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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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A theory of bazookas; or, "when (and when not) to use large-scale official sector support" *

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Abstract

This paper develops a theoretical model for "bazookas," a term coined by US Treasury Secretary Hank Paulson in 2008 and since applied to various large-scale public sector support programs for distressed borrowers. The intention behind such programs is to provide so much available financing ("firepower") as to trigger a complementary market reaction, i.e. a sustained reduction in the borrower's credit spreads, in turn reducing the probability that support will actually have to be used. With a four-period partial equilibrium framework, and balance sheet interactions between a public sector creditor and distressed borrower, the model formalizes the conditions under which a "bazooka" will be effective. Among other things, the effectiveness in reducing spreads will rise with the size of public sector support funds compared to potential borrowing needs; the creditworthiness of the public sector creditor; and the appropriateness of conditionality under which support is available. This framework helps explain the effectiveness of several recent public sector support programs for banks and sovereigns, in particular the relative success of the ECB's Outright Monetary Transactions (OMT).

Keywords: bazookas, bail-outs, lender of last resort, moral hazard.
JEL classifications: F33, G01, G18.

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"*If you've got a squirt gun in your pocket, you may have to take it out. If you have a bazooka in your pocket and people know it, you probably won't have to use it.*"

- Hank Paulson, Secretary of the Treasury, to US Senate Banking Committee, 15 July 2008

1. Introduction

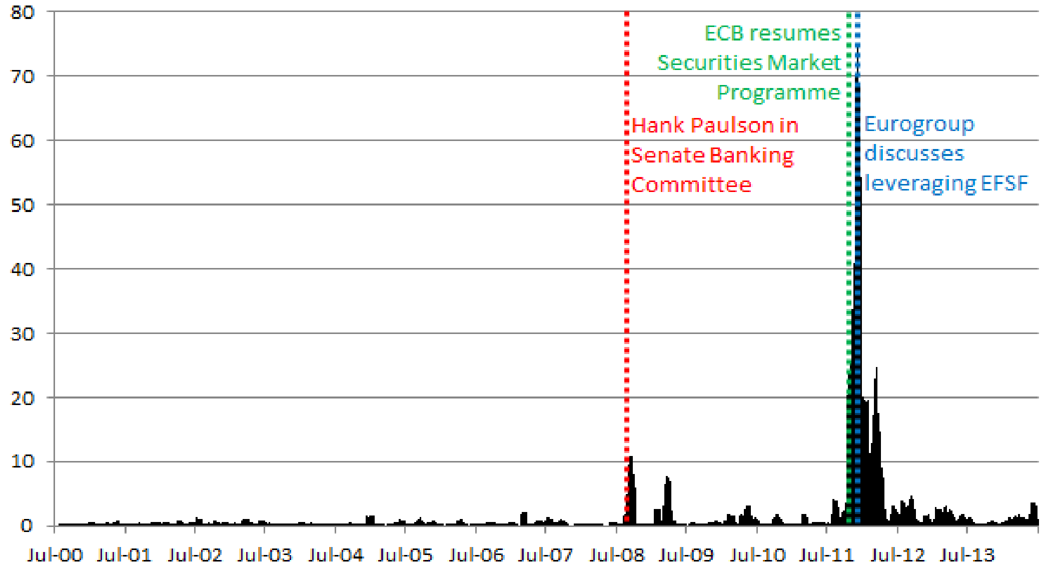
In July 2008, as the sub-prime crisis in the US escalated, Hank Paulson lobbied Congress for the authority to inject equity capital into government-sponsored entities Fannie Mae and Freddie Mac. He argued that a larger scale of support would reassure investors and thus make it less likely that support is actually needed. While Paulson's policy project was not particularly successful – Fannie and Freddie were put into conservatorship less than two months later – his bazooka metaphor had more success, accurately reflecting the logic of a number of subsequent policy interventions in the US and around the world, and adding to the nomenclature of policy discussions ever since.[1]

Indeed, along with the related ideas of "firepower," "war chests" and the less militaristic concept of a "safety net," the idea of bazookas has captured the imagination of policy makers and the financial press. The number of Bloomberg articles containing the word "bazooka" increased dramatically since 2008, peaking in 2011 with its widespread use during the euro area crisis (figure 1). The term has been connected with programs such as the US Troubled Asset Relief Program (TARP); the German *Sonderfonds für Finanzmarktstabilisiering* (SoFFin); the expanded resources of the International Monetary Fund (IMF); the European Financial Stability Facility (EFSF), European Financial Stability Mechanism (EFSM) and their successor, the European Stability Mechanism (ESM); and the unconventional monetary policies of central banks including the ECB, such as the 2010/11 Securities Market Program (SMP), or Outright Monetary Transactions (OMT), introduced in 2012 (figure 2).

While the modalities of such policy interventions by central banks, governments and multilateral organizations vary considerably, a recurring theme is a commitment to more than sufficient support (usually in the form of loans, sometimes guarantees and equity stakes) with the intention that it will not (or only hardly) be used. Some programs, such as OMT, have been very successful in mitigating market stress and preventing new bouts of instability, while most others have been much less successful. The key question of this study is: under what conditions can a public sector support program actually make itself unneeded? In other words, when is the commitment to provide financing so powerful that actual support is not needed to cut short a market panic?

[1] Formally, a bazooka is a shoulder-mounted anti-tank rocket launcher developed by the United States during World War II. The name comes from its resemblance to a musical instrument popularized by comedian Bob Burns in the 1930's – the name of which in turn may have come from the Dutch "*bazuin*," a historical predecessor of the trumpet.

Figure 1: Articles containing the word "bazooka" on Bloomberg, 2000-2013
per day, one-month rolling average



Source: Bloomberg Trends, accessed 17 July 2014; with thanks to Jurian Hoondert.

Figure 2: Klaas Knot, OMT as a big bazooka

Source: Mirjam Visser, Financieele Dagblad, 27 October 2012, reprinted with author's permission.

A factually accurate – but incomplete – answer is that a "bazooka" will work if and when it is credible to the investors of the distressed borrower. If they believe that *potential* public sector support will materially improve their chance of being repaid, investors will be more likely to continue to lend, and hence actual support is superfluous. As this paper shows formally, this will be the likelier when the distressed borrower is (sufficiently, or sufficiently close to being) solvent, when the potential size of the support (firepower) is large relative to the distressed borrower's balance sheet and small relative to the supporter's potential financial balance sheet, and when the conditions of support are targeted to improving solvency.

The contribution of this paper is to create a theoretical framework for the effects of large-scale public sector support to a distressed borrower and set out conditions under which the *commitment* to provide support can in fact reduce the need for support to be used. In turn, this approach can create a common language for examining "bazookas," and for analyzing their effectiveness. The theoretical part of the paper uses a four-period partial equilibrium set-up, in which the public sector creditor and distressed borrower inherit their existing balance sheets.[2] The creditor chooses the maximum size ("firepower"), pricing and conditionality of support, while the borrower chooses its policy effort and how much actual support to request. The key mechanism or "moving part" in this model is the risk premium charged by investors. This premium, expressed as a credit spread above the risk-free rate, will rise pro-cyclically with the balance sheet risks of the distressed borrower, and recede when internal and external factors – including the expectation of support – cause solvency to improve. Because the premium is the primary driver of the cost of borrowing – itself a key factor in solvency – there are self-reinforcing dynamics ("vicious" or "virtuous spirals"). The "bazooka effect" arises when support is effective in lowering spreads so as to ensure solvency. There are cases when this is so effective that the borrower will not request support, particularly in cases where support is accompanied by stringent policy conditionality. Yet as will be shown with real-life examples, such successes are more rare than many policymakers may expect, particularly when there are doubts about the creditor's solvency or when conditionality is difficult to enforce.

Overall, this model aims to be as simple as possible while incorporating the relevant features of recent support programs to sovereigns and financial institutions into one unified framework. Conclusions are drawn from simple optimization, as well as with a comparison to actual case studies of public support programs. Among the support programs for banks (TARP, SoFFin, FROB, and Irish liability guarantees) and sovereigns (expanded IMF resources, EFSF/ESM, SMP I and II and OMT), it can be shown that OMT is the only program so far that actually meets the strict definition of a "bazooka." This relative effectiveness is likely due to the unlimited size of OMT, the strength of the ECB's balance sheet and the strong link to policy conditionality.

The paper is organized as follows. Section 2 sketches related literature. Section 3 develops the theoretical model, first by defining variables on the balance sheets of the public sector creditor and

[2] The balance sheet approach, while familiar for financial institutions, can also be fruitfully applied to sovereigns and to economies as a whole. See Allen, Rosenberg, Keller, Setser and Roubini (2002) for an application to balance of payments crises in emerging market economies.

distressed borrower, and the role of private investors, and then describing their actions in each of the four periods. Section 4 derives results from the model, interprets these for other types of creditors (e.g. multilateral organizations and central banks) and borrowers (e.g. financial institutions) and offers some considerations on welfare effects of commitments for support. Section 5 applies the framework to recent examples of public sector support programs and compares their relative success with the predictions of the model. Finally, section 6 concludes.

2. Related literature

While the bazooka metaphor is relatively new, the concept of public support to stem financial panics is very old. Goodhart (1999) traces the literature on the lender of last resort (LOLR) back to its origins, which reach at least to Thornton (1802). Bagehot (1873) famously scrutinized the development of London's Lombard Street as a global financial center, and the peculiar role of the Bank of England as guardian of the national reserve. He argued that such a responsibility within one central body was inherent to the functioning of credit markets.[3] To paraphrase Voltaire, if the lender of last resort did not exist, it would be necessary to invent it.[4]

Yet public sector support reaches beyond just the LOLR role of the central bank. The seminal paper of Diamond and Dybvig (1983) shows that due to the risk of costly bank runs, it is optimal to have permanent public support to bank depositors through the deposit insurance system. During his tenure at the International Monetary Fund (IMF), Stanley Fischer (1999) argued for an international LOLR for governments. In turn, there is a large empirical literature on the impact of IMF support on sovereign spreads (see, for example, Lane and Philips, 2000), and there are theoretical contributions on IMF support and its interaction with potential borrower and creditor moral hazard (Jeanne and Zettelmeyer, 2005; Eichengreen, 2005). Since the crisis, there have also been studies that model the linkages between balance sheets of a sovereign creditor and distressed borrower, such as Allen, Carletti, Goldstein and Leo (2012), Acharya, Drechsler and Schnabl (2013) and König, Anand and Heinemann (2013).[5]

The design of large-scale support programs is inherently controversial, as it involves a trade-off between *ex ante* incentives and *ex post* efficiency (Tirole, 2002; Eijffinger and Nijskens, 2011; Chari

[3] In his words, "*With the advantages of credit we must take the disadvantages too, but to lessen them as much as we can, we must keep a great store of ready money always available, and advance out of it very freely in periods of panic*" (Bagehot, 1873, p. 55).

