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This paper develops a model to interpret the 2012 eurozone crisis and the ECB's policy response. In the model, bank lending is distorted by debt overhang, banks hold sovereign bonds, and the government guarantees the bailout of bank creditors. A self-fulfilling pessimistic view of the economy can trigger a banking and sovereign crisis: with pessimistic economic expectations, the value of sovereign bonds declines, the bank risk of default rises, and the debt overhang distortion worsens; this leads to a contraction in bank lending and to a decline in economic activity, which confirms the initial pessimistic expectations. A commitment by the central bank to purchase the sovereign bonds at pre-crisis market spreads manages to eliminate the crisis equilibrium.

Keywords: Debt overhang, multiple equilibria, self-fulfilling expectations, financial fragility, systemic risk.

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1 Introduction

The sequence of events surrounding the 2012 eurozone crisis and the policy response of the European Central Bank (ECB) is striking. In 2011 and in the first half of 2012, credit spreads of banks and of governments of both Italy and Spain rose sharply. In response, the ECB introduced in early September 2012 the Outright Monetary Transactions (OMT) program designed to purchase sovereign bonds, under conditionality, for potentially unlimited amounts. Right after the introduction of the OMT program, credit spreads began a steady decline and returned to their pre-crisis levels, even though the OMT program was not used. There is some evidence that part of the credit spreads decline was due to the introduction of the OMT program.

The ECB viewed the eurozone crisis as driven by self-fulfilling expectations and introduced the OMT program with the aim of eliminating the crisis equilibrium and of driving the eurozone to a normal equilibrium. In the press conference following the introduction of the OMT program, the ECB President Draghi (2012) stated:

> [...] the assessment of the Governing Council is that we are in a situation now where you have large parts of the euro area in what we call a "bad equilibrium", namely an equilibrium where you may have self-fulfilling expectations that feed upon themselves and generate very adverse scenarios. So, there is a case for intervening, in a sense, to "break" these expectations, which, by the way, do not concern only the specific countries, but the euro area as a whole. And this would justify the intervention of the central bank.

The fact that the introduction of the OMT program, without any subsequent use of the facility, seems to have put an end to the crisis suggests that the reading of the ECB Governing Council—that the crisis was of the self-fulfilling expectations type—was correct. However, there is no formal model that spells out the mechanism that led to the self-fulfilling expectations crisis and that explains why the OMT program was effective.

Furthermore, at the height of the crisis, it was not clear what was the role played by economic fundamentals. The ECB itself viewed government policy as one factor behind the crisis and made the sovereign bond purchases conditional on the government participation in a program requiring fiscal adjustments and structural reforms. In the press conference following the introduction of the OMT program, with regard to government policy, the ECB President Draghi (2012) stated:

> But then, we should not forget why countries have found themselves in a bad equilibrium to start with. And this is because of policy mistakes. That is why we need both legs to fix this situation and move from a bad equilibrium to a good equilibrium. If the central bank were to intervene without any actions on the part of governments, without any conditionality, the intervention would not be effective and the Bank would lose its independence. [...] We should not forget how these countries found themselves in a bad equilibrium to begin with, namely because of incorrect policies and policy mistakes. So to this extent, the yields that are currently in the market reflect this fact. They do not reflect only unfounded fears of possible reversibility, they also reflect the quality of the outstanding credit of these countries.

In this paper, we develop a self-fulfilling expectations crisis model that is able to account for the main eurozone crisis events and for the effectiveness of the OMT program, and we compare its predictions with the ones of a model where the crisis is driven by economic fundamentals, namely lower productivity and greater fiscal imbalance. The main mechanism is based on Myers (1977) debt overhang distortion on bank lending.[1] In the model, banks have liabilities that distort their lending choices, inducing them to lend less than the optimal amount of funds, and hold risky government bonds on their asset side. The government taxes output and guarantees the bailout of the bank creditors. The tax revenue rises with output, while the cost of bailing out the bank creditors rises with the bank default rate and declines with output. The government surplus, then, rises with output, and the government bond spread declines with economic prospects. These features make the economy financially fragile—a pessimistic view of the economy can become self-fulfilling and can trigger a financial crisis: if the economy is expected to perform poorly, then the government bond spread rises, the value of government bonds declines, the bank risk of default rises, and the associated debt overhang distortion worsens; this leads to a contraction in bank lending and a decline in economic activity, which confirms the initial pessimistic view (see Figure 1).

This paper is most closely related to the growing literature that studies the debt overhang distortion in the banking sector. Wilson and Wu (2010) and Wilson (2012) study how to efficiently recapitalize banks when bank lending is distorted by debt overhang, and show that purchases of preferred stock are less efficient than purchases of common stock or bank assets.

[1] Myers (1977) describes how the existing debt of firms discourages their investment. The marginal cost of a firm's new investment is borne by the equity holders (or by junior creditors). The marginal return, however, is seized by the senior creditors in the event of default. The higher the firm's probability of default, the lower the equity-holders' expected marginal return, the smaller their incentive to invest, the lower the investment level. The investment level is sub-optimal because the equity holders do not internalize the positive effect of the new investment on the senior creditors' payoff. In the case of banks, their existing debt discourages their lending.

Philippon and Schnabl (2013) introduce a financial contagion mechanism that is similar to the one at work in this paper. When a bank's risk of default rises, the debt overhang distortion rises, and this induces the bank to contract its loans; at the aggregate level, this reduces payments to households, increases households defaults and raises the risk of default of other banks. They emphasize that this mechanism creates a negative externality, which renders the resulting equilibrium inefficient, and study how a government should optimally intervene with a recapitalization program. Bhattacharya and Nyborg (2013) also study optimal government recapitalization of banks that suffer from debt overhang problems. Banks have private information about the quality of their assets-in-place and new investment opportunities. Menus of bailout plans, made of equity injections and asset buyouts, are used as screening devices. Although they include the possibility of public benefits to bailouts in their analysis, they do not explicitly model cross-spillover effects. Occhino (2014) describes how a self-fulfilling expectations banking crisis can arise when the value of bank assets is sensitive to economic prospects and the liabilities of banks distort their lending choices. Finally, in their analysis of the objectives and tools of macroprudential regulation, Hanson, Kashyap and Stein (2013) point out that the debt overhang problem prevents banks from raising the socially-optimal amount of capital during a crisis, and leads them to shrink their assets and balance sheets excessively, which creates the need for policy intervention.[2]

In the rest of the paper, Section 2 describes the eurozone crisis events and the ECB's policy response; Section 3 introduces the model and de-

[2] In addition, there is a growing literature that explores the aggregate implications of debt overhang on business investment, and includes Lamont (1995), Philippon (2009), Occhino and Pescatori (2014, 2015), Arellano, Bai and Kehoe (2012), Gomes, Jermann and Schmid (2013), and Kobayashi and Nakajima (2014).

scribes the debt-overhang mechanism; Section 4 uses the model to interpret the eurozone crisis and to study the design and effectiveness of the OMT program; Section 5 concludes with some directions for future research.

2 The events

Our focus is on the events that took place in 2011 and 2012: the rise of credit spreads of Spanish and Italian sovereigns and banks, the ECB's policy response, and the subsequent fall of the same credit spreads. However, to understand these events, it is helpful to take a step back and review the key economic and policy developments in the eurozone since the Great Recession.

The rise of sovereign and banking risk

Economic activity in the euro area plunged during the 2008:Q1-2009:Q2 Great Recession, and recovered only partially during the subsequent 2009:Q3-2011:Q2 recovery (Figure 2). Real GDP in the euro area declined 5.7 percent during the Great Recession, and did not return to its pre-crisis level by the end of the subsequent recovery. While economic activity bounced back in Germany and France, it remained depressed in Spain and Italy. In 2011:Q3, the euro area entered another recession.

After the Great Recession, eurozone governments ran larger primary and total deficits, and the ratio of their debt to GDP rose (Figures 3, 4 and 5). Starting in the second half of 2009, yields for sovereign debt of Greece, Ireland and Portugal began to rise (Figure 6). Yields for Italy and Spain, however, remained relatively stable up to the second half of 2010 (Figure 7). Their spreads with German government bonds rose during the Great Recession, pointing to a rise in the risk of default, then declined and remained relatively stable until the beginning of 2010, when they surged again (Figure 8). In May 2010, the ECB started the Securities Markets Programme (SMP), detailed in ECB (2010), designed to purchase euro area government and private debt securities with sterilized open market operations, with the aim of addressing some financial markets malfunctioning that was hampering the monetary policy transmission mechanism. This program notwithstanding, credit spreads jumped higher in 2011, and remained elevated until mid-2012. Credit spreads remained high even after Spain obtained a 100 billion euro financial package in June 2012. The dynamics of government credit default swaps (CDS) spreads depict a similar evolution of sovereign risk (Figure 9).

Market indicators of stress of Italian and Spanish banks evolved in a way very similar to those of governments. Bank CDS spreads for the four largest Italian and Spanish banks, namely Banco Santander, UniCredit, Intesa Sanpaolo and Banco Bilbao Vizcaya Argentaria, rose during the Great Recession, then declined and remained relatively stable until the beginning of 2010; after that, they surged again, and jumped higher in the first half of 2011 (Figure 10). In December 2011, the ECB lent 489.2 billion euro for a three year term to European banks, mainly from the European periphery countries, through longer-term refinancing operations. In February 2012, the ECB lent an additional 529.5 billion euro. Credit spreads, however, remained high until mid-2012.

