-and-now* based on all available information and anticipating future uncertain information. As new information arrives we have *recourse* decisions that are conditioned on the received information and the outcome of previous decisions. Stochastic programming finds numerous applications in asset/liability management, see the edited handbook by Zenios and Ziemba (2007) and extensive bibliography therein.

4.1 The scenario setting

We use a discrete set of time-stages when decisions are made $\mathcal{T} = \{0, 1, 2, \dots, T\}$. We denote by $t \in \mathcal{T}$ the time index, where $t = 0$ indicates here-and-now and T is the risk horizon. At each time instance t , economic and financial parameter dynamics follow some stochastic processes, possibly correlated, on a scenario tree, such as the one of Figure 7. Parameters take values from a finite set indexed by the set of *nodes* \mathcal{N}_t , where each node $n \in \mathcal{N}_t$ represents possible states of the economy at time t . Not all nodes at t can be reached from every node at $t - 1$ and we define *paths* from *root node* 0 to final nodes in \mathcal{N}_T to denote the unique way of reaching each terminal node. Each path is a *scenario*. Our example tree has 12 scenarios, two possible states at $t = 1$, three at $t = 2$ and six at t . We denote by $\mathcal{P}(n)$ the set of nodes on the unique path from the root node to $n \in \mathcal{N}_t$, and by $p(n)$ the unique predecessor node for n , with $p(0)$ being empty. For a given node n all information on the path $\mathcal{P}(n)$ is known.

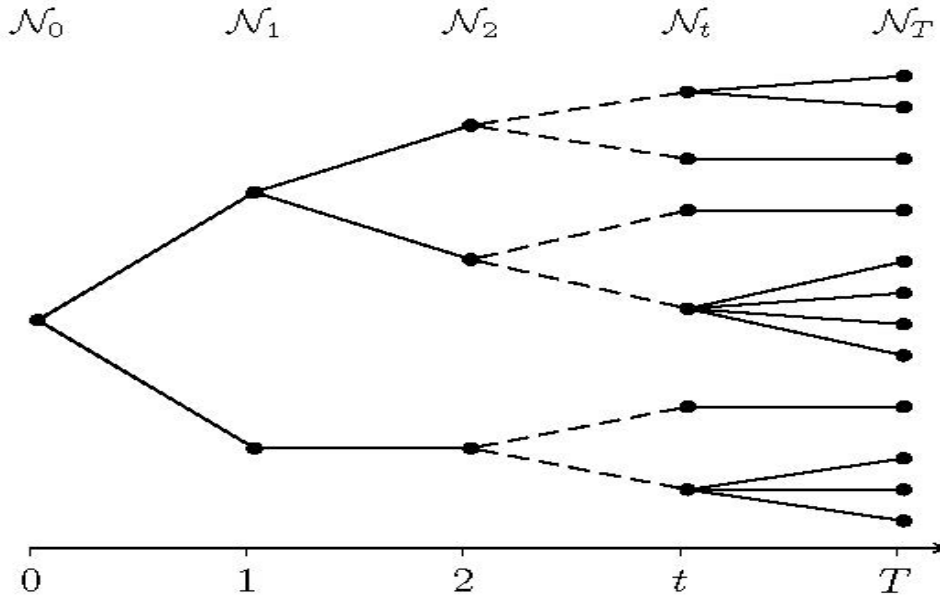


Figure 7: A scenario tree.

The example scenario tree is asymmetric and non-recombining. This is done for generality —symmetric recombining trees are a special case— but also to capture salient aspects of our problem. For instance, to the best of our knowledge, there is no methodology to calibrate recombining trees for multiple correlated risk factors such as those facing a sovereign. Asymmetry emerges, for example, when a country enters an IMF adjustment program and receives concessionary financing during the adjustment program, or when a threshold is breached and there is a fixed scenario of no payments for the duration of the standstill.

The stochastic process of the term structure of interest rates is generated using the simulator of Bernaschi et al. (2007) developed for public debt management of the Italian treasury. ECB interventions are modeled as a Poisson process, a Markov process models the direction of the intervention, and principal component analysis simulates the evolution of the term structure of interest rates in response to ECB interventions, with long term reversion to the mean. The CDS spread simulations were discussed above. For GDP and primary surplus we use IMF projections used also in Consiglio and Zenios (2015b).

