QUADERNI

Università degli Studi di Siena
DIPARTIMENTO DI ECONOMIA POLITICA

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n. 347 – Maggio 2002

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April 19, 2002

Abstract

This paper shows how public debt repurchases can be used to reduce the costs of debt service, under the hypothesis of asymmetry of information between the government and the private sector. At the beginning of a fiscal stabilisation, for example, a government typically does not enjoy full credibility among investors and interest rates could incorporate excessive risk premia, reflecting this lack of credibility. The idea of this paper is that buybacks could be used to eliminate unfair risk premia since they can signal the government commitment to an announced policy.

JEL classification: D82, H63.
Keywords: Buybacks, public debt management.

*I want to thank Jonathan P. Thomas, for dedicated supervision throughout all this work. I would like to thank Wiji Arulampalam, Alessandro Missale, Jeremy Smith and Emanuela Marrocu and participants at 2001 RES and ESEM Conferences in Durham and Lausanne, respectively. I wish to thank Roberto Violi and Pasquale Ferro, from the Bank of Italy, Mark Deacon, from the DMO, and Alessandro Missale for providing me with the data. Errors remain my own. Correspondence: P.zza S.Francesco 7, 53100 Siena, Italy; Tel. +39/0577/235088, Fax: +39/0577/298661; E-mail: marchesi@unisi.it

1 Introduction

Since the 1980s a number of indebted countries, like Brasil, Mexico, Bolivia, Uganda, Zambia and Tanzania, have repurchased part of their debt, usually at substantial discounts on the face value. Since 1990, some OECD countries (like the UK, France, Italy, Belgium, The Netherland, Spain and Ireland) have also used repurchases of their domestic debt. Such programmes can include both bonds repurchase (with the elimination of the repurchased debt) and bonds conversions (which has the advantage of being self-financing).

While buybacks have been analysed quite deeply in the international debt literature, as far as I know, the literature on public debt management has not dealt with domestic debt repurchases (with few exceptions: e.g. Coe *et al.*, 2000).[1] The main goals of domestic debt repurchases are to reduce both the risks and the costs of debt service. The *risk* that is considered is refinancing risk. Through buybacks the government can intervene in order to smooth the maturities profile and so to avoid tensions in the secondary market. Then, buybacks could help reducing the *costs* of indebtedness for three reasons. In the first place, it could be a way to increase the liquidity in the secondary market by switching from illiquid to liquid securities. Liquid instruments, that is with standard characteristics, are more easily priced and traded and thus they can have a cost advantage respect to other types of bonds.[2]

[1] One of the most debated aspects of buybacks has been whether debtor countries benefit from repurchases of their sovereign debt, at low prices, on the secondary market. Bulow and Rogoff (1988, 1991) provide a formal statement of the critique to buybacks. Instead, different reasons for buybacks are given, among others, by Cohen and Verdier (1995), by Krugman (1989), Thomas (1996), Rotemberg (1991), Acharya and Diwan (1993), Marchesi and Thomas (1999).

[2] Quite recently, also foreign currency buybacks have been carried out in order to reduce both risks and costs of debt service. In particular, Brady bonds have been repurchased with the specific aim to eliminate the stigma of restructured debt (for example in Argentina, Brazil and Mexico).

A second way to reduce the costs of debt servicing could also derive from an opportunistic use of repurchases. The government could distinguish the more expensive bonds in the market and repurchase them issuing in their place cheaper securities (for example, short-term bonds, as in Coe *et al.,* 2000). More specifically, the authors show how it is possible to forecast, using a common set of macroeconomic factors, the difference between holding period returns of bonds of different maturities (i.e., return spreads). Therefore, it would be possible to order bonds of different maturities according to their expected costs and to replace the more expensive with the cheaper ones (repurchasing the former and issuing the latter, respectively). On the other hand, this type of reduction in the costs of debt service comes necessarily with an increase in the portfolio overall risk (since the bonds which are repurchased are those with a higher risk premium).

Finally, this paper, introducing asymmetric information between the government and the private sector, shows that there may be a third reason why buybacks can decrease the costs of debt service. That is buybacks may help a government to solve the inefficiencies which are due to the asymmetry of information.[3] The existence of asymmetric information is not new in the literature on debt management (Drudi and Prati, 2000; Missale *et. al.,* 2000). For example, at the beginning of a stabilisation programme, a government typically does not enjoy full credibility among investors and interest rates could incorporate excessive risk premia (or expected inflation and depreciation), reflecting this lack of credibility. On this respect, Missale *et. al.* (2000) studied 72 episodes of fiscal stabilisation occurred in OECD economies between 1975 and 1998. For each episode, they analysed the government issuing strategies during the first two years of the stabilisation and the evidence suggested that the government generally prefers long to short maturity. However, when long-term rates are high relative to their expectations short-term, bonds are issued in order to minimise borrowing costs.