[4] Of course, Voltaire's subject matter was a bit loftier – he was referring to the existence of God: "*Si Dieu n'existait pas, il faudrait l'inventer*" / "*If God did not exist, it would be necessary to invent Him*" (François-Marie Arouet (Voltaire), "*Epître á l'auteur du livre des Trois imposteurs*," 1768).

[5] Notably, these papers show that while support can improve the creditworthiness of the borrower, it can erode the solvency of the public sector creditor. A key example is the Irish government which, after bailing out the Irish banking sector in September 2008, itself had to turn to the IMF and European institutions for an €86 billion support program in December 2010 – what Acharya, Drechsler and Schnabl refer to as a "pyrrhic victory," or a victory achieved at great cost to the victor. See section 5.

and Kehoe, 2013). While distressed banks and governments will not necessarily welcome default due to the existence of a support program, they may be more likely at the margin to take risks ("borrower moral hazard") – and private investors will be more likely to continue funding them ("creditor moral hazard"), thus increasing overall risks. Yet when a panic hits, providing support will often cost public sector creditors a factor of magnitude less than not intervening.[6] These considerations were illustrated starkly in the debates around TARP (Berger and Roman, 2014) and the ESM (Blundell-Wignall, 2012; Kapp, 2012).[7] Both the mechanism of the "bazooka effect" and these controversies are similar for support to both sovereigns and financial institutions, by international organizations, governments and central banks.[8]

The questions posed in this paper can also be addressed with a global games framework in which short-term creditors face the binary choice of whether or not to roll over their lending to a borrower (Morris and Shin, 1998, 2006; Corsetti, Dasgupta, Morris and Shin, 2004; Daniëls, Jager and Klaassen, 2011; Vlahu, 2008). In such a setting, private investors make their decision based not only on their own expectations of the borrower's ability to repay, but also on their expectations of the expectations (of the expectations, and so on...) of other investors.[9] In contrast to global games models, this paper will assume that, as long as the distressed borrower is solvent (or has access to support), investors will roll over all of its debt at a rate equal to the risk-free rate plus the risk premium. While this is derived as the outcome of an optimization problem, the focus is more on the actions of the distressed borrower and the commitments of the public sector creditor.

3. Theoretical model

This paper uses a simple four-period partial equilibrium model with three groups of actors – a public sector (e.g. sovereign) creditor, a distressed (sovereign) borrower and private investors who finance the debt of the public sector creditor and distressed borrower.[10] The multiple-period set-up allows us

[6] See Kindleberger and Aliber (2011) for a calculation of the (large) costs of non-intervention versus the (much smaller) counterfactual of intervention for the Lehman Brothers crisis. They allude to Friedman and Schwartz (1963): "*Because no great strength would be required to hold back the rock that starts a land-slide, it does not follow that the landslide will not be of major proportions*."

[7] In early 2012, a number of commentators, including the OECD, called for a large increase in the size of the EFSF/ESM. Yet in a March 2012 speech, Jens Weidmann, Governor of Deutsche Bundesbank, famously rejected such calls, arguing that "*just like the 'Tower of Babel,' the 'Wall of Money' will never reach heaven*."

[8] Various quantitative easing (QE) programs of central banks are outside the scope of this paper. While such programs often involve large-scale government bond purchases, which tend to lower interest rates and credit spreads, QE is qualitatively different to "bazooka" programs in that: (i) it is intended to be used (i.e. does not make itself unnecessary) and (ii) is generally not targeted at distressed borrowers.

[9] Yet another alternative approach is stock-flow consistent modeling, as pioneered by Goldey and Lavoie (2007), and applied recently by e.g. Kinsella (2013) and Carvalho and Di Guilmi (2014). A key feature of these models is the use of accounting identities by which all transactions by one sector are related to changes in the income or balance sheet position of counterparty sectors.

[10] Initially, this will be explained in terms of support from a sovereign creditor to a sovereign borrower, but later this will be extended to the case of multilateral and central bank creditors, and to financial institution

to examine actions at the time that support is announced and at a later stage when support is requested and granted; the choice of four periods is for ease of illustration. Results are driven by the risk premium charged by investors – which depends on current equity levels and uncertainty; by the optimization behavior of the distressed borrower and by comparing possible choices of the public sector creditor.

3.a. Key variables and actors

The public sector creditor (denoted throughout the paper with the sub-script C) has a balance sheet with assets at time t of $A_{C,t}$, and support granted to the borrower, S_t, which can take the form of a loan.[11] (Initially, no support has been granted, i.e. $S_0 = 0$). Assets yield the risk-free rate r_{RF}. Support in the form of loans is compensated at an interest rate r_S which is set when the support program is created.[12] On the liability side, the public sector creditor has debt financing $D_{C,t}$ and equity $E_{C,t}$.[13] Not on the balance sheet, but important for the model, is F, the total committed resources ("firepower") up to which the creditor will support the borrower. Whether F is an explicitly communicated quantity or simply the maximum level that the creditor is financially able to carry, the creditor works under the constraint that support S_t cannot exceed this level ($S_t \leq F$).

Table 1: Illustrative balance sheet of the public sector creditor

Assets	Liabilities
$A_{C,t}$	$D_{C,t}$
S_t	$E_{C,t}$

$$A_{C,t} + S_t \equiv D_{C,t} + E_{C,t} \tag{1}$$

The creditor pays an interest rate $r_{C,t}$ on its own borrowing. Together, the income from assets (at the risk-free rate) and support (at r_S) and the payments on debt in the previous period determine the income of the creditor in the current period, and in turn its new equity level. Because equity is a simple difference between overall assets (excluding support) and overall debt, this is equivalent to

borrowers.

[11] Most support to sovereigns is in the form of loans, but some programs, like the EFSF/EFSM, have used guarantees. In recent support programs for financial institutions, funding guarantees and capital injections have been more common than outright loans. While the theoretical set-up initially focusses on liquidity support (loans), the case of guarantees and equity stakes will be revisited in section 4.c.

[12] In practice, interest rates have sometimes been altered after support programs were announced. For example, the interest rates were lowered and maturities extended on the Greek Loan Facility (GLF) and European Stability Mechanism (ESM) in order to provide debt relief to Greece, Ireland and Portugal. For the purposes of tractability, these interactions are not modeled here.

[13] As will be shown in section 5, this "sovereign equity" can be viewed as the distance of the current gross public debt level from the maximum sustainable level.

adding any positive income stream over the period to the gross assets, or reducing gross assets by any negative income stream. (Often, it will be convenient to refer to the solvency ratio, given by equity over total assets, $E_{C,t}/A_{C,t}$.) Thus, the income equation is given by:

$$E_{C,t} \equiv E_{C,t-1} + A_{C,t-1} * r_{RF} + S_{t-1} * r_S - D_{C,t-1} * r_{C,t-1} \tag{2}$$

Meanwhile, the distressed borrower (denoted by the sub-script B) has assets $A_{B,t}$ yielding the risk-free rate r_{RF}, and liabilities, which include debt financing $D_{B,t}$, support S_t and equity $E_{B,t}$.[14] Positive equity implies that the borrower is solvent, while negative equity implies that the borrower defaults. ("Distress" arises because the borrower's initial equity level – while positive – is sufficiently close to zero.) The borrower pays interest rates of r_S on support from the creditor, and $r_{B,t}$ for its debt from private investors. Either on a voluntary basis or in exchange for the creditor's support, the borrower may take certain policy measures – such as fiscal consolidation or structural reforms, which we describe as M_t – that will improve its solvency. These bear quadratically increasing utility costs to the borrower which are scaled by parameter κ.[15]

Table 2: Illustrative balance sheet of B

Assets	**Liabilities**
$A_{B,t}$	$D_{B,t}$
	S_t
	$E_{B,t}$

$$A_{B,t} \equiv D_{B,t} + S_t + E_{B,t} \tag{3}$$

$$E_{B,t} \equiv E_{B,t-1} + A_{B,t-1} * r_{RF} - S_{t-1} * r_S - D_{B,t-1} * r_{B,t-1} + M_t \tag{4}$$

The debt of both the distressed borrower and public sector creditor has a maturity of one period and thus has to be rolled over at the beginning of each new period. For both the creditor and borrower, private investors will roll over all debt as long as current equity is positive (or, for the borrower, sufficient support is committed so as to ensure that investors can be repaid). Yet they will charge an

[14] In practice, most support programs – including those described in section 5 – are targeted at multiple borrowers. Here, the interaction between the creditor and only one distressed borrower will be modeled. In section 5, the balance sheets of multiple borrowers will be aggregated so as to allow comparison with the theoretical model.