4.2 Tradeoffs: expected cost of debt and tail of debt distribution

Before we give the dynamics of debt on the scenario tree we calculate the cost of debt financing decisions at the risk horizon. Denote by C^n the total amount due at each end node $n \in \mathcal{N}_T$. This variable adds up maturing debt, payments due to borrowing at nodes on the path leading to n , and the market price of any outstanding debt and its dynamic equations will be given later. Let G^n denote GDP and consider the debt-to-GDP ratio $c^n = C^n/G^n$, which is a key indicator for debt sustainability (Sturzenegger and Zettelmeyer, 2006, pp. 308–313). c^n is a random variable whose distribution depends on debt financing decisions, on the term structure of debt, on the economic and financial random variables, and on any payment standstills. It is the risk of this distribution we wish to optimize.

Its mean value is given by

$$\mathbb{E}[c] = \sum_{n \in \mathcal{N}_T} \pi^n c^n, \quad (1)$$

where π^n are the probabilities of terminal states. This is the expected debt-to-GDP ratio

accounting for the cost of debt financing. It is more informative than the nominal value of debt ratios since it takes into account the term structure of debt maturities and the term structure of interest rates in financing debt. In the context of standard debt sustainability analysis this would be the future value of debt-to-GDP ratio under some projection of growth and debt financing rates. However, in our case, instead of using one projection we employ a range of plausible scenarios with their associated probabilities and calculate the expectation.

To assess the risk of deviations from the mean we need a risk measure. We define the *stress debt* for each terminal state as the non-negative difference of state-dependent debt-to-GDP ratio from the mean

$$sd^n = \max[0, c^n - \mathbb{E}[c]]. \quad (2)$$

Stress debt signals that debt-to-GDP ratio deviates from a (presumably sustainable) mean. Following the seminal work of Artzner et al. (1999), we use a coherent risk measure on stress debt, which we call *Conditional Debt-at-Risk* (CDeaR). This is the expected value of stress debt, conditioned on stress debt exceeding its Value-at-Risk at a given confidence level α , which we call Debt-at-Risk (DeaR). CDeaR is the well known conditional Value-at-Risk (CVaR) of the finance literature or the expected shortfall (ES) of the insurance literature. It is also known to provide a bound on the Value-at-Risk used by bank regulators.

4.3 Model parameters, variables and dynamics

We formulate now the model. First we define parameters and variables, and then give the debt dynamic equations. Without ambiguity we drop the time index since each node n takes values from a time-indexed set \mathcal{N}_t . We introduce index $j = 1, 2, \dots, J$, to denote debt instruments of different maturities.

The model parameters are the following:

D^n Legacy debt stock to be financed.

$CF^j(n, m)$ Cash flows at node n for bond with maturity j issued at some node m on the path leading to $n, P(n)$. The timing of cashflows from S-CoCo is contingent on the trigger.

$P^j(n, m)$ State-dependent value of outstanding debt at node n for debt with maturity j issued at node m on path $P(n)$. $P^j(n, n)$ is the price at the state when a bond is issued.

O^n Payments due at each node n based on borrowing at nodes on path $P(n)$.

The model variables determine the maturity of instrument to be used at each state to finance the debt. The variables are given for all $n \in \mathcal{N}$ by:

x^n Vector of debt financing decisions at each node n . x^0 is the *here-and-now* decision and x^n are future decisions conditioned on the state of the economy $n \in \mathcal{N}_t$ at time period t . Recalling that we may drop the time index the decision vector at each node is given by $x^n = (x^{n1}, x^{n2}, \dots, x^{nj}, \dots, x^{nJ})$. x^{nj} denote nominal amount borrowed at the n th node with maturity j . It can be borrowing using simple bonds or S-CoCo. (To develop a model that includes both types of instruments we need two vectors of decision variables $x_{No-CoCo}^n$ and x_{CoCo}^n but we do not give this model as it complicates notation.)

To model standstills we introduce a stochastic triggering parameter δ , with value δ^n on node n , and associated binary variable z^n to activate the standstill. In particular, payments to S-CoCo holders are due according to schedule if the threshold is not exceeded, otherwise payments are delayed for the standstill period. The following integer programming construct models triggering the standstill for each node n when the indicator exceeds the threshold:

δ^n is the difference of the indicator value from the threshold.