The main idea of this paper is that buybacks can be another way of reducing borrowing costs. While in Missale *et. al.* (2000) the government chooses "strategically" the maturity of the *new* debt to be issued (in order

[3]In the international debt literature, buybacks may also solve the inefficiencies which are due to the asymmetry of information between creditors and debtors (Acharya and Diwan, 1993; Marchesi and Thomas, 1999).

to minimise the cost of debt service), here the government actually changes the structure of the outstanding debt to reach the same objective. Domestic debt repurchases can then be used in order to eliminate "unfair" risk premium since they may help a government to enhance its commitment to an announced policy.[4] The government is not generally supposed to exploit its information advantage (respect to the private sector) although this could be good when the authorities are actually signalling the implementation of an announced stabilisation plan.

More specifically, a theoretical model is developed to show that buybacks of public debt may signal a government type. It is assumed that the government could be of two types: a dry type and a wet type, according to their willingness to implement a fiscal stabilisation. Asymmetry of information between the government and private investors is assumed. In particular, interest rates are assumed to incorporate a risk premium which reflects the expectation that the inability to implement a stabilisation programme may result in more inflation and/or taxation, or debt default.[5]. Thus, a dry type which has to finance new spending may want to signal its resolution to lower its interest costs by repurchasing a fraction of the outstanding debt. The wet type could also decide to buy-back some of its debt in order to pretend to be dry and to (possibly) lower its interest payments. It is showed that a critical amount of buyback exists such to separate the two types. Finally, both the pattern of long-term Italian bonds prices and of the differential between yield to maturity on the Italian and the German benchmark bond (constant 10 years maturity bond) look consistent with the main implication of the model.

The rest of the paper is organised as follows: in Section 2 we briefly review the institutional evidence on buybacks. Section 3 contains the theoretical model and in Section 4 some evidence is provided in favour of the hypothesis that the repurchase of public debt is actually perceived as a good signal by private investors, consistently with the model. Finally, Section 5

[4]Differences in the expected returns of debt instruments are "fair" if they reflect properly called risk premia, asked by risk-averse investors who do not make systematic mistakes, are fully informed about the likelihood of future events and confident that fiscal and monetary policy actions will be carried out as announced.

[5]Default will be used here as a general term which indicates anything which may go wrong in the service of public debt: outright repudiation, rescheduling or *una-tantum* capital levy.

concludes.

2 Institutional evidence

According to a questionnaire carried out by the Bank of Italy and the Italian Treasury, in November 1996, before 1990 programmes of repurchase in advance of maturity of outstanding securities (RAMS) were a rarity: only Sweden and the United Kingdom carried out them before that year. From 1990 onwards, countries began to acquire experience in the use of debt repurchases instruments and some of them have established regular bond repurchasing programmes. The percentage of debt that was repurchased in different countries ranged from 0.3% (in Italy) to significant amounts (such as 12% in Ireland).[6] In 1999 and 2000 repurchase operations have been carried out quite intensively, at least in a number of European countries (Table 5, in the Appendix).

Table 1, in the Appendix, reports the analytic answers of 19 OECD countries (out of the 24 countries which have been interviewed by the Bank of Italy and by the Italian Treasury). RAMS have actually included both bonds repurchase and bonds conversion. Among the most frequent objectives of the repurchase there are: the reduction of the outstanding debt, a greater smoothing of the maturity profile, the reduction of debt servicing costs, elimination of securities with poor liquidity. Table 2, in the Appendix, contains the analytic answers of the interviewed countries.

In sum, the main objectives of a buyback are to reduce the risks and the costs of indebtedness. The risk which is considered is refinancing risk. Through buybacks the government can intervene in the market in order to avoid a heavy infra-year concentration of debt redemption. A debt repurchase could also help reducing the costs of debt service. They could be a way to increase the liquidity in the secondary market by switching from illiquid to liquid securities. A government could decide to issue "fungible bonds" (i.e., bonds with coupon and maturity identical to those of existing issues)

[6] Actually, in order to make comparisons, also absolute values must be considered. In fact, due to the different sizes of the outstanding debt, a percentage that appears negligible might correspond to a major operation in the profile of the debt.

repurchasing at the same time securities with poor liquidity (for example older securities). Simpler instruments are more easily priced and traded so they can have a cost advantage respect to other types of bonds. Increasing bonds liquidity also implies that the market become thicker (i.e., bonds are available for trade in large amount) and thus more efficient.[7]