Comparing Figures 9 and 10, it is striking how close together the credit spreads of the four banks and of the Italian and Spanish governments moved, which suggests that banking and sovereign risk were interconnected. (see also Figures 1 and 3 of Merler and Pisani-Ferry 2012). While there were likely several reasons for this interconnection, one important mechanism through which banking and sovereign stress reinforced each other is the one highlighted by Merler and Pisani-Ferry (2012). On one hand, governments were perceived as implicitly guaranteeing the banking sector, so a rise of the financial sector risk raised the expected liability of the governments and increased sovereign risk. The size of the implicit guarantee was very large: in 2010, total bank assets in Italy amounted to 8 times Italy's tax receipts, while total bank assets in Spain amounted to 17.5 times Spain's tax receipts (Figure 4 of Merler and Pisani-Ferry 2012). On the other hand, banks were holding sovereign bonds so a rise of sovereign risk lowered the value of bank assets and increased bank risk. The bank exposure to bonds of the European periphery countries was large (Tables 2 and 3 of Angeloni and Wolff 2012). In particular, Angeloni and Wolff (2012) document that, for the set of banks that were included in the December 2011 Capital Exercise performed by the European Banking Authority, Italian banks were exposed to Italian sovereign bonds for 156 billion euro compared with a Core Tier 1 capital of only 108.4 billion euro, while Spanish banks were exposed to Italian sovereign bonds for 167.6 billion euro compared with a Core Tier 1 capital of only 132.9 billion euro. Also, French banks were exposed to bonds of the European periphery countries for a total of 66.1 billion euro compared with a Core Tier 1 capital of 211.6 billion euro, while German banks were exposed to bonds of the European periphery countries for a total of 58.5 billion euro compared with a Core Tier 1 capital of 154.9 billion euro.

The 2012 ECB's policy response

On July 26, 2012, the ECB President Draghi declared that "the ECB is ready to do whatever it takes to preserve the euro", and on August 2, 2012, he announced that the ECB "may undertake outright open market operations". Right after that, in early September 2012, the ECB introduced the Outright Monetary Transactions (OMT) program designed to purchase sovereign bonds with a maturity of between one and three years. The program was officially aimed at safeguarding an appropriate monetary policy transmission and the singleness of the monetary policy.

The main features of the program, detailed in ECB (2012), were the following:

> Coverage. No ex-ante quantitative limits were set on the size of OMT.
>
> Creditor treatment. The ECB was accepting the same (pari passu) treatment as private or other creditors.
>
> Sterilization. The liquidity created through OMT was fully sterilized.
>
> Conditionality. OMT were conditional to the country participation in an appropriate macroeconomic adjustment or precautionary European Financial Stability Facility/European Stability Mechanism (EFSF/ESM) program.
>
> Transparency. Aggregate OMT holdings and market values were published weekly, and average duration and breakdown by country were published monthly.

The main differences with the SMP were: the OMT program was introduced to safeguard an appropriate monetary policy transmission and the singleness of the monetary policy, whereas the SMP had the more limited scope of addressing some financial markets malfunctioning that was hampering the monetary policy transmission mechanism; the ECB was accepting the same (pari passu) treatment as private or other creditors; the purchases were conditional on a EFSF/ESM program; there was greater transparency.

As highlighted in the Introduction, the ECB President Draghi (2012) clarified two key points about the readings of the crisis by the Governing

Council and the motivation for the introduction and for the structure of the program. First, the Governing Council's assessment was that large parts of the euro area were in the self-fulfilling expectations "bad equilibrium" of a multiple equilibria situation—the OMT program was aimed at "breaking" these expectations and eliminating the bad equilibrium. The ECB viewed the market prices for sovereign bonds prevailing during the crisis as not fully reflecting the economic fundamentals, and was aiming at restoring the connection between market prices and economic fundamentals. Second, the ECB viewed government policy as one factor behind the crisis, and the conditionality was introduced to make governments correct their "policy mistakes", i.e. implement fiscal adjustments and structural reforms.

Right after the introduction of the OMT program, credit spreads began a steady decline (Figure 8). Mainly because of the timing of these events, there is some agreement that part of the credit spreads decline was due to the introduction of the OMT program. Some evidence is provided by Altavilla, Giannone and Lenza (2014) who use an event study methodology with daily data on bond yields and find that the announcements regarding the OMT program that were made between July and September 2012 had the effect of lowering the Italian and Spanish 2-year government bond yields by about 2 percentage points, while they left the German and French 2-year government bond yields largely unaffected. A key fact is that the OMT program was not used.

3 Model

In this section, we develop a self-fulfilling expectations crisis model that is able to account for the main eurozone crisis events, and for the design and effectiveness of the OMT program. In our interpretation, Italy and Spain were stuck in the crisis equilibrium of our model before the introduction of the OMT program, and were driven toward the normal equilibrium as a consequence of the ECB's policy action.

Two features of the banking and government sectors play a key role in our explanation of the eurozone crisis. Banks were holding large amounts of sovereign debt of their own countries. At the same time, governments were implicitly guaranteing the solvency of their banking system. Several papers have emphasized the importance of either of these two features or both in explaining the correlation between bank and sovereign risk in the eurozone crisis as well as in other financial crises.[3]

We model these two key features, and we add Myers (1977) debt overhang distortion on bank lending. The model has two periods, a continuum of representative households, a continuum of representative banks, and a government. There is no aggregate fundamental shock and no aggregate uncertainty, i.e., in each equilibrium aggregate variables are non-stochastic—however, there can be multiple equilibria and aggregate variables may differ across different equilibria.

Before describing these three sectors in detail, it is helpful to briefly outline their initial financial arrangements. Each household owns one share of each bank. In addition, households are creditors of banks—the face value of this bank debt is b, payable at the end of the second period, but banks may default on their debt. The government taxes output at the tax rate τ, collects lump-sum taxes $\bar{\tau}$ from households, and bails out the bank creditors in the case of bank default. Banks hold financial assets promising a risk-free payoff equal to $\bar{a}$, with households as their counterpart for this financial

[3]See for instance Angeloni and Wolff (2012), and Merler and Pisani-Ferry (2012), and the references therein. Also, van der Kwaak and van Wijnbergen (2014) develop a DSGE model with leverage constrained banks lending to firms and holding domestic government bonds and show that with intertwined weak banks and weak sovereigns, bank recapitalizations become much less effective.

position. Banks also hold B government bonds. Each government bond has a face value equal to one, payable at the end of the second period. The government, however, may default on its debt, so the payoff may be lower than one. Let $\varphi(Y) \leq 1$ be the actual payoff of one government bond, where Y is the aggregate output—the payoff $\varphi(Y)$ will be determined below.[4]

Banks

One key feature of the mechanism that we describe is that banks' loans are distorted by the overhang of the existing bank liabilities. To model this feature, we assume that, initially, each bank has financial liabilities (e.g. deposits and long-term bonds) with a given face value b due at the end of the second period.[5] On the asset side, each bank begins with a given amount of real funds $m \geq 0$, financial assets promising a risk-free payoff equal to $\bar{a} \geq 0$, and B bonds issued by the government promising a payoff $\varphi(Y)$. The sum of the payoff promised by the financial assets and by the government bonds, payable at the end of the second period, is

$$\pi(Y) \equiv \bar{a} + B\varphi(Y) \tag{1}$$

In the first period, each bank distributes dividends d_1 to households and grants new loans l, subject to the constraint

$$d_1 + l = m \tag{2}$$

Banks do not take any other decision.

[4]The model builds upon the one in Occhino (2014). The main difference is the addition of a government and of government bonds, and the important role played by the endogenous bailout cost and by the endogenous payoff of the government bonds.

[5]As in most of the debt-overhang literature, including the two closely related papers of Lamont (1995) and Philippon and Schnabl (2013), we examine the economic implications of a given capital structure, without explaining it.

In the second period, loans are used for production. The output produced with each individual bank's loans l is

$$y = \omega f(l) \tag{3}$$

where ω is a log-normally distributed idiosyncratic shock, and $f(l) \equiv Al^{\alpha}$ is a production function, with $A > 0$, and $\alpha \in (0, 1)$.

In equilibrium, aggregate output is

$$Y = E\{y\} = E\{\omega\}f(l) \tag{4}$$

where E is the expectation over the idiosyncratic shock ω.

Each bank receives net-of-taxes output, $(1-\tau)y$, in return of its loans.[6] It also receives the return $\pi(Y)$ on its financial assets and government bonds. If the sum of the two is less than the face value of its liabilities, $(1-\tau)y + \pi(Y) < b$, then the bank defaults, repays $(1-\tau)y + \pi(Y)$ to the creditors, and does not distribute any dividend. Otherwise, the bank repays the entire face value b to the creditors and distributes the rest, $(1-\tau)y + \pi(Y) - b$, as dividends. The debt payoff to the creditors is, then,

$$\min((1-\tau)y + \pi(Y), b)$$

and dividends are

$$\begin{aligned} d_2 &= (1-\tau)y + \pi(Y) - \min((1-\tau)y + \pi(Y), b) \\ &= \max(((1-\tau)y + \pi(Y) - b, 0) \end{aligned} \tag{5}$$

Notice that all decisions are taken before the realization of the idiosyncratic shock ω, and banks are ex-ante identical, so all banks make the same decision. Ex-post, however, banks are heterogeneous, and a subset of banks default.