For CDS indicator we have $\delta^n = s^n - \bar{s}$ where s^n is the sovereign spread of CDS and \bar{s} is the threshold. If indebtedness is the indicator we set $\delta^n = d^n - \bar{d}$ where d^n is debt-to-GDP ratio and \bar{d} is a threshold.

z^n is a binary variable.

It is easy to verify that the system of inequalities below sets $z^n = 0$ if the indicator exceeds the threshold, and $z^n = 1$ otherwise:

$$\delta^n \geq -Mz^n \quad (3)$$

$$\delta^n \leq M(1 - z^n). \quad (4)$$

Now we express debt dynamics in terms of model parameters and variables. At each node $n \in \mathcal{N}_t$ the amount of new debt is given by the total payments to each instrument —principal and/or coupon— that was issued at some node on path $P(n)$ times the total amount issued, and summed up over all instruments and all nodes on the path

$$O^n = \sum_{m \in P(n)} \sum_{j=1}^J x^{mj} \text{CF}^j(n, m). \quad (5)$$

The total debt to be raised at each node $n \in \mathcal{N}$ has to finance legacy debt plus any debt obligations created from previous financing decisions. The binary variable is used to trigger the standstill, and we have

$$\sum_{j=i}^J x^{nj} P^j(n, n) = D^n z^n - \sum_{m \in p(n)} D^m (1 - z^m) + O^n.$$

At each node $n \in \mathcal{N}_T$ at the risk horizon, we have the cost of financing decisions

$$C^n = D^n + \sum_{m \in p(n)} D^m (1 - z^m) + O^n + \sum_{m \in P(n)} \sum_{j=1}^J x^{mj} P^j(n, m),$$

or, scaled by GDP, as $c^n = C^n/G^n$. The four terms summed up are the debt that matures at the risk horizon, plus debt whose maturity was extended from a previous node on the path due to standstill, plus obligations created from previous financing decisions, plus the market value of debt instruments that mature past the risk horizon. The cost is now endogenous to the model. Its expected value is given by linear eqn. (1). The risk measure CDeaR can be modeled following Rockafellar and Uryasev (2000) by the system of equation and inequalities

$$\text{CDeaR} = \zeta + \frac{1}{1 - \alpha} \sum_{n \in \mathcal{N}_T} \pi^n y_+^n, \quad (6)$$

$$y_+^n \geq sd^n - \zeta, \quad (7)$$

$$y_+^n \geq 0, \quad (8)$$

where y_+^n is a dummy variable denoting the non-negative values of debt in excess of ζ . ζ is the Value-at-Risk of debt (DeaR), i.e., the lowest possible value so that the probability of excess debt not exceeding DeaR is $(1 - \alpha)$.

We now have all the components and the full model is given in the Appendix.