Both bonds repurchases and conversions may be carried out using various techniques (see Table 3 in the Appendix). Debt exchange operations have been mostly used since they are self-financing: exchange offers always take place on the issue of new bonds. In fact, they are not meant to reduce the stock of debt but to increase the market activity through an improvement of the characteristics of liquidity and maturity of outstanding bonds. Buyback operations can be made either through reverse auctions or in the secondary market. In countries with greater experience of this instrument, auctions usually take place on a competitive basis where an advance announcement is given concerning the bonds to be repurchased.[8] In general, both debt exchange or reverse auction are held in a standardised procedure and, thus, they are less flexible instruments than secondary market buybacks. For this reason, several countries decided to choose a combination of the two.[9]

With the only exceptions of the Netherlands and New Zealand (where these operations are open to all kind of investors), repurchase programmes usually take place through intermediaries. Most of them are "market makers", like primary dealers or specialists in Government bonds. In some other cases, these operations take place through the Central Bank while the Treasury usually coordinates them. Market information is given through professional channels in an appropriate way. Every operator should be able to know about the opportunity that the Treasury is giving the market.[10]

[7] In OECD countries there has been a clear trend towards standardisation and reduction of the types of securities on offer (Missale, 1999).

[8] The bids submitted by operators are generally met with cut-off prices determined either by the Treasury or by the Central Bank. UK has a different procedure with a more active role of the Central Bank.

[9] For example, in France, large operations were carried out with both reverse auction and debt exchange offers, while small adjustments were made through "standard repurchase." In Italy a composite set of instruments was used: reimbursement of bonds at maturity, buyback both with reverse auction and on the secondary market.

[10] A few countries do not give any information: Australia (where the operations are conducted only by the Central Bank) and Iceland (where a press release is issued only after the operation is closed).

Usually the first technique (reverse auction) is preferred when a substantial amount of debt should be repurchased and only few types of (liquid) bonds are chosen. When a great number of not liquid bonds, each with a small amount outstanding, must be repurchased, a government may decide, alternatively, to buy-back directly in the secondary market. In this case the choice of the intermediaries is crucial.

Finally, four kind of financial resources have been used (Table 4 in the Appendix). The majority of OECD countries use funds generated mainly by the issue of new debt. Then, there are the credit facilities with the central Bank (as the access to funds of the Treasury, at the Central Bank, which are used to finance Government expenditure). Budget surplus are used as well and, finally, there are also special Fund ("Sinking Funds") created, in Italy and in France for example, with the outcome of the privatisation.[11]

More recently, in the United States (March 2000), the Treasury Department actually paid $1,345 billion to repurchase $1 billion of the national debt. Buybacks took the form of a reverse auction, in which the Treasury selected offers on a competitive basis based on the lowest prices and the buyback was limited to 30-years bonds. Following news of the buyback plan bonds prices have actually increased.[12]

3 The model

This section shows how buybacks could be used to eliminate excessive risk premia. To this end I develop a signalling model of public debt repurchases where the risk of default on public debt is the government private information. The government objective is to lower the debt service cost. I assume that the government could be of two types: a dry type willing to implement a fiscal stabilisation plan (in this model this basically means reducing fiscal spending) and a wet type unable to. Interest rates are assumed to incorpo-

[11] While in France there are also other options, in Italy, a law (27/10/'93, No. 432) establishes that all funds arising from privatisation must be used exclusively for the purpose of reducing public debt.

[12] In 1999 the Clinton administration announced it had planned to spend the forecast (over the decade) budget surplus (worth around $3,000bn) to buy-back 1,700 billions of dollars of public debt within the next 10 years (and to eliminate it entirely by the 2015).

rate an "unjustified" risk premium which is higher for the wet type (under full information). However, only the government is aware of its type, which is unobservable to private investors. Thus, a dry type who has to finance some new spending (issue some new debt) may want to signal her resolution in order to lower her interest costs and one way to do that would be to repurchase a fraction of the outstanding debt. The wet type could also decide to buy-back some of his debt in order to pretend to be dry and to (possibly) lower his interest payments. It is showed that a critical amount of buyback exists such that the two types can be separated.

The concept of a buyback in a public debt framework is introduced gradually. In what follows, I start by considering the particular case in which the amount of additional spending is zero ($F = 0$). However, in the more general model, some new debt must be issued ($F > 0$). The first model represents a reference case, which is useful to illustrate what is needed to get an interesting model, while the second model is the main one. The following are the features common to both cases.

The model extends over two periods, period zero and period one. I assume that, at $t = 0$, the government has inherited an amount D of public debt at the fixed gross 2-period interest rate $\bar{i}$, so $D\bar{i}$ is due at $t = 2$ (D is normalised to one). Thus, interest rate repayments on the outstanding debt are set before the "game" starts. Let's define b as the amount of debt which could be repurchased at $t = 0$.