[6] To focus on the main mechanism, we lump the financial and production sectors together. The mechanism, however, does not depend on this assumption and would be at work even if firms were modeled separately, banks received only a share of the output produced, and firms distributed the rest to households as dividends.

Government

The government taxes output at the tax rate $\tau > 0$, and collects lump-sum taxes $\bar{\tau} \geq 0$ from households. It also bails out the creditors of banks. The average payoff of bank liabilities is:

$$\begin{aligned}\psi(Y) &\equiv E\{\min((1-\tau)y + \pi(Y), b)\} \\ &= (1-\Phi(\delta(Y)))(1-\tau)Y + (1-\Phi(\tilde{\delta}(Y)))\pi(Y) + \Phi(\tilde{\delta}(Y))b \end{aligned} \tag{6}$$

where $\Phi(\cdot)$ is the cumulative distribution function of a standard normal, $\delta(Y)$ and $\tilde{\delta}(Y)$ are distances to default defined by

$$\delta(Y) \equiv \frac{\ln((1-\tau)Y/(b-\pi(Y)))}{\sigma} + \sigma/2 \tag{7}$$

$$\tilde{\delta}(Y) \equiv \delta(Y) - \sigma \tag{8}$$

and σ is the standard deviation of $\ln(\omega)$. The bailout cost is equal to $b - \psi(Y)$, the difference between the face value and the average payoff of bank liabilities. The government primary surplus is the difference between the tax revenue and the bailout cost:

$$s(Y) \equiv \bar{\tau} + \tau Y - (b - \psi(Y)) \tag{9}$$

There are B government bonds outstanding. Since each government bond has a face value equal to one, this is also the face value of all the government debt outstanding. The government liability is limited to its primary surplus $s(Y)$, so the payoff of each government bond is

$$\varphi(Y) \equiv \frac{\min(s(Y), B)}{B} \tag{10}$$

The total payoff that the government repays to banks is $B\varphi(Y)$. The remaining part, the net surplus $s(Y) - B\varphi(Y)$, the difference between the primary surplus and the bond payoff, is distributed to the households.

Households

The households' objective function is

$$u(c_1) + \beta u(c_2)$$

where $\beta \in (0, 1)$, the utility function satisfies $u'(c) \equiv c^{-\gamma}$, with $\gamma > 0$, and c_1 and c_2 are the non-stochastic consumption levels in the two periods.

Households don't take any decision. They enter the first period holding a short position in the financial assets held by banks and claims to the banks' liabilities.

In the first period, they receive an endowment e_1 and banks' dividends d_1, so their first-period consumption is

$$c_1 = e_1 + d_1 \tag{11}$$

In the second period, they receive an endowment e_2, they pay the financial assets' payoff $\bar{a}$ to banks, and they receive average dividends $E\{d_2\}$ and the average debt payoff $\psi(Y)$ from banks. They also pay lump-sum taxes $\bar{\tau}$ to the government, and receive the bailout funds $b - \psi(Y)$, and the net surplus $s(Y) - B\varphi(Y)$ from government. Their consumption in the second period is

$$c_2 = e_2 - \bar{a} + E\{d_2\} + \psi(Y) - \bar{\tau} + [b - \psi(Y)] + [s(Y) - B\varphi(Y)] \tag{12}$$

Bank's problem

Each bank is owned by the representative household, so it makes its choices to maximize the representative household's objective function, discounting the future using the non-stochastic discount factor

$$\Lambda = \frac{\beta u'(c_2)}{u'(c_1)} \tag{13}$$

The following is the bank's problem:

$$\max_{d_1,d_2,l,y} \{d_1 + E\{\Lambda d_2\}\} \text{ subject to (2), (3) and (5)} \tag{14}$$

given Λ and Y.

Using the fact that the discount factor Λ is non-stochastic, the first-order condition is

$$\Lambda \frac{\partial E\{\max((1-\tau)\omega f(l) + \pi(Y) - b, 0)\}}{\partial l} = 1$$
$$\Lambda(1-\tau)E\{\omega\}f'(l)\Phi(\zeta(l,Y)) = 1$$

where

$$\zeta(l,Y) \equiv \frac{\ln((1-\tau)E\{\omega\}f(l)/(b-\pi(Y)))}{\sigma} + \sigma/2$$

In equilibrium, $E\{\omega\}f(l) = Y$, so $\zeta(l,Y) = \delta(Y)$, and the first-order condition becomes

$$\Lambda(1-\tau)E\{\omega\}f'(l)\Phi(\delta(Y)) = 1 \tag{15}$$

where $\delta(Y)$ is given by (7).

This first-order condition implies that, since $\Phi(\delta)$ is less than one, bank loans l are lower than they would be without risk of default and debt overhang. What distorts the bank's lending decision is the anticipation that, in the event of default, the marginal benefit of lending will accrue to the bank's creditors, not to the equity holders. Consider the bank's marginal decision to lend one extra-unit of resources. This unit is expected to increase the revenue by the marginal expected product

$$\partial E\{(1-\tau)\omega f(l)\}/\partial l = (1-\tau)E\{\omega\}f'(l)$$

However, this unit will also increase the expected debt repayments to the bank's creditors by

$$\frac{\partial E\{\min((1-\tau)\omega f(l) + \pi(Y), b)\}}{\partial l} = (1-\Phi(\delta))(1-\tau)E\{\omega\}f'(l)$$

since the marginal benefit of lending will be reaped by the creditors in the case of default, and this discourages the bank's lending.

For intuition, it is helpful to interpret δ as the normalized distance between $(1-\tau)E\{y\}$ and $b-\pi(Y)$, i.e. the distance to default; $\Phi(\delta)$ as the adjusted probability of full debt repayment, i.e., of $(1-\tau)y+\pi(Y)-b \geq 0$; and $1-\Phi(\delta)$ as the probability that the bank defaults on its liabilities. The default probability, $1-\Phi(\delta)$, acts like a tax that discourages banks' new lending, and is the correct indicator for the size of the debt overhang distortion.

Bank loans have positive spillovers. The decision of other banks to increase aggregate lending, raises aggregate output Y, raises the value of the government bonds held by a bank, lowers its risk of default and debt overhang distortion, and raises the expected marginal return of loans, $(1-\tau)E\{\omega\}f'(l)\Phi(\delta)$, for any given level of bank loans l. The strength of these spillovers depends both on the sensitivity of the government bond payoff to aggregate economic activity, and on the sensitivity of the bank risk of default to the government bond payoff.

These spillovers have the potential to generate multiple equilibria and can give rise to a self-fulfilling expectations financial crisis. If there are pessimistic views on the economy, the value of government bonds declines, banks' risk of default and debt overhang distortion rises, which leads to under-lending and a poor economic outcome. This mechanism, first described in Occhino (2014), is similar to the one studied by Lamont (1995), who shows that multiple equilibria can arise when firms' investments are distorted by debt overhang and have positive spillovers, i.e. the net present value of investing depends positively on other firms' investment. In our paper, banks play the role that firms play in Lamont's model, and banks' loans play the role of firms' investments, leading to the potential for multiple equilibria.

Equilibria

The variables $\{m, \bar{a}, b, B, e_1, e_2\}$ are given and can be treated as parameters.

> An **equilibrium** is a set of values $\{d_1, d_2, l, y, Y, c_1, c_2, \Lambda\}$ that satisfy equations (4), (11), (12) and (13), and that solve the bank's problem (14), where the functions $\delta(Y)$, $\tilde{\delta}(Y)$, $\pi(Y)$, $\varphi(Y)$, $s(Y)$ and $\psi(Y)$ are given by equations (1), (6), (7), (8), (9) and (10).

To compute an equilibrium, first, use the equilibrium equations to obtain the following equations:[7]

$$c_1 = e_1 + m - l$$
$$c_2 = e_2 + Y$$
$$\Lambda = \frac{\beta u'(e_2 + Y)}{u'(e_1 + m - l)}$$

Then, substitute the previous expression for Λ into the first-order condition (15), and obtain the following system of two equations in the two unknowns l and Y:

$$\frac{\beta u'(e_2 + Y)}{u'(e_1 + m - l)}(1 - \tau)E\{\omega\}f'(l)\Phi(\delta(Y)) = 1$$
$$Y = E\{\omega\}f(l)$$

[7]The expression for c_2 follows from:

$$c_2 = e_2 - \bar{a} + E\{d_2\} + \psi(Y) - \bar{\tau} + [b - \psi(Y)] + [s(Y) - B\varphi(Y)]$$
$$c_2 = e_2 - \bar{a} + [(1 - \tau)Y + \pi(Y) - \psi(Y)] + \psi(Y) - \bar{\tau} + [b - \psi(Y)] + [\bar{\tau} + \tau Y - (b - \psi(Y)) - B\varphi(Y)]$$
$$c_2 = e_2 - \bar{a} + Y + \pi(Y) - B\varphi(Y)$$
$$c_2 = e_2 - \bar{a} + Y + [\bar{a} + B\varphi(Y)] - B\varphi(Y)$$
$$c_2 = e_2 + Y$$

where the functions $\delta(Y)$, $\tilde{\delta}(Y)$, $\pi(Y)$, $\varphi(Y)$, $s(Y)$ and $\psi(Y)$ are given by equations (1), (6), (7), (8), (9) and (10). After finding a solution $\{l, Y\}$ to the system, compute the values for the other equilibrium variables $\{d_1, d_2, y, c_1, c_2, \Lambda\}$ using equations (2), (3), (5), (11), (12) and (13).