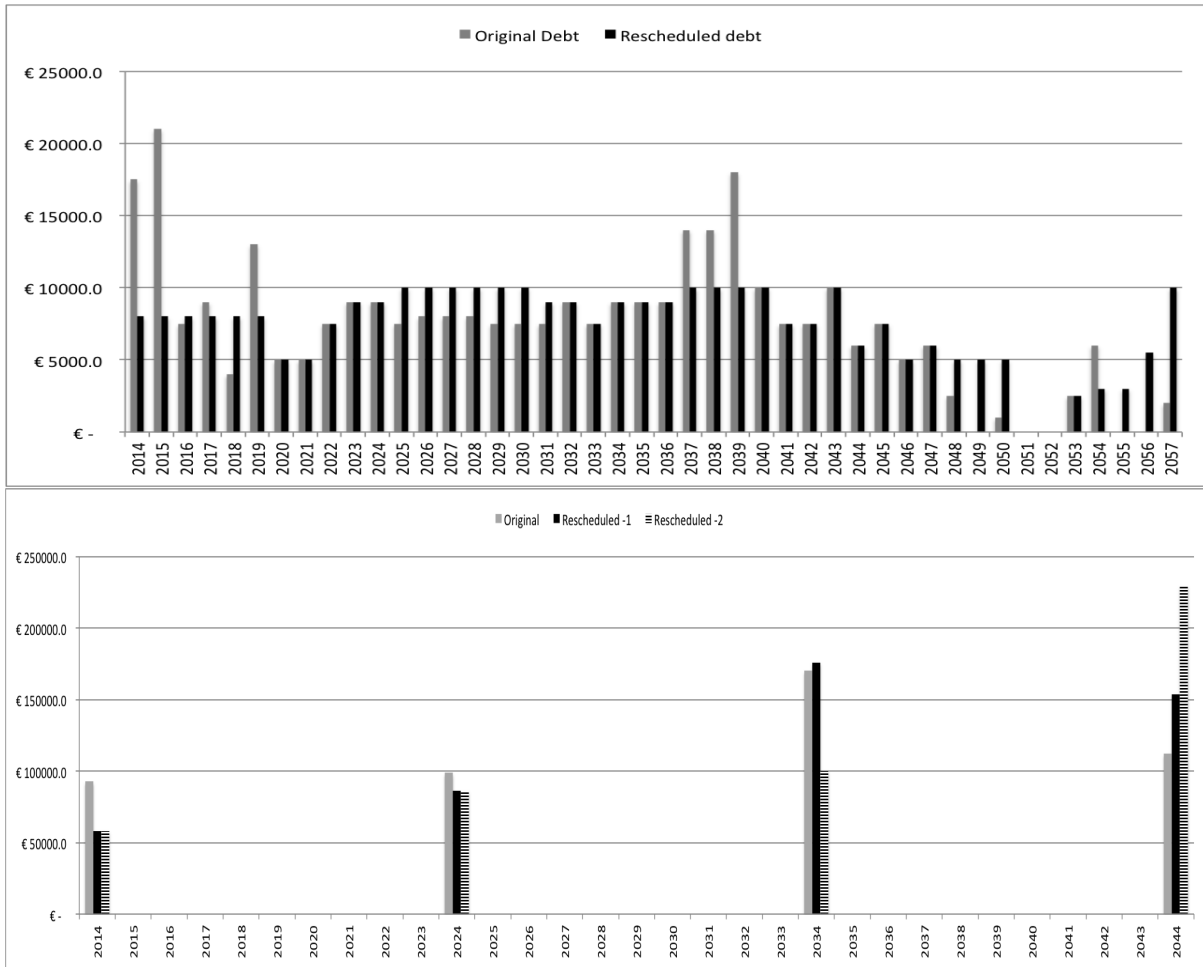


Figure 8: Greece debt profile and 4-stage discretization with two hypothetical reschedulings.

5 Case study: Greece

Greece is a good candidate for S-CoCo financing and in this section we perform two experiments using the model. We have already seen that if Greece debt was in S-CoCo the country would have received a warning four months before it signed an agreement with IMF, and would have benefited from a payment standstill about 20 months before the eventual debt restructuring with the PSI. In this section we make two points: first, how the situation could have been better if debt was in S-CoCo, and, second, how to move Greece forward using contingent debt. For a discussion of the Greek crisis see Zettelmeyer et al. (2013).

Greece was also used as a case study in Consiglio and Zenios (2015b) to identify appropriate debt rescheduling and/or nominal value haircuts that would render Greek debt sustainable, and Consiglio and Zenios (2015a) provide a critique of the IMF debt sustainability studies. We use the exact same problem setting in the present experiments. The country's debt with a 4-stage discretization and two alternative reschedulings are shown in Figure 8. From the several variants solved in Consiglio and Zenios (2015b) we use the setup for Figure 14 —reproduced here as Figure 9— where debt was financed in its current form and under the two hypothetical reschedulings. Details of the calibration are given in the reference and we emphasize that runs with and without S-CoCo were done under strictly identical data so that conclusions can be drawn about the use of contingent debt.