There is asymmetry of information between the government and private investors and the latter have a (common knowledge) prior π that the government is of the dry type. A dry government carries out larger cuts and has a level of spending G^L (at the end of period zero) which is lower than the level of spending G^H of a wet government. The fundamental characteristic that distinguishes the two types is a risk premium on period one interest payments p, which can either be p^W or p^D, depending on whether the government is perceived as wet or dry by investors. In particular, at $t = 1$, interest rates will be determined after the uncertainty about the government's type is resolved and they will be lower if the level of spending is low, or higher if spending is high. Period one interest rates contain a risk premium which reflects the expectations that the inability to stabilise the economy may result in debt

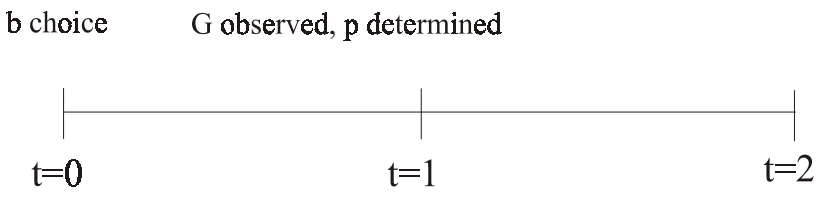

Figure 1:

default (or higher inflation and/or taxation) and which is greater for the wet type government.

At $t = 0$, after the dry government implements a stabilisation programme (here it basically consists in cutting public spending) which is going to affect the level of spending (and thus the interest rate in period one), she might find it beneficial to buy-back a fraction of the outstanding debt, issuing at the same time short-term debt to be rolled over at the beginning of period one. This strategy might be preferred here by the dry type (to issuing 2-periods debt) because, in this way, she could benefit from the consequences of her implementation of the stabilisation programme, in terms of reduced interest costs.

Here I assume that a buyback is made only through a bond conversion (for example as there is no cash for repurchases at the beginning).[13] The sequence of events is described in Figure 1.

3.1 Reference case

In this section I examine the simplest case in which the amount of new spending is zero ($F = 0$). Here the debt repurchase may actually leave the dry type indifferent and the wet type worse off (if believed dry). So while it separates the two types, there is no advantage to the authority in undertaking the buyback. The two levels of spending G^L and G^H will not actually enter the analysis, except as signals that invariably identify the two types i.

The following assumptions are made: ($A1$) There are no resources for repaying at the end of period zero, therefore all debt has to be carried forward

[13] A RAMS (or buyback) can actually include both bonds repurchase and bonds conversions.

to the end of period one; ($A2$) There is neither additional spending, nor stabilisation risk during period zero. (Assumptions one and two make sense if the period zero is "very short term.") ($A3$) Information of wet/dry is revealed before debt can be rolled over.

Let's define i^* as the gross safe world interest rate ($= 1 + r$), where i^* is assumed constant over the two periods. Suppose there is a separating equilibrium in which the (critical) size of the repurchase of debt at the outset of period zero signals the type, then the following "arbitrage" condition should hold (that is for the government to be indifferent between the two strategies):

$$\overline{i}(1 - p^j) = q^j i_0(1 - p^j)i_1^j, \qquad j = W, D \tag{1}$$

where p^j is the risk premium in period one and it can either be p^W or p^D. Notice that I allow the wet type to repurchase some debt, i.e., I want to consider a range of separating equilibria, including those in which the wet type does a positive repurchase, but at a different level. q^j is the price of the repurchase of one unit of the inherited debt and it can either be q^W or q^D; i_0 is the interest rate in period zero, it is equal to i^* (there is no risk in period zero); i_1 is the interest rate in period one and can take the two values i_1^W or i_1^D. The left hand side of (1) represents the expected returns to a bondholder from one unit of inherited debt over the two periods, while the right hand side contains the returns from selling one unit of old debt at the start of period zero and buying new debt at the price q^j, earning i_0 in period zero and $(1-p^j)i_1$, in period one. Notice that the probability of default, in period one, is the same either holding long-term or short-term debt. Below, I will take into account the possibility that holding short term debt can involve some default probability in period zero as well.[14]

The arbitrage condition in period one is:

$$i^* = (1 - p^j)i_1^j \qquad j = W, D \tag{2}$$

and substituting (2) in (1), the price of one unit of debt becomes:

$$q^j = \frac{\overline{i}(1 - p^j)}{(i^*)^2}. \qquad j = W, D \tag{3}$$

[14] This is more consistent with the literature on debt default according to which shortening the maturity of government's debt can increase the possibility of a crisis equilibrium, if the country is highly indebted (see for example Alesina *et al.*, 1990).