Finally, check that this set of values is an equilibrium by checking that, given Λ and Y, $\{d_1, d_2, l, y\}$ solve the bank's problem (14).

For each equilibrium, we then compute the asset values discounting the expected payoffs with the discount factor Λ. The banks' bond value is equal to $\Lambda\psi(Y)$, while the banks' equity value is equal to $d_1 + \Lambda E\{d_2\}$. The value of banks' assets is equal to the sum of the bond and equity value, i.e. $d_1 + \Lambda((1-\tau)Y + \pi(Y))$. The capital ratio is defined as the ratio of the equity value to the asset value.

The risk-free rate is equal to $1/\Lambda - 1$. Notice that, since there is no aggregate uncertainty, the expected rate of return of any asset is equal to the risk-free rate. The bond yield (which is not an expected rate of return), is equal to the ratio of the bond face value b, to the bond value, as defined above, minus one. The bond spread is the difference between the bond yield and the risk-free rate. Similarly, the government bond price is $\Lambda\varphi(Y)$, the government bond yield is the inverse of the government bond price minus one, and the government bond spread is the difference between the government bond yield and the risk-free rate.

4 Interpreting the eurozone crisis and the ECB's policy response

In this section, we use the debt-overhang model to interpret the 2012 eurozone crisis and to explain why the OMT program was effective.

In our interpretation, the Great Recession and the subsequent recession that started in the third quarter of 2011 worsened the economic fundamentals of Italy and Spain and drove the two economies into a multiple equilibria region, with a normal equilibrium characterized by government solvency and a moderate bank risk of default, and a self-fulfilling expectations crisis equilibrium characterized by government insolvency and high bank risk of default. The two economies first entered the normal equilibrium, then transitioned to the crisis equilibrium and remained there until the ECB introduced the OMT program. The introduction of the OMT program had the effect of eliminating the crisis equilibrium, so the two economies moved back to the only equilibrium left, the normal equilibrium.

Parameter values

To illustrate this interpretation, we set the parameter values so that the debt-overhang model has two equilibria: a crisis equilibrium designed to represent the economies of Italy and Spain at the height of the crisis, immediately before the introduction of the OMT program; and a normal equilibrium designed to represent the two economies before and after the crisis.

Our aim is to explain the mechanics of the crisis and the effectiveness of the policy response, and to draw any policy implications—it is not to replicate the events precisely, which cannot be done with a stylized model. Hence, rather than estimating or calibrating the parameter values, we jointly set them so that the resulting two equilibria display the essential features of the two economies before the crisis and at the height of the crisis.

In general, each feature of the two equilibria is the result of the all parametrization, and not of a single parameter value. However, each feature is especially sensitive to a subset of parameters, so, to gain intuition, in what follows, we associate each feature with the subset of parameters that affect it the most.

The parameter values are listed in Table 1. One period is one year. Both A and $E\{\omega\}$ are normalized to 1. The production function parameter $\alpha = 0.3$ is set to approximate the average capital share before the crisis—according to OECD data, in the 1980-2010 period, the average labor share in Italy and in Spain was, respectively, 72.5 percent and 67.4 percent.

The preference parameter values $\beta = 0.98$ and $\gamma = 0.1$ are set so that the values of the real interest rate in the two equilibria lie within the range of historical values—a more standard value for γ, around 1, would generate implausibly large fluctuations in the real interest rate.

The tax rate $\tau = 0.4$ is set to approximately match the high average tax rates prevailing in the two countries. Lump-sum taxes $\bar{\tau}$ are set so that the government bond spread is 5 percent in the crisis equilibrium, to approximately match the data on government spreads displayed in Figures 8 and 9. The face value B of all government debt outstanding is set so that it is equal to aggregate output Y in the normal equilibrium, to approximately match the data on government debt displayed in Figure 5.

The first-period household endowment e_1 is set so that, in the normal equilibrium, the first-period aggregate consumption c_1 is 91 percent of the aggregate real resources available in the first period, $e_1 + m$, to approximate the average ratio of aggregate consumption to the domestic product net of depreciation before the crisis—according to OECD data, in the 1980-2010 period, the average ratio of final consumption expenditures to GDP in Italy and Spain was, respectively, 94.2 percent and 87.8 percent. The second-period household endowment e_2 is set so that, in the normal equilibrium, the growth rate of consumption $c_2/c_1 - 1$ is 2.2 percent, to approximate the average consumption growth rate before the crisis—according to OECD data, in the 1980-2010 period, the average growth rate of real final consumption expenditures in Italy and in Spain was, respectively, 1.66 percent and 2.74 percent.

The face value b of bank liabilities and the volatility of the idiosyncratic productivity shock σ, are set so that the bank bond spread is 2 percent and 5 percent, respectively, in the normal equilibrium and in the crisis equilibrium, to approximately match the data on bank spreads displayed in Figure 10.

The other bank balance sheet parameters, m and $\bar{a}$, are set so that, in the normal equilibrium, the bank equity-asset ratio is equal to 8.65 percent, and first-period dividends d_1 are equal to the equilibrium real interest rate (2.26 percent) times the ex-dividend bank equity value. The bank equity-asset ratio approximates the corresponding ratio before the crisis—according to ECB data, at the end of 2010, the ratio of capital and reserves to total assets for Italian and Spanish monetary financial institutions (excluding central banks) was, respectively, 9.2 percent and 8.1 percent.

The normal equilibrium and the crisis equilibrium

Table 2 lists the key variables of our model in the two equilibria.

In the normal equilibrium, government debt is risk-free, so the government bond yield is equal to the risk-free rate, and the bank bond spread is low, equal to 2 percent.

In the crisis equilibrium, economic activity is dramatically lower. Loans are 36.9% smaller, output produced with loans drops by 12.9%, and the risk-free rate drops by 1.32 percentage points. The tax revenue drops and the government liability related to the guarantee of bank creditors rises, which causes the government to become insolvent and the government bond spread to rise to 5 percent. The value of government bonds held by banks drops, and the bank credit spread rises by 3 percentage points. The rise of the bank risk of default and the worsening of the debt overhang distortion is what leads to a contraction in bank lending and a decline in economic activity. Yields on government bonds and bank bonds rise because the rise in spreads more than offsets the decline in the risk-free rate. Bank equity values plunge by 16.2% and the capital ratio drops from 8.65% to 7.46%.

Explaining the design of the OMT program and its effectiveness

We now introduce the OMT program in the model to explain the key aspects of its design and effectiveness. To model the OMT program, we introduce a central bank in the model, and we assume that it stands ready to purchase government bonds without limits at the pre-crisis market spread, i.e. at a spread equal to zero since in the pre-crisis normal equilibrium of our model government bonds are risk-free. The central bank, then, stands ready to purchase government bonds in exchange for risk-free financial claims, with the same face value, issued by the central bank itself. Equivalently, the central bank fully guarantees the creditors of the government, i.e. the banks, and promises the banks to deliver in the second period a real transfer

$$\xi(Y) \equiv B - B\varphi(Y) \tag{16}$$

equal to the difference between the government bond face value and their actual payoff—notice that the transfer is equal to zero if the government does not default.

After adding the transfer $\xi(Y)$ to the bank asset payoff, equation (1) becomes:

$$\pi(Y) \equiv \bar{a} + B\varphi(Y) + \xi(Y) = \bar{a} + B \tag{17}$$

so the effect of the introduction of the OMT program is to substitute, in the bank asset payoff (1), the government bond payoff $\varphi(Y)$ with the constant equal to one, equal to the government bond face value. The central bank guarantee of the government bonds adds a floor to the government bond payoff, which is key to eliminate the crisis equilibrium.

To close the model and to abstract from issues related to the real transfer of resources from a foreign sector, we add the simplifying assumption that the central bank obtains the transfer $\xi(Y)$ in the second period from the households in a lump-sum way, so the household consumption in the second period is given by

$$c_2 = e_2 - \bar{a} + E\{d_2\} + \psi(Y) - \bar{\tau} + [b - \psi(Y)] + [s(Y) - B\varphi(Y)] - \xi(Y) \quad (18)$$

instead of equation (12).

> An **equilibrium for the economy with the OMT program** is a set of values $\{d_1, d_2, l, y, Y, c_1, c_2, \Lambda\}$ that satisfy equations (4), (11), (18) and (13), and that solve the bank's problem (14), where the functions $\delta(Y)$, $\tilde{\delta}(Y)$, $\pi(Y)$, $\varphi(Y)$, $s(Y)$, $\psi(Y)$ and $\xi(Y)$ are given by equations (17), (6), (7), (8), (9), (10) and (16).

We now show that, in the economy with the OMT program, there is a unique equilibrium, the same as the normal equilibrium in the benchmark economy without the OMT program. We show this by showing first that the normal equilibrium continues to be an equilibrium in the economy with the OMT program, and then that the equilibrium in the economy with the OMT program is unique.