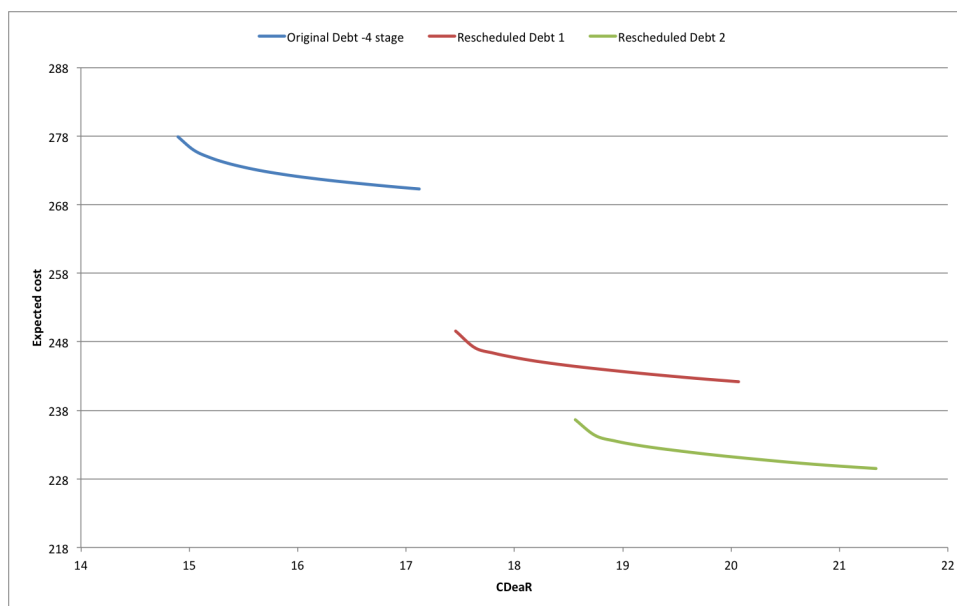


Figure 9: Risk profile for financing Greece debt in its current form and under two hypothetical reschedulings (from Consiglio and Zenios, 2015b, Figure 14).

5.1 Pre bail-out: what could have been

In the first experiment, we run the model assuming that Greece could turn the clock back and accumulate all its debt in S-CoCo while it still enjoyed low CDS spreads and borrowing rates. We run the model switching off and then on the trigger mechanism. To keep the current paper consistent with the previous work we use debt-to-GDP ratio as a proxy for the CDS trigger. In this case debt-to-GDP thresholds have to be chosen to be consistent with the pricing model. For debt-to-GDP ratio of 1 roughly the same proportion of scenarios trigger a standstill as with a CDS spread of 400bp. Hence, we use S-CoCo with discount prices 10% and 5% which correspond to thresholds of 300bp to 400bp.

In Figure 10 we plot the frontier of the expected cost of financing Greece debt against the tail risk. In the same figure we also show the frontier when using S-CoCo with zero discount, i.e., priced as a straight bond, which represents the best possible improvement using S-CoCo. Two intermediate frontiers show the improvements with price discounts 5% and 10%.

We observe improvements in all cases. Comparing the left-most points of the frontiers we note, for instance, that with 5% price discount the expected cost of debt financing decreases by about 10% (from 280bn to 260bn euro) with an increase in tail risk from 11bn to 14bn. Compare with Figure 9 to note that the risk profile with the zero-cost S-CoCo is roughly the same with the profile obtained with the extension of debt maturities analysed in Consiglio and Zenios (2015b). The country’s risk profile improves by the same order of magnitude from a standstill as could have been achieved with a rescheduling, but now the standstill is embedded in the contract.

5.2 Post debt-relief: a way forward

Our second experiment considers what happens if the latest IMF program is successful and Greece receives debt relief. We use the rescheduled debt marked “2” in Figure 8 which restores sustainability, CDS spreads decline and Greece reaccesses the market with rates similar to Italy.

How would Greece benefit from replacing its restructured debt with S-CoCo? Developing the risk profiles in Figure 11 we observe again significant improvements with properly designed