More specifically, if the wet type does the repurchase, he will be believed to be dry and therefore the price per unit of debt repurchased will be:

$$q^D = \frac{\overline{i}(1-p^D)}{(i^*)^2},$$

rather than:

$$q^W = \frac{\overline{i}(1-p^W)}{(i^*)^2},$$

where q^D is higher than q^W as the dry type is safer which implies that the secondary market price for inherited debt is higher. Correspondingly, the interest rate the wet type has to pay in period 1 is greater since it is a riskier type. That is:

$$i_1^W = \frac{i^*}{(1-p^W)},$$

while

$$i_1^D = \frac{i}{(1-p^D)}.$$

I assume that the government is interested only in minimising the amount it has to repay at the end of period one, assuming it does not default. Thus, the cost of the repurchase of one unit of debt, at the end of $t = 1$, for the wet government (assuming it does not default) is:

$$C = q^D i_0 i_1^W;$$

that is:

$$C = \frac{\overline{i}(1-p^D)}{(i^*)^2} i^* \frac{i^*}{(1-p^W)} = \overline{i}\frac{(1-p^D)}{(1-p^W)} > \overline{i}. \tag{4}$$

As we can see, for the wet type, the buyback (no matter what its size) is bad if it signals the dry type, since it forces to pay higher interest rates on the point of debt rolled-over. The same calculation for the dry type (i.e. where buyback signals dry) leads to (4) with $(1-p^D)$ in the denominator and thus C is equal to $\overline{i}$. The dry type has the same interest payment and so she will be indifferent. Likewise, the wet type is indifferent about doing a buyback if this signals he is wet, and in this case the dry type would strictly prefer to mimic the wet type (just replace p^W by p^D in (4) and you would get a fraction that is smaller than $\overline{i}$) so there cannot be a separating equilibrium in which the wet type makes a positive repurchase.

Therefore, if there were a separating equilibrium, it would be of the form: if *any* repurchase is made, then the probability of the dry type would

be one. There cannot be a positive threshold value for the buyback, since the dry type would like to undertake a smaller buyback to signal she is wet. More specifically, there are a *continuum* of separating equilibria where wet does not buy-back whereas dry does an amount b^* where b^* lies between 0 (> 0) and the maximum amount 1. Each of these equilibria is supported by the belief that $Prob(D \mid b > 0 = 1)$, 0 otherwise.[15]

Let's now consider pooling equilibria. We have a pooling equilibrium when the dry does not do any repurchase because in this case they both send the same signal ($b = 0$). Can there be one at positive level of repurchase? Suppose that they both do positive repurchase of b^*. The price would reflect the average risk, which is good for the dry and bad for the wet. Clearly the wet would be better deviating to $b = 0$ in this case. Hence I cannot have a pooling equilibrium.

In conclusion, in this model there is no reason to have a buyback as this does not affect the ultimate allocation in terms of interests payments made by either type. The reason why the dry type does not benefit from the reduced risk premium (obtained by signalling her type) is that the current holders of debt simply value their debt more highly once they believe they were facing the dry type, and so the buyback takes place at a high price which just reflected this reduced risk. Basically, in this context, being thought to be safer implies that the secondary market price for debt is higher.

This conclusion will not change if I modify assumption ($A2$) introducing some (very small) risk in period zero as well. (Notice that period zero risk does not affect the risk on long-term debt). Condition (1) becomes:

$$\bar{i}(1 - p^j) = q^j i_0^j (1 - s) i_1^j (1 - p^j), \qquad j = W, D \tag{5}$$

where i_0^j can either be i_0^W or i_0^D. Let's assume that the wet type has a period zero default risk equal s (for the dry type s is zero) so $i^* = (1 - s) i_0^W$ (and $i^* = i_0^D$) and the cost of one unit repurchase for the wet type is:

$$C = q^D i_0^D i_1^W$$

which is the same as before (see (4)). Again, interest costs are not diminished and so there is no reason to have a buyback.

[15] If there are, for example, beliefs such that $Prob(W \mid b > 0 = 1)$, 0 otherwise, the dry type would choose this, upsetting the equilibrium. Thus, $Prob(D \mid b > 0 = 1)$, 0 otherwise seems the only belief consistent with the equilibrium.

3.2 New spending

In this model, in addition to period 0 risk, some additional spending F, to be financed at the beginning of period zero, is introduced and it is shown how it *can* make the repurchase worthwhile (this is the same as issuing some new debt). If some new borrowing takes place at the beginning of period zero, to be rolled over in period one, the costs of that borrowing will depend on the interest rates both in period zero and in period one. At $t = 1$, interest rates will be determined after the uncertainty about the government's type is resolved and they will be lower if the level of spending is low. Under this case, interest rates contain, in both periods, a risk premium which reflects the same expectations as above (probability of either debt default or higher inflation and/or taxation) and which is greater for the wet type government.