[15] The variable for measures is comparable with (policy) effort e in many other models, such as Jeanne and Zettelmayer (2005) for sovereigns and Chari and Kehoe (2013) for private borrowers. In these models, effort has linear utility costs, but an indirect effect on the probability of default. The parameter κ can be understood as the domestic political costs of enacting reforms.

interest premium which compensates them for the expected probability of default in the next period, $E(\pi_{B,t+1})$ and $E(\pi_{C,t+1})$, and the (constant) loss given default λ.[16] In turn, investors calculate the probability of default subject to uncertainty about the valuation of assets. This *uncertainty* is denoted by σ_C and σ_B, which defines the expected range of possible shocks (in percent) to the creditor's or borrower's asset values. These shocks, denoted by $\theta_{C,t+1}$ and $\theta_{B,t+1}$, are uniformly distributed over the ranges $[-\sigma_C, \sigma_C]$ and $[-\sigma_B, \sigma_B]$.[17] As derived in Annex 1, the interest rates for the borrower and creditor are given by:

$$r_{B,t} = \frac{r_{RF} + E(\pi_{B,t+1}) * \lambda}{1 - E(\pi_{B,t+1})} \tag{5}$$

$$r_{C,t} = \frac{r_{RF} + E(\pi_{C,t+1}) * \lambda}{1 - E(\pi_{C,t+1})} \tag{6}$$

Throughout the model, r_{RF} will be calibrated at 2% and λ at 60%.[18] The probability of default is simply the chance that – given current values of debt and equity and the distribution of shocks $\theta_{C,t+1}$ and $\theta_{B,t+1}$ – the borrower or creditor will run into negative equity in the following period. Investors do not take into account the impact of current-period interest payments on future solvency.[19]

With these building blocks, we have a model which allows for interactions between the balance sheets of the public sector creditor and distressed borrower, and which translates these into time-varying credit spreads based on the solvency of each party. The commitment of the creditor to provide support can change expectations about the probability of default, thus lowering private borrowing costs and improving the future solvency position of the distressed borrower – a virtuous cycle. At the same time, this support may encourage strategic behavior by the borrower, that is, allowing the borrower to take fewer measures to improve solvency in the hopes of actual support. In order to model this interaction and understand the impact of *commitments* of support on credit spreads, we need to introduce multiple periods in which borrower policy effort and investor expectations of support are included.

[16] The loss given default is modeled as a dead-weight loss, or the value which is destroyed at default, regardless of the remaining assets.

[17] This variable introduces a simple element of uncertainty into the model so as to drive pro-cyclical credit spreads. Yet given the uniform distribution between two (known) extremes, this is more comparable with "risk" than with uncertainty in the sense of Knight (1921). Such an element of fundamental uncertainty, whereby the scale of potential shocks is not understood by actors could help the model further approximate reality, yet would also make it significantly less tractable.

[18] The level of 2% is based on the conventional real interest rate used in the Fisher equation, while 60% is a commonly assumed loss given default for credit default swap (CDS) contracts. Risk aversion by investors could be proxied with a scalar increase of the loss given default.

[19] Including current interest payments in expectations on the probability of default would introduce an additional "feedback loop" into the model. While this would strengthen the pro-cyclicality of the risk premia, it would make the solutions significantly more complicated to solve without adding important insights.

3.b. Four-period set-up

In order to understand how the commitment of support can affect behavior and expectations, we need a concept of *time* in the model. In many game theoretical settings, the choice for a particular number of periods (e.g. an odd or even number of periods) can have an important impact on overall results, particularly when models are solved with backward induction. A repeated game set-up, in which a particular interaction recurs in multiple (or even infinite) periods in the future, may also lead to different outcomes. For ease of explanation, this model assumes a one-off interaction between the borrower and creditor over 4 periods, where the primary purpose of the time dimension is to distinguish between initial distress, the commitment to provide support and the actual request and granting of support.[20]

Let us begin with period $t = 0$, in which the borrower and the creditor inherit a balance sheet with equity and debt. In this period, it becomes clear how distressed the borrower is (i.e. $E_{B,0}/A_{B,0}$ is observed). Without any intervention, the self-reinforcing cycle of rising interest payments and eroding equity may lead to insolvency within the coming periods.

Recognizing the potential for default, the public sector creditor jumps into action in period $t = 1$ and decides on a maximum level of potential support, given by F (for "firepower"). This can take any value in the range $[0, \infty]$, where ∞ represents an open-ended commitment ("whatever it takes"). Yet, as will be shown below, this commitment is only credible to the extent of the creditor's own solvency ("whatever the creditor can afford"). The creditor can also choose the conditions attached to support, modeled as a required amount of policy effort on the part of the borrower (see below), and the interest rate for support r_S. Concurrently in $t = 1$, the distressed borrower decides on the level of (costly) policy effort or "measures" M_1 that it should expend in order to improve its solvency and thus lower its probability of default. Measures taken in this period are purely voluntary – i.e. not yet subject to conditionality, but are accompanied by a proportional utility cost κ.

Finally, in period $t = 2$, the borrower can decide on the scale of support, $S \leq F$, it wishes to request from the creditor. The borrower knows that this suport is subject to conditionality, that is, the measures M_2 must be at least as high as a level that is proportional to S at a factor of μ ("policy conditionality parameter") decided by the creditor:

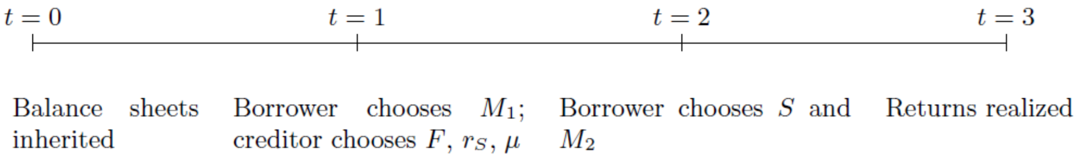
$$M_2 \geq \mu * S_2 \tag{7}$$

The scale of support S, the interest rate r_S, the measures M_2 and the credit spreads paid by both the

[20] At the beginning of this interaction, the borrower does not yet reckon with the possibility of large-scale support, and hence only changes its behavior once support has been announced. As will be shown in section 4.e, there are important effects on the borrower's behavior when this assumption is relaxed or when the model is extended to a repeated game.

borrower and the creditor will determine their solvency in period $t = 3$, in which all returns are realized. This is given schematically in figure 3.

Figure 3: Timeline of borrower and creditor actions



3.c. Objectives and optimization

The optimization problem for the borrower takes place both in period $t = 1$ and period $t = 2$, in which it must choose M_1^*, M_2^* and S^* in order to maximize its own utility, given by:

$$U_B \equiv \sum_{t=0}^{3} (E_{B,t} - \kappa * (M_t)^2) \tag{8}$$

Because the distressed borrower cares only about its own solvency across periods and the utility costs of measures, but not about the costs of default for others (particularly the public sector creditor), there are externalities in the model which may lead the borrower to take fewer measures than socially optimal in period $t = 1$ (and, without conditionality, in $t = 2$). As a simplifying assumption, there is no discounting across periods.

Meanwhile, the creditor will choose F, μ and r_S in period $t = 1$. While the creditor's objective function is not explicitly given, it can be assumed that the creditor is willing to provide support because of the potential contagion from a default by the borrower (Kapp, 2012).

Throughout our set-up, investors are largely passive players, absorbing the full debt of the creditor and borrower as long as they remain solvent, at an interest rate commensurate with the expected credit risk. Yet crucially for our model, investors understand in period 1 that the announcement of maximum support F forms a binding constraint on how much the creditor is actually willing to lend to the borrower in period $t = 2$. Hence, where this support is sufficiently large, investors may change their expectations about the probability of default π_B and π_c. This change in expectations is what drives the "bazooka" effect. Yet when actual support is granted, expectations also raise the possibility of a "pyrrhic victory" or a sharp rise in the probability of joint default (or near-default) by both the borrower and creditor.

4. Results

Having set up the model and the four-period framework, we now turn to the theoretical results of the model. This section first shows what effects the optimization by investors and the borrower will have on interest rates, policy measures and requested support in periods 1 and 2 given support by the public sector creditor. It next analyzes the outcomes in period 3, including the possibility that support erodes the creditor's solvency, leading to (the risk of) joint default by the borrower and creditor. The next sub-section discusses the alternative cases of guarantees and equity stakes, and the role of policy conditionality. Finally, the last sub-section gives some caveats and general conclusions of the theoretical model.

4.a. Optimal levels of interest rates, policy measures and requested support

If a support program is announced in period $t = 1$, this alters the distribution of potential outcomes in period $t = 2$. For some cases in which investors expect that the borrower would have become insolvent ($E_{B,t}/A_{B,t} + \theta_{t+1} < 0$), the borrower can now request support up to the maximum committed (or affordable) level ($S \leq F$) and thus roll over all its maturing debt.[21] Due to the change in investor expectations, the model predicts a decline in the expected probability of default and hence the interest rate paid by the borrower. In general, a support program will be more effective in reducing spreads the larger the firepower F is compared to the borrower's assets $A_{B,t}$ and uncertainty σ_B. Indeed, there exists a "safe" level of firepower $\overline{F}$ which – assuming the creditor can commit this level of support – completely eliminates investor expectations about the possibility of default in period $t = 2$. As derived in Annex 2, this safe level is given by:

$$\overline{F} = \sigma_B * A_{B,1} - E_{B,1} \tag{9}$$

Intuitively, the required firepower is higher when the borrower's balance sheet ($A_{B,1}$) is larger, when uncertainty σ_B is higher and when equity $E_{B,t}$ (interpretable as distance to default) is very low. As shown later, however, this safe level can become decidedly unsafe for the creditor when it approaches the creditor's equity level $E_{C,1}$.

The optimal levels of policy measures in periods 1 and 2, denoted by M_1^*, M_2^*, and the requested support level S^*, can be obtained by first-order conditions; these are formally derived in Annex 3. The optimal levels of policy measures are given by:

$$M_1^* = \frac{3 + E(r_{B,2})}{2\kappa} + \frac{E(D_{B,2}/A_{B,2}) + (D_{B,1}/A_{B,1})}{4\kappa\sigma_B} \tag{10}$$

[21] For purposes of tractability, investors will expect support to be used up to the maximum level; the possibility that the borrower prefers default over requesting support, or that F is subsequently altered is ruled out.

$$M_2^* = \frac{1}{\kappa} + \frac{(D_{B,2}/A_{B,2})}{4\kappa\sigma_B} \tag{11}$$

Hence, the optimal level of measures to be taken in the first period is increasing in the borrower's expected private interest rate $E(r_{B,2})$ and in the (expected) ratio of debt to total assets in periods $t = 1$ and $t = 2$ (i.e. the proximity to insolvency). It is decreasing in the utility costs of measures κ and uncertainty σ_B. In other words, the borrower will take more measures the closer it is to insolvency (so as to prevent default) but fewer measures when these are politically costly or when there is greater investor uncertainty about its asset valuations, which reduce the marginal benefit of individual measures.