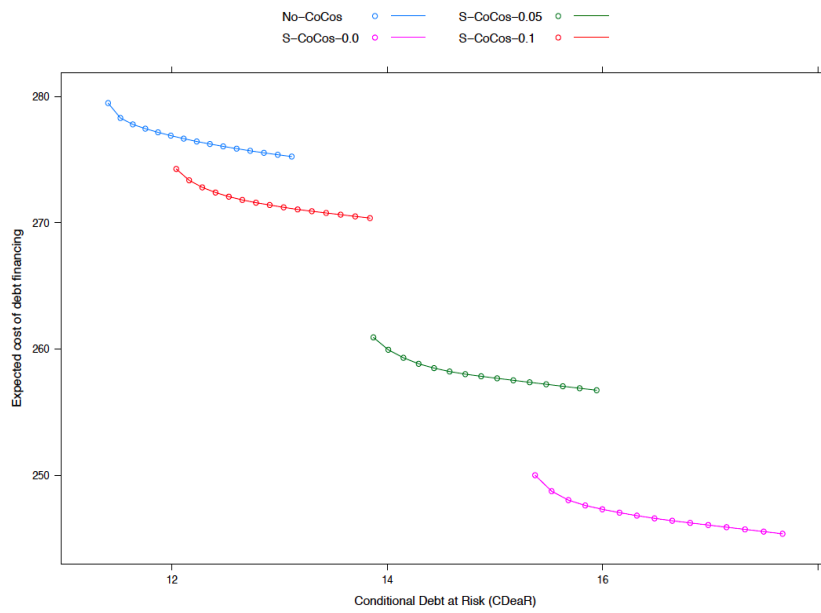


Figure 10: Risk profiles of Greece debt without and with S-CoCo at discount 0, 5, 10%.

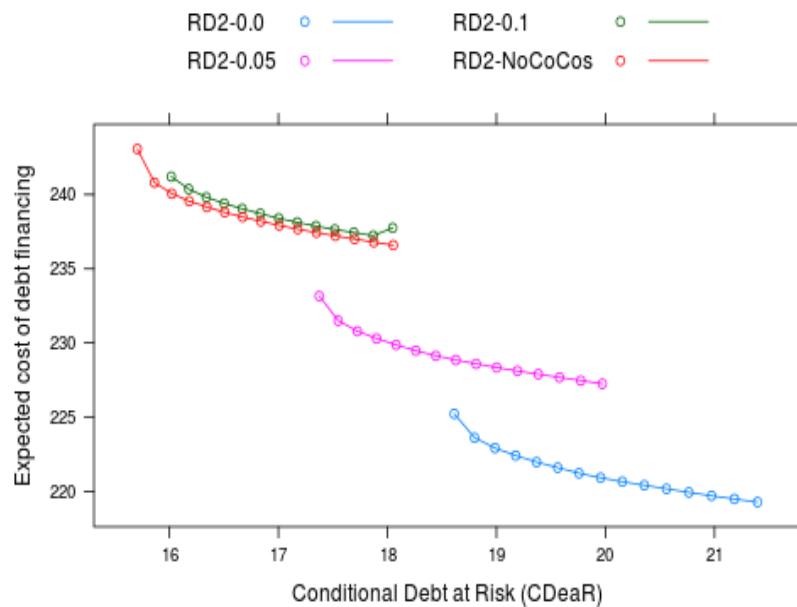


Figure 11: Risk profiles of post debt-relief Greece without and with S-CoCo at discount 0, 5, 10%.

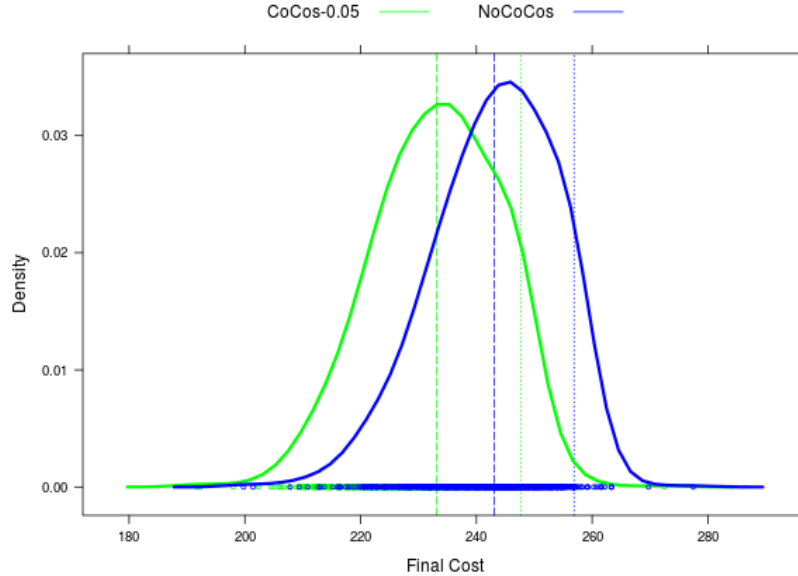


Figure 12: Distribution of debt at the risk horizon with and without the use of S-CoCo.