At $t = 0$, after implementing a stabilisation programme, the dry type might find it beneficial to buy-back a fraction of her outstanding debt, issuing at the same time short-term debt to be rolled over at the beginning of period one. In this way she could benefit from a "reputation effect" of her policy in terms of reduced interest rate in both periods. In period one, because after public spending is actually observed, the government type is distinguished and the risk premium on interest payments can decrease (if the type is dry). In period zero, because the buyback could be the signal that a government is dry (assuming only the dry type can actually benefit from reduced rates in period one, if there is a separating equilibrium), and so it could influence the risk premium of period zero, as well.

The dry type will gain for sure from the buyback because she is normally indifferent about that, but assuming additional spending to be financed in period zero and a small risk premium that could be reduced by the repurchase, she will be surely better off.[16] The wet type is normally worse off with the buyback, since this takes place at a high price, corresponding to the dry type's risk premium. But with the financing of new expenditure, he could find it advantageous to pretend to be dry in order to benefit from better conditions on the new borrowing. I show there will be a critical amount of

[16] Note that, without any uncertainty, interest costs with and without buybacks would be the same, that is (10) and (11) are the same when $s = 0$. Thus, as above, there would be no reason to have a buyback.

the repurchase such that the two types will be separated.

I defined b as the amount of debt which can be repurchased. At the beginning of period zero, the dry type should decide whether to do the buyback or not. Thus, she should compare the interest costs of the outstanding debt and of the new borrowing in the two circumstances of with and without buyback. If she opts for the buyback strategy, the timing will be the following: at $t = 0$ the government repurchases an amount b of its outstanding debt, to be rolled over in period one, and simultaneously finances the new borrowing with short term debt, to be rolled over at the beginning of period one as well. At the end of period zero, the level of public spending G is observed and the risk premium of period-one interest rate is determined.

Therefore, assuming again a separating equilibrium and that there is some default risk in period zero as well as in period one (as above), if the wet government does the buyback, his interest costs would be:

$$\begin{aligned} R_b^W &= bq^D i_0^D i_1^W + (1-b)\overline{i} + F i_0^D i_1^W \\ &= b\overline{i}\frac{(1-p^D)}{(1-p^W)} + (1-b)\overline{i} + F\frac{(i^*)^2}{(1-p^W)} \end{aligned} \tag{6}$$

and, without it, they are:

$$\begin{aligned} R^W &= \overline{i} + F i_0^W i_1^W \\ &= \overline{i} + F\frac{(i^*)^2}{(1-s)(1-p^W)} \end{aligned} \tag{7}$$

In order to obtain the critical value of b such that the two types are separated, we need to find that $b\ (= b^S)$ such that the interest costs the wet type has to pay with the repurchase (R_b^W) are equal to the interest costs he should pay without it (R^W): then any $b \geqslant b^S$ will be separating. That is:

$$b^S\overline{i}\frac{(1-p^D)}{(1-p^W)} + (1-b^S)\overline{i} + F\frac{(i^*)^2}{(1-p^W)} = \overline{i} + F\frac{(i^*)^2}{(1-s)(1-p^W)} \tag{8}$$

which reduces to:

$$b^S = F\frac{(i^*)^2}{(p^W-p^D)\overline{i}}\frac{s}{(1-s)} \tag{9}$$

where b^S is increasing in the quantity of new borrowing F and in the risk premium s (these two factors make the buyback more advantageous for both types) and decreasing in the difference between p^W and p^D and in $\overline{i}$ (both of

them increase the costs of doing the repurchase). If this difference tends to zero (i.e., $p^W = p^D$) b^S tends to infinity as the bonds issued by the good type tend to cost the same as those issued by the bad type. On the other hand, if $s = 0$, $b^S = 0$, as the advantage of carrying out a repurchase vanishes. The reason why the separating equilibrium can actually work is that the dry type is more willing to convert its debt to short term debt because she is not afraid of adverse information becoming available during the course of longer maturities, whereas the wet type would have to roll over the debt at a higher interest rate (at the end of period zero).

On the other hand, the dry type's interest costs with the separating buyback are:

$$\begin{aligned} R_b^D &= bq^D i_0^D i_1^D + (1-b)\overline{i} + F i_0^D i_1^D \\ &= \overline{i} + F\frac{(i^*)^2}{(1-p^D)}, \end{aligned} \tag{10}$$

while, without any buyback, they would be:

$$R^D = \overline{i} + F i_0^W i_1^D = \overline{i} + F\frac{(i^*)^2}{(1-s)(1-p^D)} \tag{11}$$

where, although after observing no buyback beliefs put probability one on the wet type, this reverts to probability one on the dry type once spending is observed. As we can see, $R_b^D < R^D$ and the repurchase is always advantageous.