The optimal scale of support to be requested is given by:

$$S^* = \frac{E(r_{B,2} - r_S) + \mu(1 - 2\kappa M_2^*)}{2\kappa\mu^2} \tag{12}$$

This level is increasing in the difference between the (expected) interest rate on private debt and the interest rate on support. It is decreasing in the utility cost κ of policy measures, and in the stringency of policy conditionality μ.

To capture the "bazooka effect," we are most interested in the conditions under which no or only very little support will be requested, i.e. $S^* \approx 0$. The most relevant case in which this will happen is when the announcement of support has pushed the market rate below the cost of support r_S. In case solvency would not have been guaranteed without the announcement of the support program, it can be concluded that the "bazooka" initially (i.e. in period $t = 2$) had its desired effect.

4.b. Effects on final-period outcomes and creditor solvency

The true test of the success of a support program comes not in the announcement phase (period $t = 1$), when effects on credit spreads can be observed, or even during implementation (period $t = 2$) when support requests are observed, but thereafter (period $t = 3$), when the effect of support can be compared with the counterfactual of no support.

If the counterfactual is assumed to be borrower default, then there are at least four possible scenarios in period 3 for borrower and creditor solvency:

1. **The "bazooka" is successful in lowering borrower spreads, but support is not actually requested** ($S^* \approx 0$, because $r_S > r_{B,2}$ or $\mu * S > M_2^*$). Because the creditor has no claim on the borrower, there is no change to creditor solvency relative to the counterfactual of no support.[22]

[22] While this framework does not model contagion effects, this channel would lead to a positive impact on the creditor's solvency relative to no support.

On the other hand, the "insurance" of potential support has lowered the borrower's private borrowing costs and thereby strengthened the borrower's distance to default.

2. **Support is granted, but at a level which does not threaten creditor solvency**. Formally, this is the region in which $S^* < \sigma_C * A_{C,2} - (E_{C,2})$. In this case, the creditor continues to pay the risk-free rate on its own debt, because equity is still large enough that even given investor uncertainty it is safely far from default. The borrower will benefit from lower borrowing costs, but is bound by the concomitant conditionality to take additional measures in period $t = 2$.
3. **Support is granted, but is insufficiently large to prevent default by the borrower**. This is possible in case $S^* > F$, or the support fund is too small to accommodate the full request (e.g. because a larger committed level of support would have eroded the creditor's equity position). In this case, the borrower defaults in period 3, leading to a loss of $S^* * \lambda$ to the creditor, and potentially pushing up creditor interest rates $r_{C,3}$, thus eroding equity in future periods.
4. **Support is granted, but causes the creditor to default**. When the creditor is already close to insolvency, or makes a support commitment that is very large relative to its own balance sheet (more than the creditor can afford, i.e. $F > E_{C,2}$), it is possible that the support request will fully erode the creditor's equity. If support is actually granted, the additional claim will push the creditor into insolvency ($S^* > E_{C,2}$).

These four scenarios are presented graphically in figure 4 (for borrower's equity) and figure 5 (creditor's equity). The scenarios are calibrated such that the borrower is initially close to insolvency ($E_{B,0}/A_{B,0} = 0.2, \sigma_B = 0.24$), while the public sector creditor is in a more comfortable solvency position ($E_{B,0}/A_{B,0} = 0.33, \sigma_C = 0.2$).

Thus, in the narrow case that the support fund makes itself superfluous and the "bazooka effect" arises (scenario 1), the effects are unequivocally positive. In the other three cases (scenarios 2, 3 and 4), there is the possibility of a transfer between the creditor and borrower, which may have pernicious effects on creditor solvency. While this model does not extend beyond period $t = 3$, this increase in the risk of creditor insolvency can spark a vicious spiral in future periods, in which rising interest rates subsequently erode creditor equity. Costly policy reforms or another source of external support may be necessary to ensure the sustainability of debt levels going forward.

Figure 4: Borrower equity in 4 scenarios

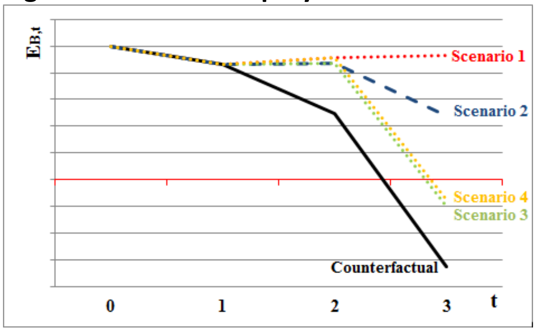
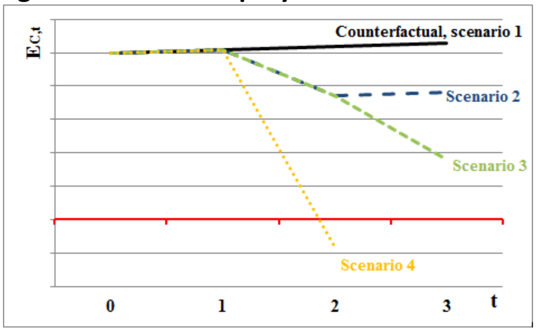


Figure 5: Creditor equity in 4 scenarios



Note: The left panel shows the equity position (solvency) of the distressed borrower in the four scenarios described above, versus the counterfactual of no support. Any value below zero (red line) indicates borrower default. The right panel shows the equity position of the public sector creditor in the same scenarios.

4.c. Guarantees, equity stakes and policy conditionality

Until now, the model has been presented in terms of support from a sovereign creditor to a sovereign borrower. Yet the basic framework can be extended to multilateral and central bank creditors, and to financial institution borrowers. The following may aid interpretation:

- **Multilateral creditors:** The balance sheets of some multilateral institutions (like the IMF, Chang Mai Initiative Multilateralization, etc.) are generally not constrained by equity positions, but rather by the total amount of resources made available by their members for lending. Hence, "equity" can be understood as the uncommitted resources of the institution. Interest rates are not determined by market borrowing but by the arrangements with member states. In the case of organizations with paid-in capital (World Bank, ESM), equity can be understood in a more direct sense, and market financing is similar to the debt issuance of a sovereign.
- **Central bank creditors:** The key difference between a sovereign and central bank creditor is the degree to which overall debt levels are binding. A central bank can in theory "print" local currency as needed, and can even operate at negative equity – with deleterious consequences for the credibility of monetary policy and, ultimately, for fiscal authorities that are liable for central bank losses (Reis, 2015; Hall and Reis, 2015). This makes the central bank "deep-pocketed" in the sense that financing constraints are *less* relevant (but not irrelevant). At the same time, the ability to demand measures (conditionality) of borrowers tends to be very low.[23] As will be shown in section 5, these peculiarities make central banks much more credible in large-scale support commitments, but also aggravate issues of borrower moral hazard.

[23] Central banks can demand that bank borrowers bring in high-quality collateral or (as a prudential supervisor or in cooperation with the supervisor) additional capital. The central bank can even incentivize lending, as the Bank of England has done with its "funding for lending scheme," or the ECB through "targeted long-term refinancing operations" (TLTROs). Yet this is likely less effective than what a government with a capital stake in a bank – i.e. full or partial ownership – can do. The influence of central banks on sovereigns is even lower. The central bank can advise a government to tighten fiscal policy or can raise interest rates (with an impact on r_B), but it cannot demand policy measures which are in the realm of parliamentary and executive decisionmaking.

- **Financial institution borrowers:** Whereas measures M_t have been interpreted until now as policy measures such as fiscal consolidation or structural reforms, in the case of financial institutions these may relate more to the divestment of specific assets or firm restructuring measures intended to improve solvency. The utility costs κ can be seen as reputational costs for the current management of taking required measures. The "conditionality parameter" μ is less straightforward in the case of financial institutions, because conditions (such as replacement of management or limits on executive pay) may be less directly related to firm solvency.

On top of the differences in interpretation of the variables, there is also often a difference in the form of support. For example, while most support to sovereigns is in the form of loans or related debt instruments,[24] support to financial institutions is more often in the form of funding guarantees or recapitalization (equity stakes).[25] This section briefly considers these cases in terms of this model.

A funding guarantee is a contingent claim, whereby the public sector creditor (for a fee) promises to reimburse investors for credit losses on all or a part of the distressed borrower's debt. This essentially links the borrowing costs of the borrower to those of the creditor. While the guarantees do not immediately show up as a new liability on the creditor's balance sheet, the new liability will arise at the moment that the borrower defaults. Thus, guarantees have the advantage of providing support without (initially) burdening the creditor's balance sheet. As long as the creditor is highly solvent, the interest rate on support will remain fixed. Yet if investors take the possibility of borrower default into account in their expectations one period ahead, then support in the form of guarantees will impact the creditor's solvency, and potentially the interest rate of support.[26]

By contrast, equity stakes must be funded immediately on the creditor's balance sheet, yet also directly improve the solvency of the distressed borrower. Such support is compensated through dividends, which depend on the state of the borrower's finances. Naturally, this form of support implies more volatility in the value of the creditor's claim than in the case of a loan – but not necessarily more overall risk, because default (now a more remote possibility) would lead to a loss on either a loan or an equity stake. Moreover, there is also more potential to share in potential positive shocks to the borrower's income and equity value.

[24] IMF support formally takes the form of "purchases" of foreign currency by the country's central bank or Treasury in exchange for domestic currency. Yet given the rule-based framework for the disbursement schedule, maturity and interest rates, this "exchange of assets" is economically equivalent to a loan. Central bank purchases of government bonds in the secondary market represent the transfer (for a price) of the debt claim on the sovereign from private investors to the central bank.

[25] While sovereigns cannot be "recapitalized," official debt relief decreases a country's debt burden and thus increases its sovereign "equity" (distance from default). Debt restructuring and relief goes beyond the bounds of the current study.

[26] In practice, creditors could choose to renege on guarantees, as the Austrian government did in 2014 for guarantees by the state of Carinthia for the junior debt of Hypo Alpe Adria Bank. This additional flexibility by the government relative to a loan has to be weighed against the potential that such steps could increase uncertainty and reduce the effectiveness of guarantees in the future.