S-CoCo. If the S-CoCo is designed to be triggered at 400bp (5% discount) than the risk profile improves, with the expected cost of debt financing decreasing from 243bn to 233bn and an increase in tail risk from 15.5bn to 17bn. However, S-CoCo with 300bp threshold is expensive.

Another way to understand the improvements is to compare the distribution of debt at the risk horizon, when using either plain debt or S-CoCo with 5% discount. The results are shown in Figure 12 for the most expensive (left-most) points of the respective risk profiles. The distribution of debt with the use of S-CoCo has a lower mean and lower upside cost risk.

5.3 Discussion

Are the improvements Pareto efficient, in the sense that the creditor or the debtor or both are better off, but none is worse off? The risk profiles in Figures 10–11 refer to the debtor and we observe significant decrease in expected cost with marginal increases in risk. Hence, a risk neutral debtor is better off when using S-CoCo. The creditor has received a discount in exchange for the standstill, and if pricing is fair he or she is neutral. These are Pareto improvements.

However, there is an important assumption underlying the pricing (and therefore the risk management) model. That is, the S-CoCo, being presently a small percentage of the country's debt, does not materially change market data. This is a limitation of the model setup, manifested by using calibrated yield curve spreads based on observed market data from a market without S-CoCo. In the long-run S-CoCo will reduce yields and as a result (i) plain bonds would be commanding a premium, and (2) S-CoCo discount will be smaller. With these price adjustments the risk profiles using S-CoCo or plain bonds will converge, and both debtor and creditor will be indifferent between S-CoCo and plain bonds. But the reduction in yields implies that probability of default has decreased, with gains for both debtor and creditors.

Further work is needed to develop a model with endogenous spreads on the yield curve. In the absence of such a model—and market data to calibrate it—we iterate by pricing S-CoCo and plain bonds using discount rates interpolated between two extremes: (i) all debt is priced at zero spread over the risk-free yield curve assuming that default is eliminated with the issue of S-CoCo, and (ii) all debt is priced on the original spread assuming no material change on default probabilities from issuing S-CoCo. Figure 13 illustrates the S-CoCo price converging to par when the yield curve shifts downwards by approximately 80bp.

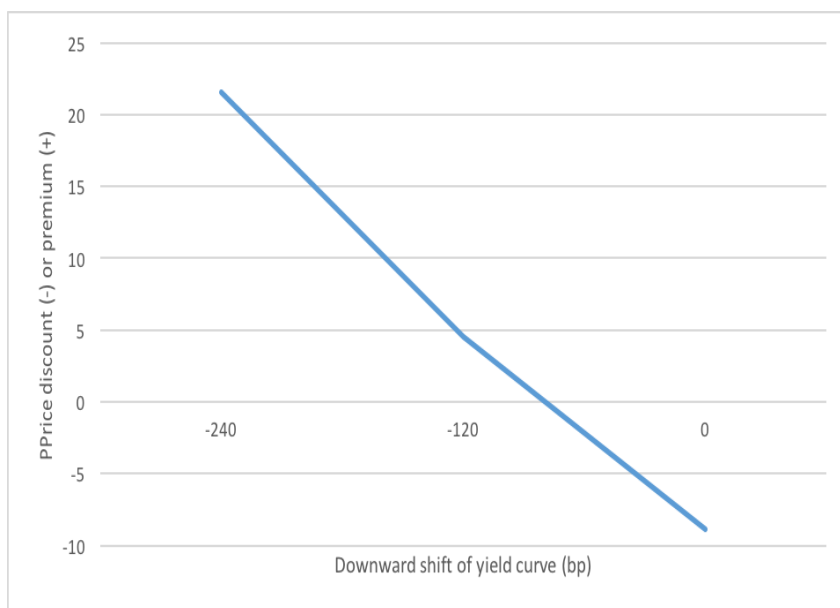


Figure 13: Convergence of S-CoCo price to par with declining yield spreads.