First, notice that, if the government does not default, the government bond payoff $\varphi(Y)$ is equal to one, and the transfer $\xi(Y)$ is equal to zero—no sovereign bond purchase is actually carried out by the central bank. Then, in the case of government solvency, the equations that characterize the equilibria are the same in the economy with and without the OMT program—in particular, equations (18) and (17) are the same as equations (12) and (1). Therefore, the equilibria where the government does not default are the same in the economy with and without the OMT program. Hence, the normal equilibrium in the benchmark economy without the OMT program, the one where the government does not default, continues to be an equilibrium in the economy with the OMT program.

Next, notice that the solution for l in the bank's problem does not depend on Y and is increasing in Λ. The bank's problem is equivalent to

$$\max_{l}\{(m-l)+\Lambda g(l)\}$$

given Λ, where $g(l) \equiv E\{\max(((1-\tau)\omega f(l)+\bar{a}+B-b,0)\}$ is increasing. Since the problem does not depend on Y, the solution does not depend on Y either. To show that the solution for loans l is increasing in Λ, consider $\Lambda_1 < \Lambda_2$, and let l_1 and l_2 be the arg max of the previous problem with, respectively, $\Lambda = \Lambda_1$ and $\Lambda = \Lambda_2$. By definition,

$$(m-l_2)+\Lambda_2 g(l_2) \geq (m-l_1)+\Lambda_2 g(l_1)$$
$$(m-l_1)+\Lambda_1 g(l_1) \geq (m-l_2)+\Lambda_1 g(l_2)$$

Summing side by side,

$$(m-l_2)+\Lambda_2 g(l_2)+(m-l_1)+\Lambda_1 g(l_1) \geq (m-l_1)+\Lambda_2 g(l_1)+(m-l_2)+\Lambda_1 g(l_2)$$
$$\Lambda_2 g(l_2)+\Lambda_1 g(l_1) \geq \Lambda_2 g(l_1)+\Lambda_1 g(l_2)$$
$$[\Lambda_2-\Lambda_1][g(l_2)-g(l_1)] \geq 0$$
$$g(l_2)-g(l_1) \geq 0$$
$$l_2-l_1 \geq 0$$

which completes the proof.

Finally, use the equilibrium equations to obtain that the discount factor is given by

$$\Lambda = \frac{\beta u'(e_2+E\{\omega\}f(l))}{u'(e_1+m-l)} \tag{19}$$

so it is a strictly decreasing function of the equilibrium aggregate loans l. Recall that the solution for loans l in the bank's problem does not depend on Y and is increasing in Λ. It follows that there is a unique set of values $\{l, \Lambda\}$ that satisfy equation (19) and such that l solves the bank's problem given Λ. Then, using the equilibrium equations, it is easy to show that there is a unique set of values $\{d_1, d_2, l, y, Y, c_1, c_2, \Lambda\}$ that satisfy the equilibrium conditions, so the equilibrium in the economy with the OMT program is unique.

To sum up, in the economy with the OMT program, there is a unique equilibrium, the normal one. The effect of the introduction of the OMT program is to eliminate the crisis equilibrium and to drive the economy toward the only equilibrium left, the normal one, where no sovereign bond purchase is actually carried out.

Notice how, in the proof that the equilibrium is unique, it is crucial that $\pi(Y)$ is given by equation (17), rather than by equation (1), so the bank asset payoff does not depend on Y. The central bank guarantee of government bonds makes the bank asset payoff insensitive to economic prospects, and this eliminates the positive spillovers of bank lending and the multiplicity of equilibria. Also notice that, in order to reduce the sensitivity of bank assets to economic prospects, it is crucial that the central bank accepts the same (pari passu) treatment as banks, rather than imposing to be paid in preference, and this explains why the ECB introduced this feature in the OMT program.

Since the central bank does not purchase any government bond in equilibrium, there is no change in economic fundamentals, and no transfer of resources from the central bank to the banks. However, in the longer run, the introduction of the OMT program may generate moral hazard risks that our model does not capture. Once a program of sovereign bond purchases at below-market spreads is introduced, the perceived guarantee of a bailout may lower the government's incentives to be fiscally disciplined. The conditionality to the participation to a macroeconomic adjustment program, which was added to the OMT program, likely helped mitigate this risk.

An alternative view of the crisis based on fundamentals

At the height of the crisis, it was not clear the importance of the role played by economic fundamentals, particularly by government solvency. As highlighted in the Introduction, the ECB itself viewed government policy as one factor behind the crisis. In fact, in this section we show that, at the height of the crisis, the view that the crisis was driven by economic fundamentals, rather than by self-fulfilling expectations, was consistent with data.

To illustrate this alternative interpretation, we start with the same normal equilibrium as in the previous section and we add a combination of shocks that eliminate the multiplicity of equilibria and leave a unique equilibrium with government insolvency and high bank spread.

To model a greater fiscal imbalance, we lower the tax rate from 40 percent to 35 percent—this is key to attenuate the positive spillovers and to eliminate the multiplicity of equilibria. Also, we lower the aggregate productivity A by 4 percent, from 1 to 0.96. Finally, lump-sum taxes $\bar{\tau}$ are lowered by 2.2 percent, from 0.2925 to 0.2861—with this setting, the government bond spread continues to be 5 percent in the crisis equilibrium.

Before the shocks, the economy is described by the normal equilibrium of the benchmark economy, where the government is solvent and the bank credit spread is low, which is designed to represent the economies of Italy and Spain before the crisis. After the shocks, the economy has a unique equilibrium, where the government is insolvent and the bank credit spread is high, which is designed to represent the economies of Italy and Spain during the crisis, immediately before the introduction of the OMT program. In this alternative interpretation, a worsening of economic fundamentals, namely lower productivity and greater fiscal imbalance, led the economies of Italy and Spain toward a region characterized by a unique equilibrium with insolvent governments and a high risk of default of banks.

Table 3 lists the key variables of our model for the pre-crisis equilibrium, and for the crisis equilibrium, when the crisis is driven by economic fundamentals. Qualitatively, the change in economic variables is consistent with data. Quantitatively, the change in economic variables is dramatic as well, due to the working of a debt-overhang amplification mechanism: any fiscal deterioration lowers the value of government debt, weakens the bank balance sheets, and discourages lending and production, and this further weakens the fiscal situation. At the height of a crisis, then, it is difficult to distinguish whether the crisis is due to self-fulfilling expectations or to economic fundamentals.

The two interpretations, however, have different predictions as to what happens *after* the introduction of the OMT program. In a crisis driven by economic fundamentals, the introduction of the OMT program cannot have any effect unless some sovereign bond purchases are actually carried out at spreads that are below the ones prevailing during the crisis. This is because, once the economic fundamentals have worsened, the pre-crisis equilibrium is not an equilibrium any more and the crisis equilibrium is unique, so the equilibrium cannot change unless the sovereign bond purchases change the economic fundamentals. The view of a fundamentals-driven crisis, then, cannot explain why the OMT program was effective even without any purchase carried out, and this supports the multiple equilibria interpretation of the eurozone crisis.

Also, if the crisis is driven by fundamentals, banks profit from selling the sovereign bonds to the central bank, since the central bank stands ready to purchase them at pre-crisis market spreads, so sovereign bond purchases are actually carried out in equilibrium and there is a positive transfer $\xi(Y)$ from the central bank to the banks. This has a positive effect on the economy and on the fiscal situation, as the debt-overhang distortion diminishes, bank lending and output expand, and the government and bank bond spreads decline. However, the government ends up defaulting anyway after the introduction of the OMT program, because the economic fundamentals—lower productivity and higher fiscal imbalance—remain worse than before the crisis.[8] The government bond spread decreases but does not drop to zero. This explains why the ECB added to the OMT program the conditionality to the participation to a macroeconomic adjustment program—to make governments implement the policies of fiscal adjustments and structural reforms that were needed to reduce the government risk of default to zero.

Finally, in a fundamentals-driven crisis, the central bank ends up carrying out sovereign bond purchases in equilibrium, and the central bank's ownership of sovereign bonds generates additional longer-term risks, not captured by our model, that are associated with a distortion of the incentives faced by the government and by the central bank. First, the government may have smaller incentives to be fiscally disciplined, since any loss associated with its own default is sustained by the central bank rather than by the banks. Second, there is a risk to the central bank's independence, since the government is able to affect the value of the central bank's portfolio by affecting its own risk of default. Third, there is a risk to the central bank's credibility, since the ownership of risky sovereign bonds may distort the central bank's incentives to implement policy actions that affect the government solvency. Had the ECB carried out sovereign bond purchases, the conditionality to the participation to a macroeconomic adjustment program might have helped mitigate these risks.

[8]To see this, notice that, if the government did not default, then the equilibrium would also be an equilibrium for the economy without the OMT program. But then there would be multiple equilibria with the OMT program, and the crisis would be of the self-fulfilling expectations type, rather than driven by economic fundamentals.

5 Conclusions

In this paper, we have developed a self-fulfilling expectations crisis model that is able to account for the essential features of the eurozone crisis and for the design and effectiveness of the OMT program. We have shown that, at the height of crisis, it was difficult to distinguish whether the crisis was due to self-fulfilling expectations or to a deterioration of economic fundamentals, since economic variables tend to behave similarly in the two cases. Ex-post, however, the fact that the OMT program was effective, even though no sovereign bond purchase was actually carried out, suggests that the crisis was of the self-fulfilling expectations type.