Yet because of this effectiveness, equity stakes (in this paper's model) also dull the incentives for the borrower to take measures to improve solvency. Equity stakes also represent a transfer from existing equity holders to bond holders. Borrower moral hazard considerations can be ameliorated with targeted conditionality (denoted in the model by an appropriate level of μ). Investor moral hazard (over-lending in anticipation of support) remains in place and, in fact, is a key driver of the potential effectiveness of these forms of support.

4.d. Welfare implications

The fundamental question behind the commitment of support is whether the policy intervention is simply a risk transfer between the borrower and creditor, or can actually represent a Pareto improvement. While the partial equilibrium approach makes it difficult to derive such results quantitatively, welfare can be described in qualitative terms.

When the "bazooka effect" is successful, borrower funding costs decline without any change in the creditor's balance sheet. While the extent of policy measures taken by the borrower will also decline, this may be a welfare-improving outcome – assuming that measures have a social cost, and are not simply a utility transfer between the borrower and other actors (see Jeanne and Zettelmayer, 2005). On the other hand, the creditor has taken on *potential* liabilities. While the creditor may have a greater capacity to take on risk than the borrower – e.g. due to a much larger balance sheet, or a lower level of uncertainty around asset valuations ($\sigma_C < \sigma_B$) – the probability that support would have been needed means that the commitment of support is not necessarily costless. The cost could even be estimated as a simple product of the probability that support is called upon and the costs to the creditor in this case. Particularly if the model were extended to a repeated game setting where the availability of support increases the likelihood of future commitments, there would be non-negligible risks of permanent transfers between the creditor and borrower.

A much more clear-cut welfare improvement would arise if the granting of support actually reduced uncertainty around the valuation of the borrower's assets – for example, because support is granted jointly with a stress test or enhanced disclosure by the borrower, or because support removes the possibility of disorderly "tail events." This effect, which can be modeled as a reduction in σ_B in period $t = 1$, would lead to a reduction in the borrower's funding costs and a reduction in the probability of support by the creditor – unambiguous welfare improvements for these parties. Because investors would continue to charge a rate commensurate with the expected probability of default by the borrower, there would be no change in investor utility.[27] As will be seen in the case of TARP and OMT, such a reduction in uncertainty may have played a larger role in the effectiveness of

[27] The case that disclosure is false and provides undue reassurance to investors – and thus excessively low risk premia – is not examined here.

these programs than actual support.

4.e. Caveats and conclusions of the theoretical model

The theoretical results show that the conditions under which a support program can have a "bazooka" effect are sensitive to the initial calibration of the model. It is evident that the results depend on each of the parameters – in particular the initial solvency of the borrower and creditor, the scale of uncertainty σ_B, and the utility costs κ to the borrower of policy measures to improve solvency. Given these initial characteristics, the creditor's choices of firepower F, the form of support (loans versus guarantees, equity stakes or relief), the cost of support r_S and policy conditionality μ can have far-reaching effects on end outcomes. For now, the model has not introduced optimization by the creditor, but this could be an avenue for future work.

Because the model is based on predictable linear relationships and a uniform distribution of potential outcomes in the next period, it may not reflect some important non-linearities in financial markets. For example, while the modeling of interest rates does allow for vicious or virtuous spirals in solvency, there is no role for unexpected "tail events" or structural changes in the "rules of the game."[28] The model also does not go into detail on the creditor hierarchy in case of default, which may alter investors' incentives in the case of very large actual support.[29] Modeling these issues could be a fruitful means to more accurately reflect reality in several recent crises, but would introduce such additional complexity that it would be much less tractable to solve and for purposes of illustration.

Nonetheless, the results allow for three broad policy conclusions on the "bazooka" effect:

1. **The expectation of support can lower interest rates and improve solvency.** Liquidity support at relatively favorable interest rates can substitute for private market financing with risk premia, and thus prevent a self-sustaining decline in solvency. Even one period ahead, investors' expectation that the distressed borrower will be supported can remove the risk of insolvency in certain states of the world, and allow the borrower to borrow at lower interest rates even if no support is given.
2. **Support is more effective the larger its scale relative to the borrower's balance sheet, the more**

[28] One example is the shift in investor expectations on the possibility of sovereign default in the euro area or of a break-up of the euro area. These risks were widely seen as negligible prior to the global financial crisis, but became quite acute in 2011 and 2012 after the default of the Greek government. The announcement of OMT was accompanied by a strong shift in expectations, with expectations on the probability of a break-up of the euro area again falling considerably. See section 5.

[29] The IMF's preferred creditor status (PCS) makes it senior to private investors in case of sovereign default by a program country. If the IMF were to finance a very large share of a country's debt, this could deter investors from buying the remaining debt securities of the country, as they would have a much larger proportional exposure to potential losses. These considerations were relevant during the design of the ESM, which is agreed to have PCS (junior only to the IMF). Yet the euro area countries decided to forego the PCS in the specific case of the recapitalization of Spanish banks.

solvent the public sector creditor and the lower the uncertainty. A large or even unlimited support program by a very solvent creditor can be very effective in changing expectations about the probability of default. The required firepower to ensure solvency is lower when uncertainty is lower.[30] On the other hand, support by a creditor that is itself on the border of solvency, or promises more support than it can afford, is much less effective. In this case, the public sector creditor is unlikely to continue to provide support as it runs into its own difficulties, and future commitments in any case become worthless in the case of default.

3. **Policy conditionality can reduce the chances of actual support, and enhance its effectiveness.** Because policy conditionality requires the borrower to take additional measures to improve solvency, and because these bear a utility cost, borrowers will avoid actual support unless it is needed. When support is given, however, this conditionality mitigates borrower moral hazard and ensures that the borrower continues to take measures to remain solvent. If the cost is very high, then the borrower will only take measures when potential default is imminent.

Testing the validity of these conclusions requires recourse to actual examples of support programs.

5. Application

This section looks at real-life examples of public sector support funds, and compares their characteristics with actual effectiveness. To bridge the gap between the theoretical model and the actual examples, the attributes of the fund are expressed as much as possible in terms of the parameters of the model. Specifically, key indicators for each program are the ratio of borrower equity and firepower to total borrower assets; a rough estimate of the uncertainty around asset valuations ($\sigma_{B,1}$) is also given. Creditor solvency and policy conditionality are explained qualitatively.

In the immediate period following the global financial crisis, many countries took measures to bolster confidence in the banking sector – including by making large recapitalization funds available. These included TARP in the US, SoFFin in Germany, the *Fondo de reestructuración ordenada bancaria* (FROB) in Spain and the 2008 Credit Institutions Financial Support Scheme (CIFS) and 2009 Eligible Liabilities Guarantee (ELG) in Ireland. These funds offered support through a combination of equity stakes, asset purchases and funding guarantees.[31]

Table 3 summarizes the chief characteristics of these selected support programs for financial institutions. In terms of relative size, it is clear that the German SoFFin was significantly larger

[30] Measures which actually lower uncertainty about asset valuations could also be modeled as having an effect on uncertainty σ_B. An interesting application could be the use of stress tests – including after the activation of TARP and FROB, or in the recent Asset Quality Review (AQR) by the ECB – which provide further transparency on potential losses by financial institutions and thus allow for better differentiation between risks by investors

[31] It could be argued that the ECB's very long-term refinancing operations (VLTROs) of December 2011 and February 2012 were also a means of supporting the euro area banking sector. Yet because the VLTORs were intended to be used, they are not considered here.

relative to the supported institutions than TARP or FROB; it was also targeted at a relatively small group of banks which were in relatively poor financial shape (average total equity ratio of 2.1%, with Hypo Real Estate actually having negative equity at the time of recapitalization). This relatively large size may explain why a much smaller proportion of these support funds was ultimately used. Of the selected cases of financial sector support, the German government's initiative is the only program which came close to having the desired "bazooka effect" (scenario 1 in section 4b). TARP was initially less successful in bringing down credit spreads, and a significant fraction of the committed support was ultimately mobilized (scenario 2). The effectiveness of TARP was likely bolstered significantly by the Supervisory Capital Assessment Program ("bank stress test") of May 2009, which – in the terms of this paper's model – aimed to reduce uncertainty around initially high asset valuations (σ_B) so as to bring down credit spreads and thus restored confidence in the US banking sector, as seen in 5-year credit default swaps (CDS) (see figure 6). Ultimately, despite increased risk to U.S. taxpayers, TARP was successful in stabilizing the U.S. financial system.[32]

Table 3: Characteristics of selected public sector support programs for financial institutions

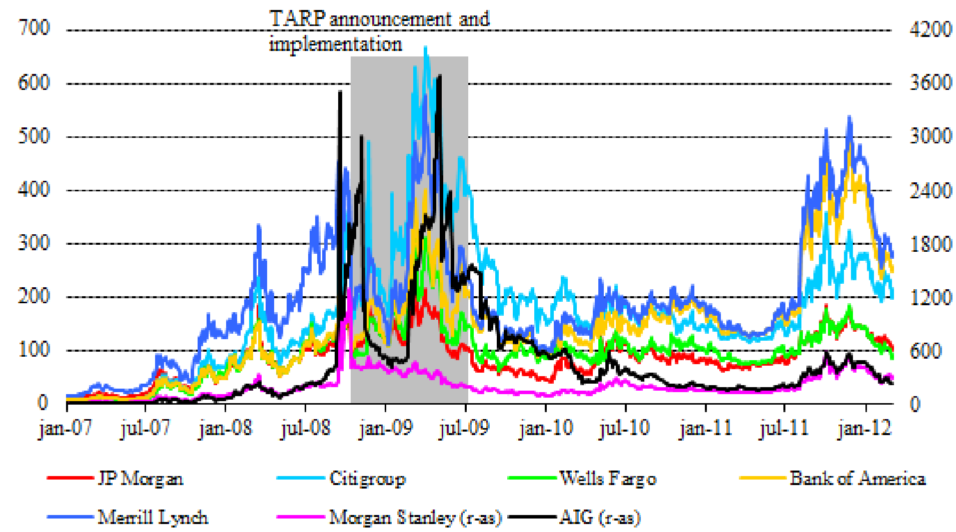
Program	**TARP**	**SoFFin**	**FROB**	**CIFS / ELG**
Creditor	US sovereign	German sovereign	Spanish sovereign	Irish sovereign
Target market	US financial institutions	German banks	Spanish banks	Irish banks
Examples of borrowers	JPM, Citi, Merill Lynch, BoA, AIG	Hypo Real Estate, Commerzbank, WestLB	Bankia, NCG, CatalunyaBank	Anglo Irish Bank, Allied Irish Bank, Bank of Ireland
$\boldsymbol{D_{B,1}}$ (date)	\$ 12.66 trn (2008)	€2.05 trn (2008)	€3.27 trn (2012)	€778 bn (2009)
$\boldsymbol{E_{B,1}}$ (date)	\$ 755 bn (2008)	€43 bn (2008)	€188 bn (2012)	€43 bn (2009)
$\boldsymbol{F}$ (date)	\$700 bn (2008)	€500 bn (2008)	€99 bn (2012)	Unannounced
$\boldsymbol{E_{B,1}/A_{B,1}}$	6.0%	2.1%	5.7%	5.3%
$\boldsymbol{F/A_{B,1}}$	5.5%	24.4%	3.0%	Unannounced
$\boldsymbol{\sigma_{B,1}}$ (estimate)	12%	10%	10%	15%
$\boldsymbol{S}$ (date)	\$431 bn (2012)	93.2 bn (2009)	61.2 bn (2013)	€75 bn (2013)
Support method	Equity stakes / asset purchases	Equity stakes / guarantees	Equity stakes	Liability guarantees
Measures	Restrictions on executive pay	Adequate capitalization	Stress test, asset transfers	Stress test, recapitalization