6 Conclusions

Contingent bonds for sovereigns with a contractually specified standstill option are a financial innovation that can forestall sovereign debt crises, or respond to one in a contractually pre-specified manner avoiding long delays and even deeper crises. The literature on contingent contracts and neglected risks justifies this innovation. The paper has specified a general design of S-CoCo and discussed the choice of triggers and standstill durations. These new instruments bring market discipline to bear on the sovereign and create the right incentives. Market manipulation, multiple equilibria and errors of false alarms or missed crises can be addressed with appropriate design choices.

We have seen how S-CoCo would have provided early warnings for eurozone periphery crises. It would have also provided debt relief for Greece much before the PSI was implemented. A risk management optimization model to incorporate S-CoCo in the portfolio of instruments used to fund a sovereign was calibrated on Greece crisis data. Two examples highlight improvements in the country's debt risk profile when using contingent debt.

The model results provide positive evidence for the use of sovereign contingent debt. To become a significant source of capital for sovereigns, however, a solid investor base is needed. Understanding their merits and developing pricing models can encourage the participation of institutional investors, asset managers, insurers and pension funds and develop the necessary market depth, volume and liquidity. The recent experiences with banking contingent debt give encouraging signs for the practical potential of sovereign contingent debt.

Future extensions of this work would develop and calibrate the models with multiple indicators to account for both systemic and idiosyncratic risks, and more drastic forms of standstills, including possible nominal value haircuts. Such extensions can easily be incorporated in the developed framework. Further work is also needed to model the effect of significant issuance of sovereign contingent debt on the sovereign's yield curve.

We emphasize that while sovereign contingent debt creates the right incentives for fiscal discipline, it can not substitute for prudent management of public finances. Vigilance is required by policy makers, professional associations and legal experts who would need to get involved, if this theoretical financial instrument is to become a practical reality.

Appendix. The complete model

We give here the portfolio model to minimize the expected cost of debt financing decisions while imposing a limit ρ on the risk measure. By varying ρ we obtain a risk profile. This model extends Consiglio and Zenios (2015b) with the introduction of binary variables to model payment standstill. The extended model is computationally more complex than the original. Nevertheless, for as long we stay with a linear risk measure, we have a mixed integer linear program that can be solved with modest computational resources using off-the-shelf optimization software.

$$\text{Minimize } \mathbb{E}[c] \tag{9}$$

s.t.

$$O^n = \sum_{m \in \mathcal{P}(n)} \sum_{j=1}^J x^{mj} \text{CF}^j(n, m), \text{ for all } n \in \mathcal{N}_t, t \in \mathcal{T} \setminus 0 \tag{10}$$

$$\sum_{j=i}^J x^{nj} P^j(n, n) = D^n z^n - \sum_{m \in \mathcal{P}(n)} D^m (1 - z^m) + O^n, \text{ for all } n \in \mathcal{N} \tag{11}$$

$$C^n = D^n + \sum_{m \in \mathcal{P}(n)} D^m (1 - z^m) + O^n + \sum_{m \in \mathcal{P}(n)} \sum_{j=1}^J x^{mj} P^j(n, m), \text{ for all } n \in \mathcal{N}_T \tag{12}$$

$$\delta^n \geq -Mz^n, \text{ for all } n \in \mathcal{N} \tag{13}$$

$$\delta^n \leq M(1 - z^n), \text{ for all } n \in \mathcal{N} \tag{14}$$

$$c^n = C^n / G^n, \text{ for all } n \in \mathcal{N}_T \tag{15}$$

$$sd^n = c^n - \mathbb{E}[c], \text{ for all } n \in \mathcal{N}_T \tag{16}$$

$$y_+^n \geq sd^n - \zeta, \text{ for all } n \in \mathcal{N}_T \tag{17}$$

$$\zeta + \frac{1}{1 - \alpha} \sum_{n \in \mathcal{N}_T} \pi^n y_+^n \leq \rho \tag{18}$$

$$x^n, O^n, c^n, y_+^n \geq 0, \text{ for all } n \in \mathcal{N}. \tag{19}$$

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