In a financial crisis driven by economic fundamentals, however, a program of sovereign bond purchases would have different effects and would raise different issues. To have any effect, sovereign bond purchases would have to be carried out in equilibrium at prices higher than the ones prevailing during the crisis, i.e., higher than fundamentals. This policy action would have benefits as well as costs and risks. A benefit would be a smaller debt-overhang distortion and a greater level of lending and output, as a consequence of the transfer to the banks. The costs and risks would include the cost of the transfer sustained by the ECB, and the longer-term risks that we have highlighted for the OMT program: the risk of a lower incentive for governments to be fiscally disciplined, the risk to the ECB's independence, and the risk of a distortion of the ECB's incentives with the consequent risk to its credibility. It would be very interesting to adapt the debt-overhang framework described in this paper, adding a government choice for fiscal policy, to study the benefits, costs and risks of a program of sovereign bond purchases in a fundamentals-driven crisis.

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Parameter values

$E\{\omega\}$	1.0000
α	0.3000
β	0.9800
γ	0.1000
σ	0.3650
$\bar{\tau}$	0.2925
τ	0.4000
m	0.0606
e_1	0.5967
e_2	0.1832
$\bar{a}$	0.0808
b	0.7149
B	0.4282
$c_1/(m+e_1)$	0.9100
$c_2/c_1 - 1$	0.0220

Table 1: Values of parameters and selected ratios in the normal equilibrium.

Self-fulfilling expectations equilibria

	Normal equilibrium	Crisis equilibrium	Percent difference
Loans	0.0592	0.0373	-36.8805
Output	0.4282	0.3730	-12.8938
Risk-free rate	0.0226	0.0094	
Bank bond yield	0.0429	0.0594	
Bank bond spread	0.0202	0.0500	
Government bond yield	0.0226	0.0593	
Government bond spread	0.0000	0.0500	
Bank asset value	0.7504	0.7292	-2.8205
Bank bond value	0.6855	0.6748	-1.5549
Bank equity value	0.0649	0.0544	-16.1856
Bank equity-asset ratio	0.0865	0.0746	

Table 2: Equilibrium values in the normal equilibrium and in the crisis equilibrium in the case of self-fulfilling expectations.

Equilibria before and after a change in fundamentals

	Normal equilibrium	Crisis equilibrium	Percent difference
Loans	0.0592	0.0562	-4.9473
Output	0.4282	0.4048	-5.4502
Risk-free rate	0.0226	0.0182	
Bank bond yield	0.0429	0.0473	
Bank bond spread	0.0202	0.0291	
Government bond yield	0.0226	0.0686	
Government bond spread	0.0000	0.0504	
Bank asset value	0.7504	0.7429	-0.9978
Bank bond value	0.6855	0.6826	-0.4184
Bank equity value	0.0649	0.0603	-7.1168
Bank equity-asset ratio	0.0865	0.0812	

Table 3: Equilibrium values before and after a change in fundamentals, i.e. a decline of the tax rate from 40 percent to 35 percent, a decline of productivity by 4 percent, and a 2.2 percent decline of the lump-sum tax.

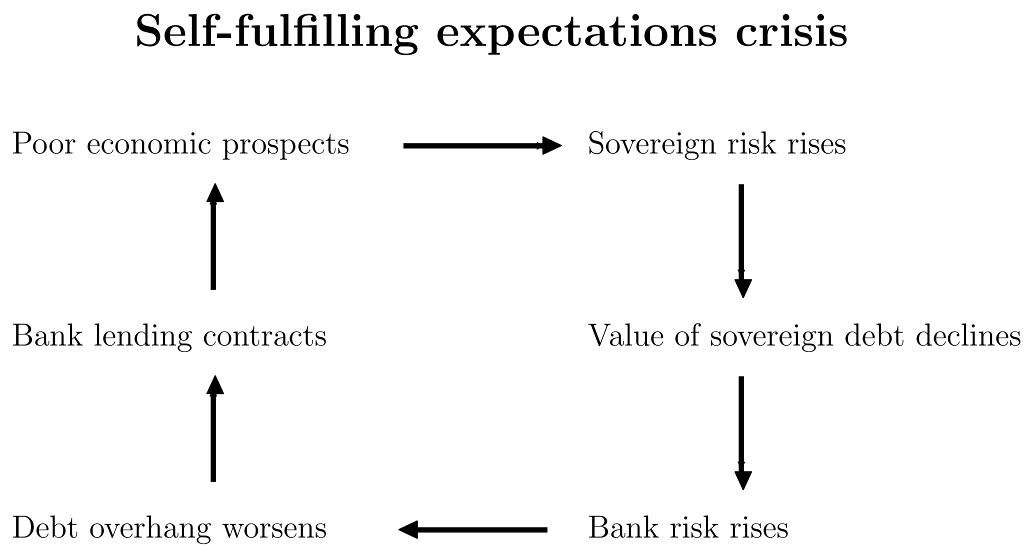

Figure 1: Main debt-overhang mechanism leading to a self-fulfilling expectations banking and sovereign crisis.

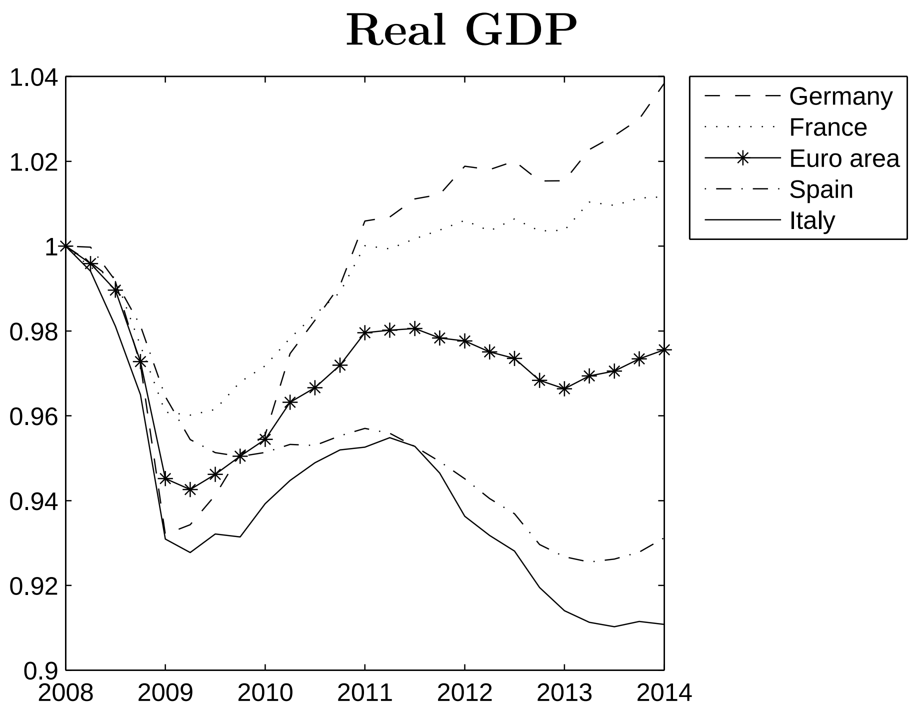

Figure 2: Real GDP, working day and seasonally adjusted. Real GDP levels have been scaled so that they are equal to 1 in 2008:Q1. The euro area refers to the euro area 17 (fixed composition). Source: European Central Bank.

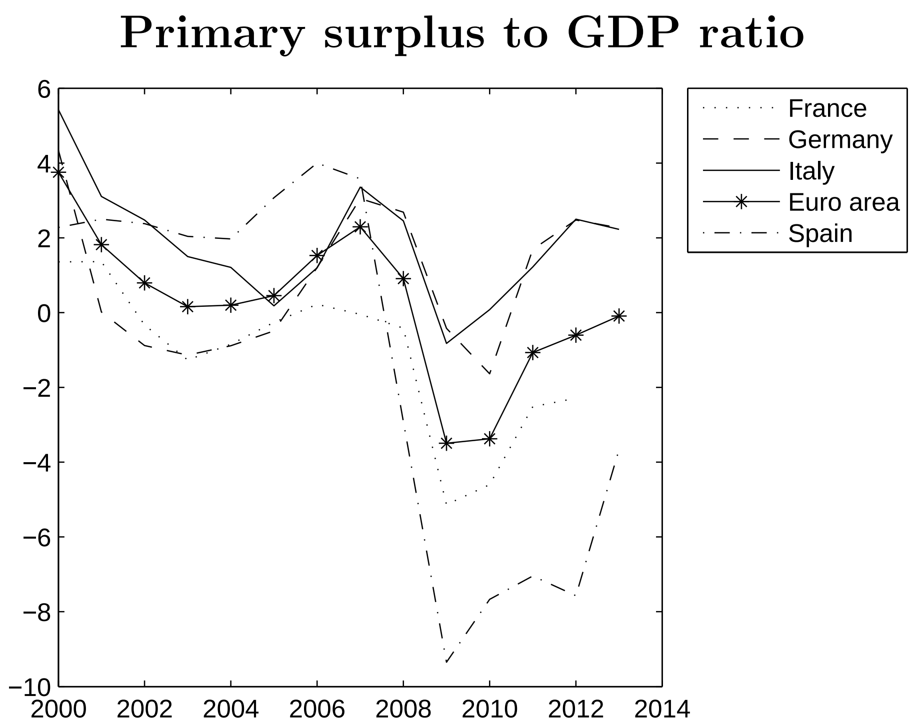

Figure 3: Primary surplus as a percentage of GDP. The euro area refers to the euro area 17 (fixed composition). Source: European Central Bank.