However, I also need to check whether her interest costs in the buyback case are always lower than the ones she pays with no separating buyback. The dry type might find it more advantageous to repurchase only a fraction $\overline{b} < b^S$ (I am assuming here that beliefs are such that $Prob(W \mid b < b^S = 1)$ in order to pay a lower buyback price in period zero and still be able to reduce her interest costs in period one, after the asymmetry of information is cleared. Obviously, b^S will be preferable if the corresponding interest payments R_b^D are lower. Let's define $R_{\overline{b}}^D$ as the interest costs that correspond to $\overline{b}$:

$$\begin{aligned} R_{\overline{b}}^D &= \overline{b} q^W i_0^W i_1^D + (1-\overline{b})\overline{i} + F i_0^W i_1^D \\ &= \overline{b}\frac{\overline{i}(1-p^W)}{(i^*)^2}\frac{i^*}{(1-s)}\frac{i^*}{(1-p^D)} + (1-\overline{b})\overline{i} + F\frac{i^*}{(1-s)}\frac{i^*}{(1-p^D)} \\ &= \overline{b}\frac{\overline{i}}{(1-s)}\frac{(1-p^W)}{(1-p^D)} + (1-\overline{b})\overline{i} + F\frac{(i^*)^2}{(1-p^D)(1-s)} \end{aligned} \tag{12}$$

$R^D_{\overline{b}} \geqslant R^D_{b^S}$ if:

$$\overline{b}\frac{\overline{i}}{(1-s)}\frac{(1-p^W)}{(1-p^D)} + (1-\overline{b})\overline{i} + F\frac{(i^*)^2}{(1-p^D)(1-s)} \geqslant \overline{i} + F\frac{(i^*)^2}{(1-p^D)} \qquad (13)$$

that simplifies to:

$$\overline{bi}\left[\frac{(1-p^W)}{(1-s)(1-p^D)} - 1\right] \geqslant -\frac{F(i^*)^2 s}{(1-p^D)(1-s)}$$

that means:

$$\begin{aligned} \overline{b} &\leq \frac{F(i^*)^2 s}{(1-p^D)(1-s)\overline{i}}\left(\frac{(1-p^D)(1-s)}{(1-p^D)(1-s)-(1-p^W)}\right) \qquad (14) \\ &= \frac{F(i^*)^2 s}{[(1-p^D)(1-s)-(1-p^W)]\overline{i}} \end{aligned}$$

under the assumption that $(1-p^D)(1-s) > (1-p^W)$ (for instance when $(1-s)$ is very close to one).

Thus, if s is low, if the dry type does the buyback she basically benefits by borrowing F at the true (low) risk premium. If she does not undertake a buyback she has to borrow F at the wet risk premium in period zero, which is obviously worse. The issue is what happens if she was to buy-back $\overline{b}$, $0 < \overline{b} < b^S$? If I assume that for any $b < b^S$, the government is assumed to be wet, then he benefits by the fact that the buyback price reflects the risk premium for the wet government over the two periods. Clearly, the larger $\overline{b}$ is the more tempting this is (and if s is lower, $\overline{b}$ does not have to be so big for the temptation to succeed). (14) says just this: if $\overline{b} \leq RHS(14)$ then it does not pay to pretend to be wet, while it does if $\overline{b} > RHS(14)$. But since it is easily checked that $RHS(14) > b^S$ (and $\overline{b}$ cannot obviously be bigger than b^S) then for the dry type it does not pays to be believed wet.

Figure 2 and 3 represent the interest costs of the wet type and of the dry type, respectively, as a function of the quantity of buyback b. Regarding the wet type, both curves (in the case of a positive repurchase: in which he could be believed either wet or dry according to the value of b) are upward sloping and have a positive intercept. For $0 < b < b^S$ the wet type would prefer being believed dry, choosing $b > 0$, but as long as he has to repurchase at least b^S to be thought dry, he doesn't want to do this (see Fig. 2). But, under separation, with beliefs $Prob[D \mid b > b^S] = 1$, 0 otherwise, he cannot be believed dry repurchasing $0 < b < b^S$ and so he is better off playing $b = 0$.