Note: Estimations of $\mathrm{A_{B,1}}$ and $\mathrm{E_{B,1}}$ are based on the aggregated balance sheets of all supported financial institutions at the time support was announced. Total equity ratios are comparable to a simple (unweighted) leverage ratio. Due to diverging accounting standards between the US and EU, total equity is not fully comparable across columns. Estimates of $\sigma_{\mathrm{B,1}}$ are based on a (rough) approximation of the ratio between

[32] Veronesi and Zingales (2010) estimate that the intervention "increased the value of banks' financial claims by \$130 billion at a taxpayers' cost of \$21-\$44 billion with a net benefit between \$86 and \$109 billion." Berger and Roman (2014) find that regions which benefited from TARP support for banks experienced significantly higher net job creation and lower business and personal bankruptcies.

credit spreads and the borrowers' equity ratio at the time support was announced.
Sources: US Treasury, German, Spanish and Irish government publications, banks' annual financial accounts and author's calculations.

Figure 6: CDS spreads of major US banks following TARP
per day, in basis points, 2007-2012



Source: Datastream, FRB

The Irish liability guarantees, which were accompanied by state recapitalizations of the affected institutions, significantly eroded the financial capacity of the government (most closely resembling scenario 3 above). Even though the supported banks initially had higher equity ratios (5.3%) than the supported banks in Germany (2.1%), the uncertainty around asset valuations (σ_B) was likely higher. More importantly, the size of the necessary support (roughly 42% of GDP in 2009) was much larger relative to the balance sheet of the Irish government. Ultimately, the Irish government was compelled to take on external (EU/IMF) support to maintain solvency. While it is not possible with hindsight to conclude whether a decision not to provide support to the banks would have led to better outcomes, the Irish case was instrumental in European policy initiatives to reduce the public costs of bank resolution.[33]

Support for sovereigns has been similarly widespread over the post-crisis period (table 4). This began with the April 2009 London Summit, in which G20 countries committed to increasing the size of the IMF's resources by $500 billion with bilateral loans and the so-called New Arrangements to Borrow (NAB). These resources gave the IMF the ability to radically increase its lending to crisis-struck member countries such as Iceland, Latvia, Romania, Hungary and Pakistan. Moreover, the IMF provided new flexible credit lines (FCLs) to Poland, Mexico and Colombia. FCLs are a precautionary

[33] These include the EU Bank Recovery and Resolution Directive (BRRD) and the Single Resolution Mechanism (SRM) in the euro area, which include the requirement of bail-in of private creditors in bank resolution.

program, available only to countries with very strong fundamentals, which is meant to serve as a backstop and not be drawn on. Together, these programs were generally effective at responding to acute balance of payments pressures and bringing down high sovereign spreads. Of course, isolating causality is difficult, given that such programs occurred concurrently with measures to bolster the solidity of financial institutions in the US and Europe, and a simultaneous wave of fiscal stimulus programs coordinated at the same G20 summit. Nonetheless, the large size of the new funds relative to the affected countries likely also provided confidence for global credit markets (see figure 7). One key mechanism, especially for the case of the FCLs, could have been the positive signal about the fundamentals of supported countries, which again contributed to lowering uncertainty (σ_B) around a group of countries which – on average – were fundamentally solvent.

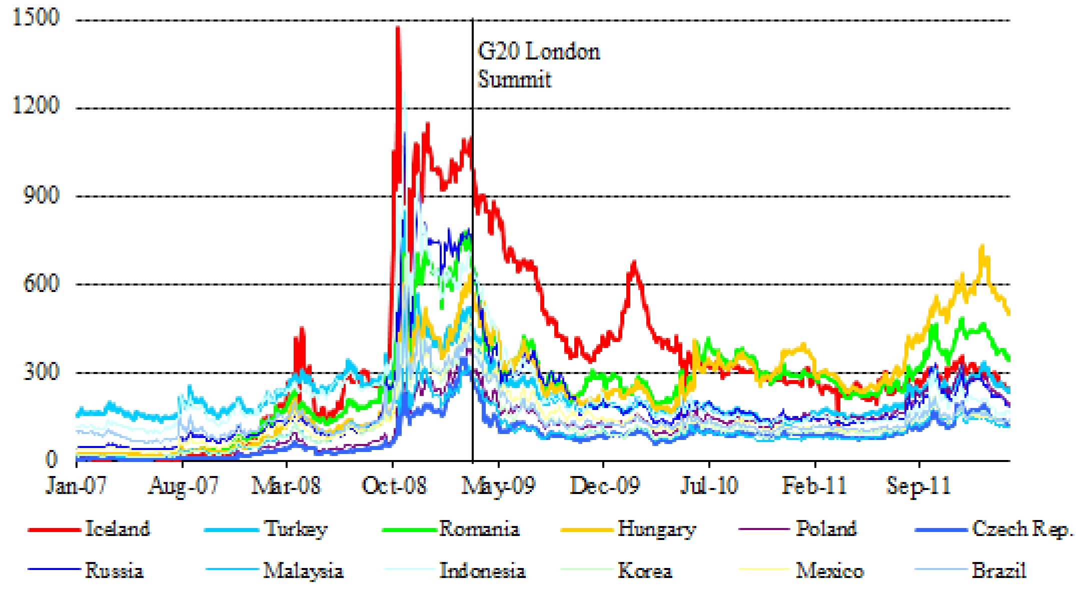
Table 4 Characteristics of selected public sector support programs for sovereigns

Program	**Expanded IMF**	**EFSF/EFSM**	**SMP I and II**	**OMT**
Creditor	IMF member countries	All euro area sovereigns	ECB	ECB
Target market	Emerging market sovereigns	Distressed euro area sovereigns	Distressed euro area sovereigns	Distressed euro area sovereigns
Examples of borrowers	Latvia, Iceland, Romania, Hungary, Pakistan; Poland, Colombia, Mexico	Greece, Ireland, Portugal	Greece, Ireland, Portugal, Cyprus, Spain, Italy	N/A
$\boldsymbol{D_{B,1}}$ (date)	\$1.36 trn (2009)	€647 bn (2010)	€3.37 trn (2011)	€3.59 trn (2012)
$\boldsymbol{E_{B,1}}$ (date)	\$1.27 trn (2009)	€46 bn (2010)	€467 bn (2011)	€183 bn (2012)
$\boldsymbol{F}$ (date)	\$500bn (2009)	€500 bn (2010)	Unannounced	Unannounced
$\boldsymbol{E_{B,1}/A_{B,1}}$	48.2%	6.6%	12.2%	4.8%
$\boldsymbol{F/A_{B,1}}$	19.0%	72.2%	Unannounced	Unannounced
$\boldsymbol{\sigma_{B,1}}$ (estimate)	30%	15%	15%	20%
$\boldsymbol{S}$ (date)	\$88bn (2010)	€235.8 bn (2011)	€260 bn (2012)	0 (2014)
Support method	IMF program	EU/IMF program	Bond purchases	Bond purchases
Measures	Standard IMF conditionality	EC(/ECB/IMF) conditionality	N/A	ESM program / conditionality

Note: Estimations of $D_{B,1}$ are based on the aggregated public debt of all supported sovereigns, while estimations of $E_{B,1}$ are the sum of distressed countries' distance from a potential maximum sustainable level of public debt, assumed here to be 80% for emerging markets and 120% for advanced economies.
Source: IMF, ESM, ECB and author's calculations

When stress spread to euro area governments, starting with Greece in late 2009, the model of large-scale support proved less effective. First with the Greek Loan Facility (GLF) of bilateral loans to support the Greek IMF program, and then with the European Financial Stability Facility (EFSF) and European Financial Stability Mechanism (EFSM), European governments attempted to provide large-scale support to "overwhelm" the markets, but were largely unsuccessful in preventing sovereign spreads in peripheral countries from rising further (see Erce, 2014, for a good overview). While the scale of potential support relative to the "assets" of affected countries (maximum debt carrying capacity) was undeniably large (an unprecedented 72.2%), effectiveness was likely undermined by the deteriorating solvency position of the affected borrowers (indeed, Greece quickly turned out to have an unsustainable debt level) and the high policy uncertainty given open disagreement between European governments on the crisis management strategy. The fact that the effective financing capacity of the EFSF and EFSM, which were based on guarantees by the member states, turned out to be much smaller than the committed €500 billion, also undermined the credibility of the support commitment. (Ultimately, many of these issues were redressed in the design of the ESM, which is financed by paid-in equity capital from member states.)