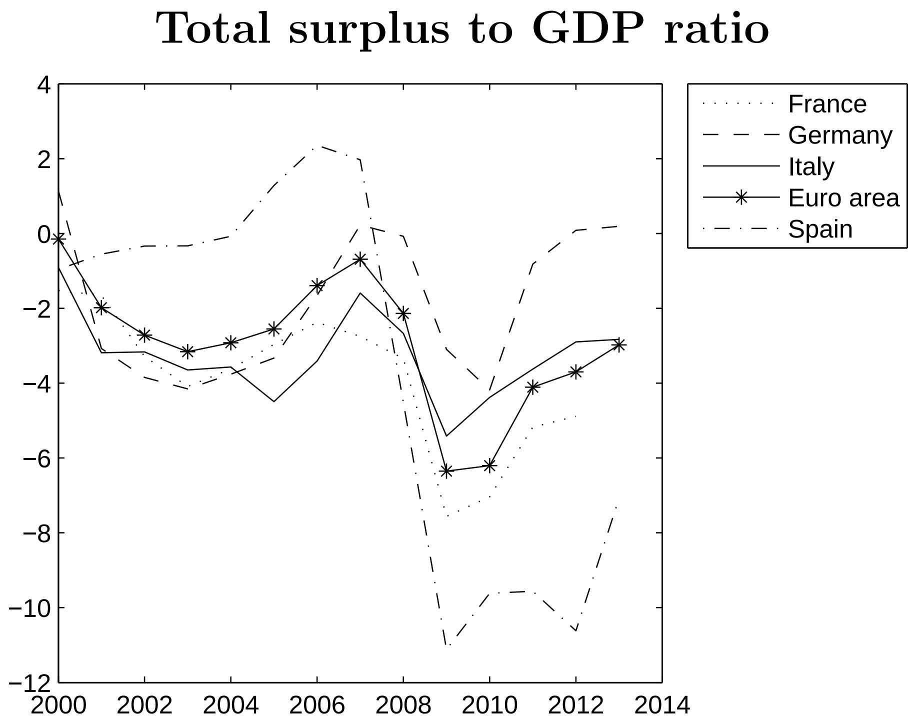

Figure 4: Total surplus as a percentage of GDP. The euro area refers to the euro area 17 (fixed composition). Source: European Central Bank.

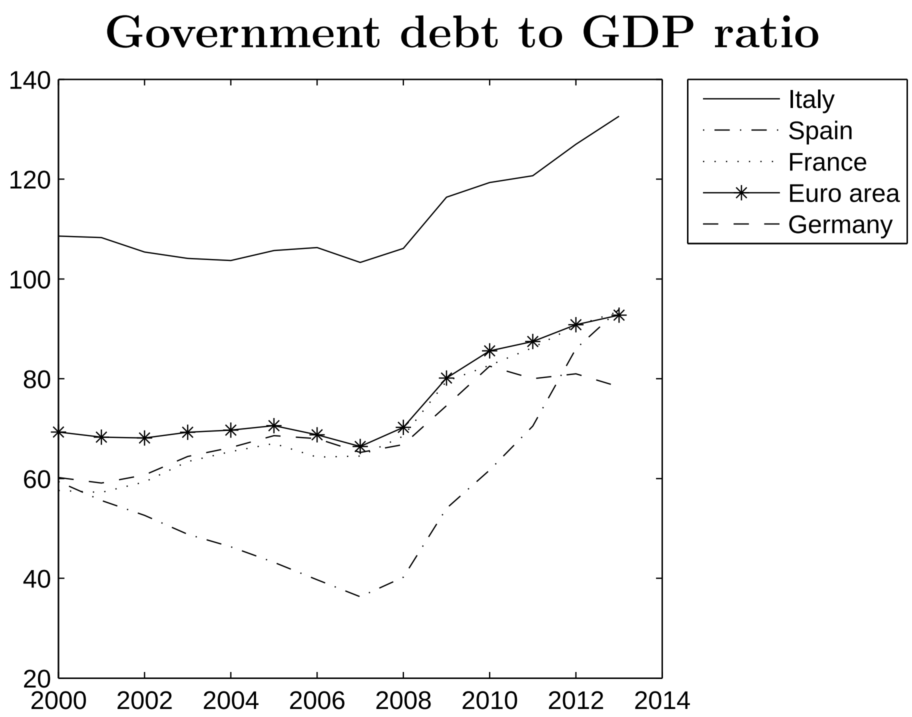

Figure 5: Government debt as a percentage of GDP. The euro area refers to the euro area 17 (fixed composition). Source: European Central Bank.

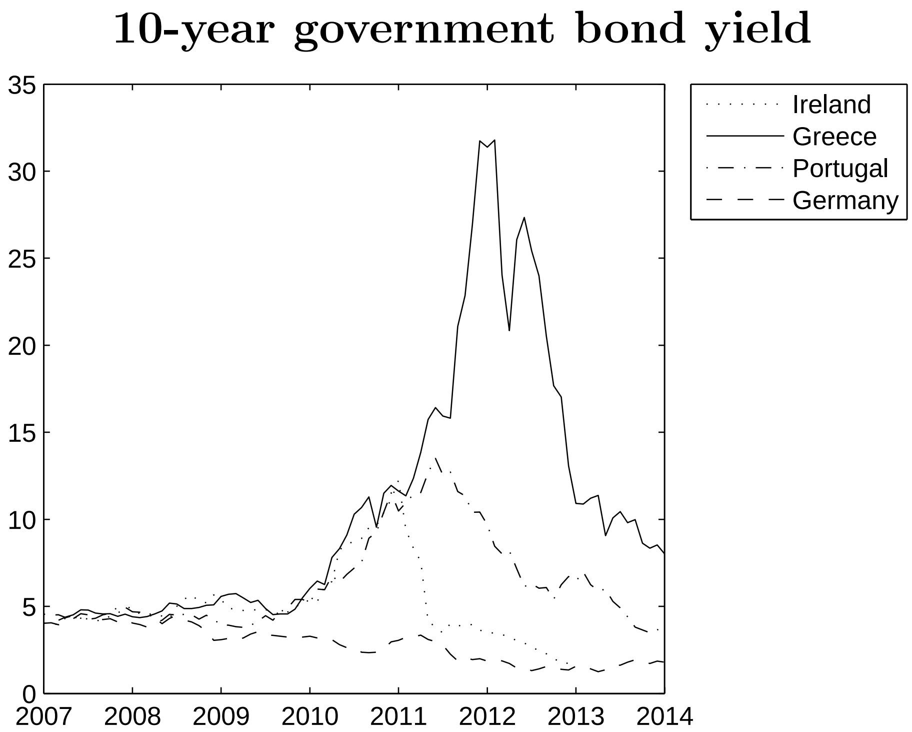

Figure 6: 10-year government bond yield, percent, monthly averages. Source: Bloomberg.

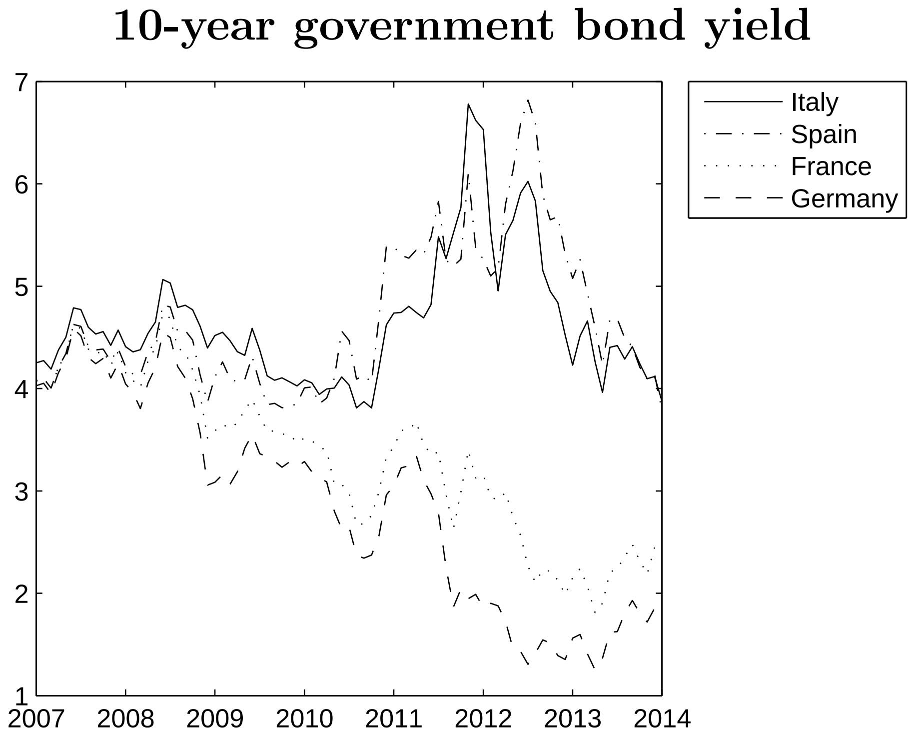

Figure 7: 10-year government bond yield, percent, monthly averages. Source: Bloomberg.

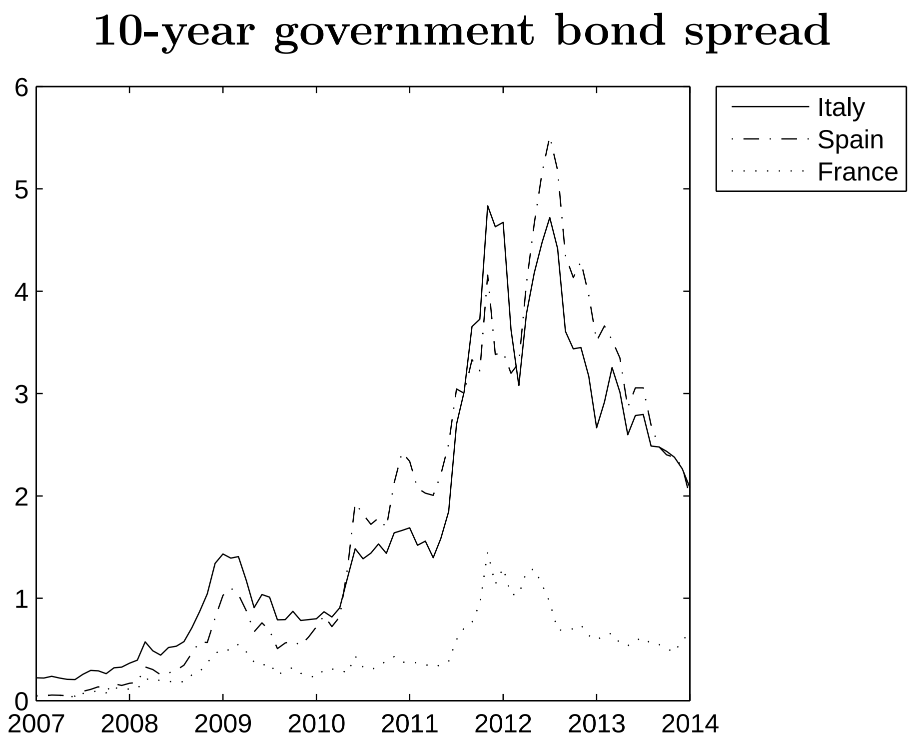

Figure 8: 10-year government bond spread with German bond, percentage points, monthly averages. Source: Bloomberg.

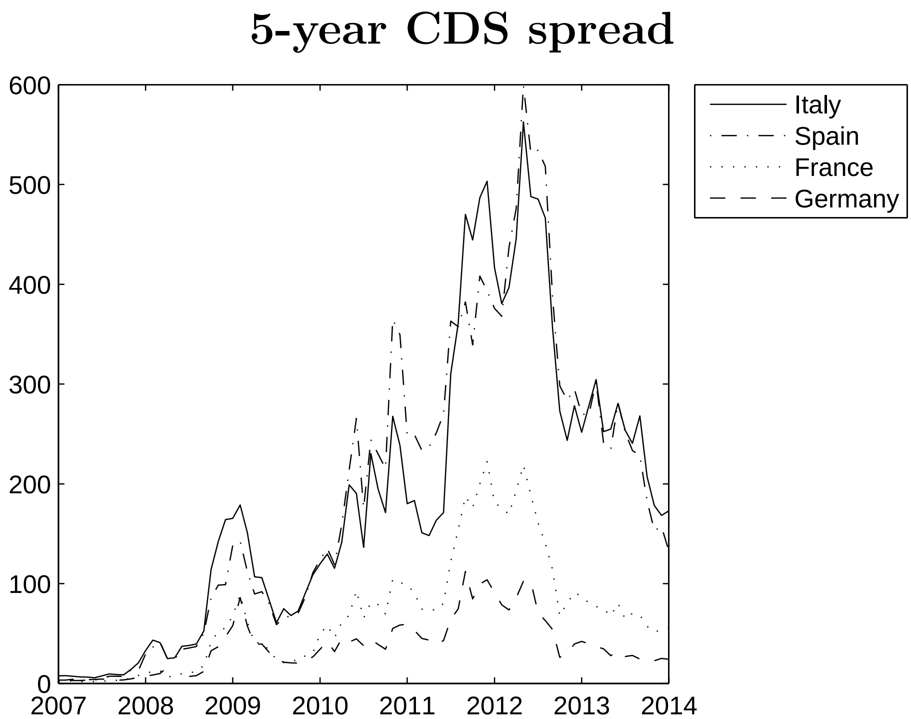

Figure 9: 5-year government CDS spread, basis points, monthly averages. Source: Bloomberg.

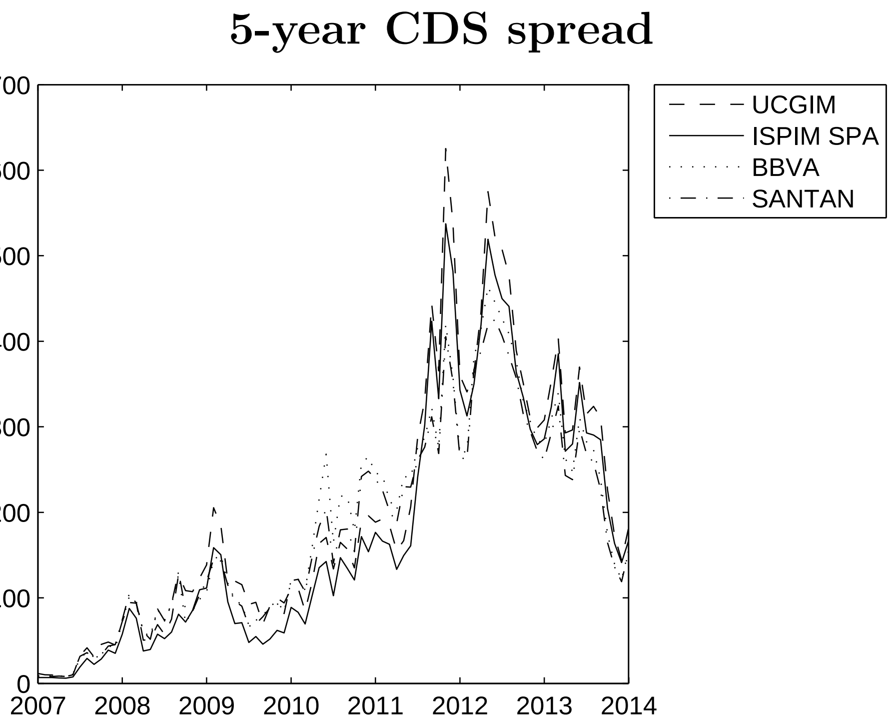

Figure 10: 5-year bank CDS spread, basis points, monthly averages. Source: Bloomberg.

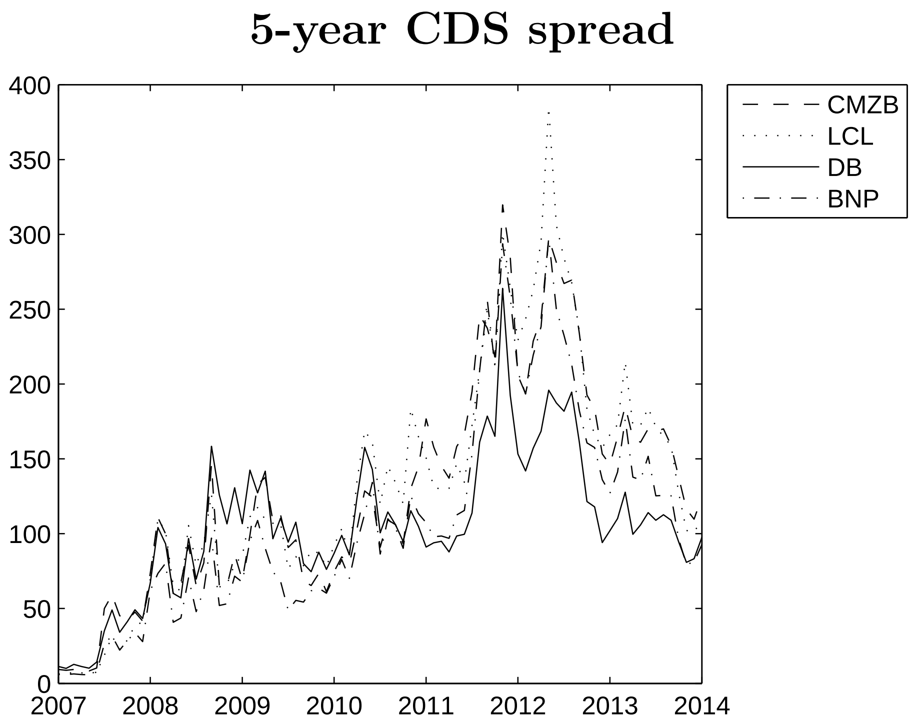

Figure 11: 5-year bank CDS spread, basis points, monthly averages. Source: Bloomberg.