Figure 7: CDS spreads of selected sovereigns around the G20 London Summit
per day, in basis points, 2007-2012



Source: Datastream

Support from the ECB through the Securities Market Program (SMP), announced concurrently with the EFSF/EFSM, was similarly unsuccessful, with the announcement and actual bond purchases having only very short-lasting effects on credit spreads (see Pattipeilohy, van den End, Tabbae, Frost and de Haan, 2013). In 2010-2012, in a period of "destructive ambiguity," the markets continually tested whether the ECB was truly committed to support, or would discontinue the program. While the size of SMP was unannounced – and hence theoretically unlimited – it was very clear that there were practical limits to the size of support, due in part to the public disagreement within the Governing Council about the program.[34] Moreover, there was no mechanism of policy conditionality

[34] In particular, Bundesbank governor Axel Weber publicly expressed that the program should be phased out,

for purchases.[35]

Speculation about the determination of the ECB to support distressed sovereign borrowers continued well into the summer of 2012, when the ECB finally decided on Outright Monetary Transactions (OMT). Formally announced on 2 August 2012, OMT was the implementation of Mario Draghi's now-famous words one week earlier that "*within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough*."[36] By 2012, debt positions of the affected countries had worsened further, meaning in the terms of our model that the average ratio of "equity" to total assets (4.8%) was even worse than in 2011 (12.2%). Yet in contrast to SMP, support under OMT was explicitly bound to the distressed borrower having an ESM program (with the understanding that IMF involvement would also be sought), with standard policy conditionality. This helped to overcome some – though not all – of the resistance in the Governing Council to an unlimited size of the program, thus increasing the credibility of the overall undertaking. The concurrent promise that "*it will be enough*" may be understood to have lowered uncertainty (σ_B), as the ECB implied that it would take action in all possible states of the world to safeguard the stability of the euro. In response, credit spreads of the affected countries fell dramatically, and remained well below peak levels in the ensuing two years (figure 8).[37]

SMP and OMT illustrate the particularities of large-scale support by central banks more generally (section 4c). While the financial capacity of the Eurosystem makes it equivalent to a large and highly solvent ("deep-pocketed") creditor, the inability to enforce policy conditionality means that support was continually hamstrung by concerns about borrower moral hazard. OMT form one model of overcoming this barrier, in that central bank purchases are explicitly linked to external support – and conditionality – from the ESM and IMF. Moreover, by removing "tail scenarios" such as a break-up of the euro area, OMT could also be seen as reducing uncertainty about the borrower's financial position in adverse states of the world. This combination of large (central bank) firepower, conditionality and reduction in uncertainty is likely the key to OMT's effectiveness in putting an end to sovereign stress in the euro area, thereby making actual support unnecessary.

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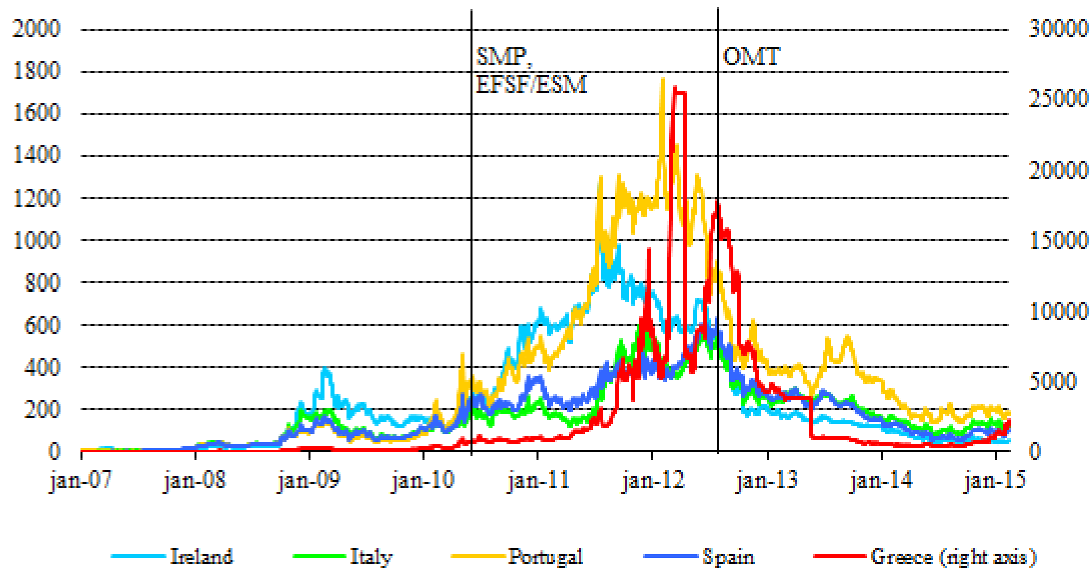
while other members of the Governing Council supported SMP. In a 2012 interview, Paul De Grauwe compared the ECB's strategy with "*a general saying that he will win a war by minimizing shooting. It just doesn't work*." See Landon Thomas Jr., " In Europe, Looking for Patient Bond Buyers," New York Times, 29 June 2012.

[35] This issue was illustrated by a leaked August 2011 letter, in which ECB President Jean-Claude Trichet and Banca d'Italia Governor Mario Draghi urged Italian Prime Minister Silvio Berlusconi to take "*pressing action... to restore the confidence of investors*" during the period of SMP purchases. Yet only shortly after ECB purchases, Berlusconi withdrew many of the initially announced legislative reforms, particularly on pensions. See Guy Dinmore and Ralph Atkins, "ECB letter shows pressure on Berlusconi," *Financial Times*, 29 September 2011.

[36] See Mario Draghi, "Speech at the Global Investment Conference in London," 26 July 2012.

[37] Of course, a key concern was whether the ECB would truly be willing to halt purchases of a government that did not abide by program conditionality, and whether OMT would facilitate or hinder the political progress on Europe-wide reforms like the banking union. For these and related quesitons, see Gene Frieda, "Is Europe's Financial Crisis Over?," *Project Syndicate*, 17 September 2012.

Figure 8: CDS spreads of GIIPS countries around SMP, EFSF/EFSM and OMT
per day, in basis points



Source: Datastream

6. Conclusions and policy implications

This paper has shown that even the expectation of support by a public sector creditor can substantially improve the financing conditions of a distressed borrower and thus contribute to a virtuous circle in which market stress ameliorates and a crisis is averted. The “bazooka effect” is possible given conditions in which the size of committed support is sufficiently large relative to the borrower’s balance sheet, the borrower and creditor are (sufficiently) solvent and the conditionality of support is appropriate for improving solvency. In practice, support can also reduce uncertainty around borrowers’ asset valuations, e.g. through stress tests (as with TARP) or by removing certain tail risk scenarios (as with OMT). In these cases, the actual credit risk of the borrower will decline and there is likely to be a catalytic effect on debt markets. Yet these conditions have not always been fulfilled in practice. When these “ideal” conditions are loosened, there can be scenarios in which the support will not work, the borrower will remain under stress or – in a worst case – the creditor will itself approach insolvency. In these cases, it is better to avoid public sector support and opt instead for an orderly restructuring of the distressed borrower’s debt.

Moreover, the model and examples raise the possibility of borrower moral hazard, by which distressed borrowers will take fewer measures due to the existence of support programs. These risks can be mitigated to a large extent by the conditionality of support. Conditions which are targeted to improve solvency and which are not too costly for the borrower can be an effective way to bolster the effectiveness of support programs, and make them more palatable to public sector creditors – a "grand bargain" which allows for large safety nets, particularly if these are to be made permanent. Yet outside the framework of this paper, the public sector may choose to complement the availability of conditional support programs with strong *ex ante* measures to limit risks to borrower solvency. In the case of private sector borrowers, such as financial institutions, these include stronger financial regulation, i.e. capital and liquidity buffers and macro-prudential policy to protect the solidity of the financial system. For sovereign borrowers, the tools at hand may include better regional and global surveillance (e.g. at the IMF) and rules to limit excessive debt levels and macroeconomic vulnerabilities (such as the Fiscal Compact and macroeconomic surveillance by the European Commission in the EU).

This paper is intended as one contribution to a conceptual framework for policy so as to help determine whether and how a support program should be designed. There are doubtless many alternative means of thinking about the same questions, and further refinements of the theoretical assumptions. By analyzing the experience with a rigorous theoretical framework and empirical approaches, such research can derive lessons to enhance the effectiveness of – and reduce the need for – bazookas in the future.

Annex 1: Optimal interest rate charged by investors

In each period, investors roll over all maturing debt of both the distressed borrower and the public sector creditor, as long as equity levels are positive (see Annex 2 for the case of support). Investors charge rates $r_{B,t}$ and $r_{C,t}$ which are commensurate with the expected probability of default in the next period, $E(\pi_{B,t+1})$ and $E(\pi_{C,t+1})$ and the (constant) loss given default λ. The probability of default is based on the expected range of possible shocks to the value of assets, which could erode equity to below zero. These shocks, denoted by $\theta_{C,t+1}$ and $\theta_{B,t+1}$, are uniformly distributed over the range $[-\sigma_C, \sigma_C]$ and $[-\sigma_B, \sigma_B]$, where σ_C and σ_B are an exogenous measure of uncertainty about asset values. Thus, without support, the probability of default is the probability that in the next period, a shock could lead the current equity ratio below zero. These probabilities are given by:

$$E(\pi_{C,t+1}) = P(E_{C,t} + \theta_{C,t+1} * A_{C,t} < 0) \tag{13}$$

$$E(\pi_{B,t+1}) = P(E_{B,t} + \theta_{B,t+1} * A_{B,t} < 0) \tag{14}$$

Given the uniform distribution of $\theta_{C,t+1}$ and $\theta_{B,t+1}$, this can be solved as:

$$E(\pi_{C,t+1}) = \begin{cases} 0 & \forall E_{C,t}/A_{C,t} > \sigma_C \\ \dfrac{\sigma_C - (E_{C,t}/A_{C,t})}{2 * \sigma_C} & \forall E_{C,t}/A_{B,t} \in [0, \sigma_C] \\ 1 & \forall E_{C,t}/A_{C,t} < 0 \end{cases}$$

$$E(\pi_{B,t+1}) = \begin{cases} 0 & \forall E_{B,t}/A_{B,t} > \sigma_B \\ \dfrac{\sigma_B - (E_{B,t}/A_{B,t})}{2 * \sigma_B} & \forall E_{B,t}/A_{B,t} \in [0, \sigma_B] \\ 1 & \forall E_{B,t}/A_{B,t} < 0 \end{cases}$$

In other words, the probability of default in the next period is 0% whenever the equity ratio is sufficiently high (greater than the amount that could be wiped out by the largest possible negative shock σ_B), 100% whenever equity is already zero or negative, and otherwise proportional to the possibility of equity being negative given the uniform distribution of shocks. This probability will increase linearly as the equity ratio $E_{B,t}/A_{B,t}$ approaches zero. This is represented graphically in figure 9 (for the borrower; the distribution for the creditor is comparable).

Figure 9: Probability of default vs. equity

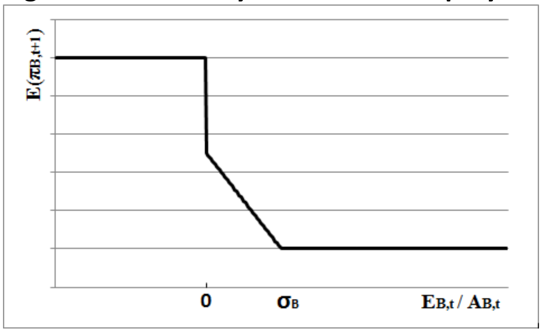
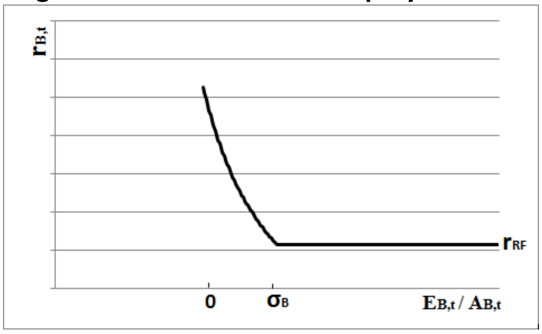


Figure 10: Interest rate vs. equity



Investors are only willing to invest in the borrowers' and creditors' debt if the return $r_{B,t}$ and $r_{C,t}$ compensates them for the risk that the borrower or creditor will default and they will only receive $1 - \lambda$. Formally, this is expressed by:

$$1 + r_{RF} = E(\pi_{C,t+1}) * (1 - \lambda) + (1 - E(\pi_{C,t+1})) * (1 + r_{C,t}) \tag{15}$$

$$1 + r_{RF} = E(\pi_{B,t+1}) * (1 - \lambda) + (1 - E(\pi_{B,t+1})) * (1 + r_{B,t}) \tag{16}$$

By rearranging, the optimal interest rate can be solved as:

$$r_{B,t} = \frac{r_{RF} + E(\pi_{B,t+1}) * \lambda}{1 - E(\pi_{B,t+1})} \tag{17}$$

$$r_{C,t} = \frac{r_{RF} + E(\pi_{C,t+1}) * \lambda}{1 - E(\pi_{C,t+1})} \tag{18}$$

This interest rate is shown in figure 10 for the borrower (again, the figure for the creditor is comparable).

Annex 2: Effect of announcement of a support program

If a support program is announced in period $t = 1$, this alters the distribution of potential outcomes in period $t = 2$. For some cases in which investors expect that the borrower would have become insolvent ($E_{B,1} + \theta_{B,2} * A_{B,1} < 0$), it can now request support up to the maximum committed level ($S \leq F$) and thus roll over all its maturing debt. If the support is sufficiently large ($F/A_{B,1} \geq \sigma_B - (E_{B,1}/A_{B,1})$), then investors no longer consider default a possible outcome, and charge zero risk premia. In other words, there exists a "safe" level of maximum committed support $\overline{F}$ that insures the borrower against default in all states of the world that investors consider realistic. This level is given by:

$$\overline{F} = \sigma_B * A_{B,1} - E_{B,1} \tag{19}$$

In the more interesting case that support is below the "safe" level ($F \leq \overline{F}$), the expected probability of default for the borrower given support is given by:

$$E(\pi_{B,2}|F) = \begin{cases} 0 & \forall E_{B,1}/A_{B,1} > \sigma_B - (F/A_{B,1}) \\ \dfrac{\sigma_B - (E_{B,1}/A_{B,1}) - (F/A_{B,1})}{2 * \sigma_B} & \forall E_{B,1}/A_{B,1} \in [-(F/A_{B,1}, \sigma_B - (F/A_{B,1})] \\ 1 & \forall E_{B,1}/A_{B,1} < -(F/A_{B,1}) \end{cases}$$

This means that the probability of default and the credit spread have declined proportionally with the size of the support fund's firepower. This is shown in figures 11 and 12, where the black solid line indicates the situation without a support fund, and the red dashed line indicates the probability of default and interest rate with a support fund in place. (In figure 12, the black line represents the private interest rate $r_{B,t}$, while the rate charged for support r_S is given by the dashed blue line.) The red line represents a shift to the left, as for certain levels of equity previously considered unsafe (including some mildly negative values of equity), investors now expect that the public sector will provide official financing up to the committed level, thus ensuring that under more states of the world (adverse outcomes of asset valuation), all debt will be rolled over and investors repaid.

Figure 11: Probability of default with support

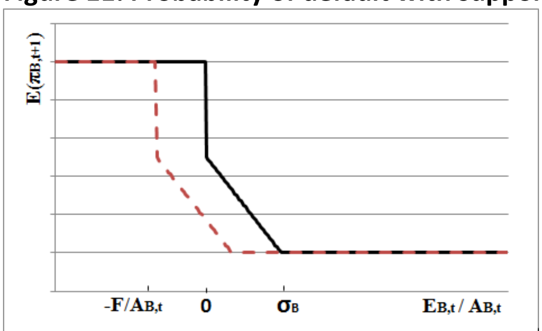
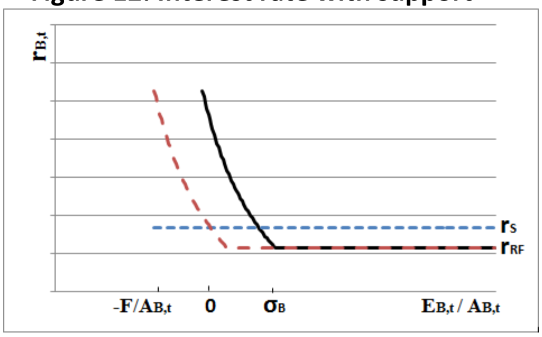


Figure 12: Interest rate with support



Annex 3: Optimal policy measures and support request

The distressed borrower faces an optimization problem in periods $t = 1$ and $t = 2$, in which it must choose M_1, M_2 and S. The optimal levels M_1^*, M_2^* and S^* which maximize utility U_B can be derived with first-order conditions. For M_1^*, this is given by:

$$\frac{\partial U_B}{\partial M_1} = \frac{\partial E_{B,1}}{\partial M_1} + \frac{\partial E_{B,2}}{\partial M_1} + \frac{\partial E_{B,3}}{\partial M_1} - 2\kappa M_1^* = 0 \tag{20}$$

By taking the partial derivative of equation (4) with respect to M_1 and substituting this into equation (20), we obtain:

$$(1 - D_{B,2} * \frac{\partial r_{B,2}}{\partial M_1}) + (1 - D_{B,1} * \frac{\partial r_{B,1}}{\partial M_1}) + (1) - 2\kappa M_1^* = 0 \tag{21}$$

By substituting in the partial derivative of equation (17) with respect to M_1 and rearranging terms, we are able to solve for M_1^*:

$$M_1^* = \frac{3 + E(r_{B,2})}{2\kappa} + \frac{E(D_{B,2}/A_{B,2}) + (D_{B,1}/A_{B,1})}{4\kappa\sigma_B} \tag{22}$$

Notably, the optimal level of measures to be taken in the first period is increasing in the borrower's expected private interest rate $E(r_{B,2})$ and in the (expected) ratio of debt to total assets in periods $t = 1$ and $t = 2$ (i.e. the proximity to insolvency). It is decreasing in the utility costs of measures κ and uncertainty σ_B. In other words, the borrower will take more measures the closer it is to insolvency (so as to prevent default) but fewer measures when these are politically costly or when there is greater investor uncertainty about its asset valuations, which reduce the marginal benefit of individual measures. The optimal level of measures to be taken in the second period looks similar:

$$M_2^* = \frac{1}{\kappa} + \frac{(D_{B,2}/A_{B,2})}{4\kappa\sigma_B} \tag{23}$$

The optimal level of support to be requested can be derived using a similar process, with the partial derivative of equation (20) with respect to S. As above, the solution depends on the partial derivatives of equations (4) and (17) with respect to S:

$$\frac{\partial U_B}{\partial S} = -r_s + r_{B,2} + \mu - 2\kappa\mu^2 * S^* = 0 \tag{24}$$

By rearranging, we obtain:

$$S^* = \frac{(r_{B,2} - r_S) + \mu(1 - 2\kappa M_2^*)}{2\kappa\mu^2} \tag{25}$$

Here, the optimal scale of support to be requested is clearly increasing in the difference between the interest rate on private debt and the interest rate on support. It is decreasing in the utility costs κ of policy measures, and in the stringency of policy conditionality μ.

Annex 4: Overview of variables

Notation	Variable name
A_C	Assets of the (public sector) creditor
E_C	Equity of the creditor
D_C	Debt of the creditor
A_B	Assets of the (distressed) borrower
E_B	Equity of the borrower
D_B	Debt of the borrower
F	Firepower (maximum available support)
S	Support granted to the borrower
r_S	Interest rate on support granted to the borrower
r_C	Interest rate paid by the creditor
r_B	Interest rate paid by the borrower
r_{RF}	Risk-free interest rate
π_B	Probability of default of the borrower
π_C	Probability of default of the creditor
λ	Loss given default
σ_C	Uncertainty around creditor's asset valuations
σ_B	Uncertainty around borrower's asset valuations
θ_C	Uncertainty shock to creditor assets
$\square_B$	Uncertainty shock to borrower assets
U_B	Borrower's utility function

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