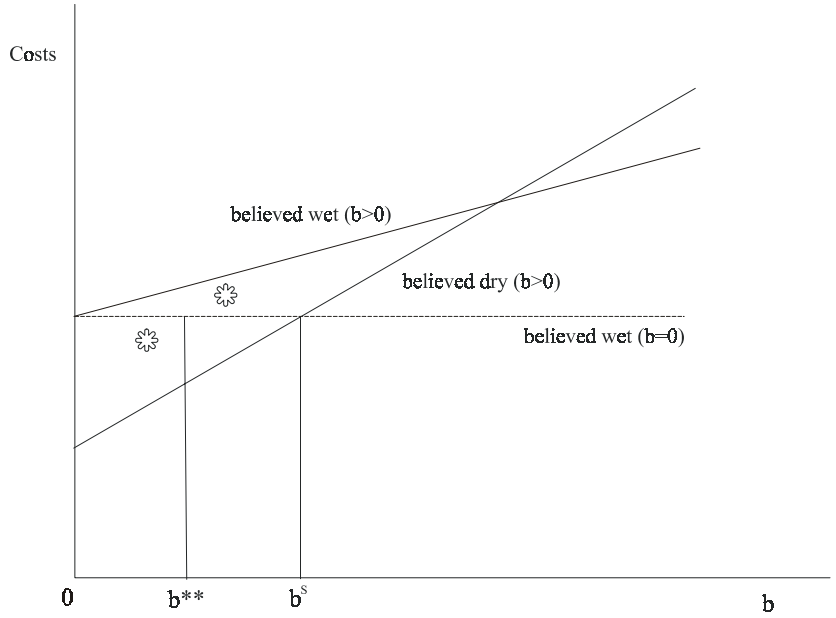

Figure 2: Wet type

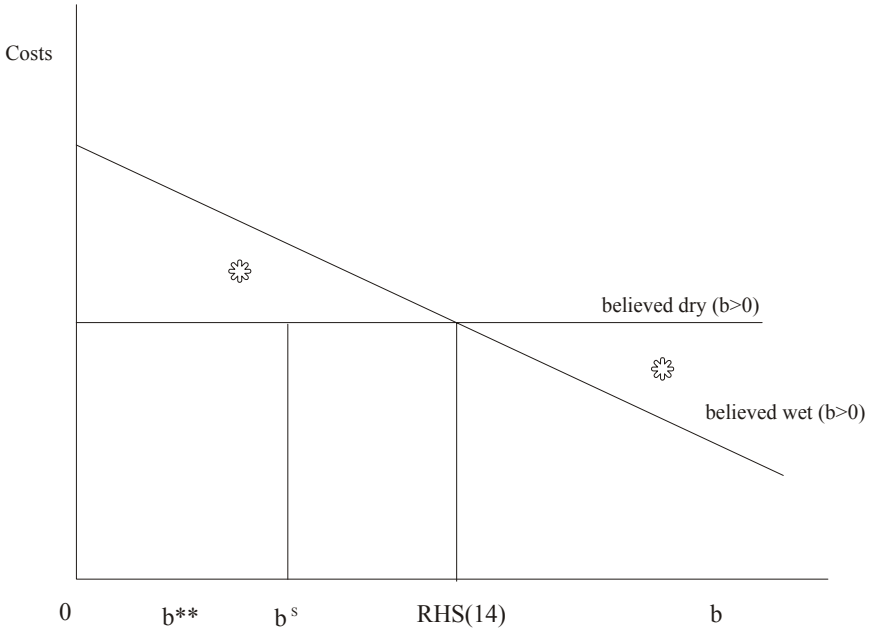

Figure 3: Dry type

When the dry type does a positive repurchase, her interest costs curve, if she is believed wet, is downward sloping, while, if she is believed dry, is constant and the two curves intersect at $b = RHS(14)$. Let's define b^* as the dry type's buyback. Any $b^* \geqslant b^S$ is an outcome of a separating equilibrium (and b^* cannot be below b^S in an equilibrium). Beliefs as follows will support a whole range of separating equilibria $Prob(D \mid b \geqslant \min(b^*, RHS(14)) = 1)$, 0 otherwise. (But there are actually many other beliefs that will support these same equilibrium actions). The wet must choose $b = 0$ in equilibrium, since if he chose $b > 0$ in equilibrium, a deviation to $b = 0$ must be better no matter what beliefs we use at $b = 0$. Likewise, the dry doesn't gain from being thought wet as that would require a repurchase of less than min (b*, $RHS(14)$) which is at most $RHS(14)$) (while she would gain from being believed wet when $b > RHS(14)$, as in Fig. 3).

I try now to examine whether the intuitive criterion can eliminate some of the separating equilibria. The idea is to use the equilibrium payoff levels as reference points (see e.g. Mas-Colell *et al.*, 1995). Suppose that the dry type was to deviate from the separating equilibrium. Is there a level of b such that the wet for sure would be worse off than in equilibrium no matter what the beliefs (this would convince the public that it is facing a dry), and such that the dry would be better off if believed dry? The answer is no, since the dry type is already believed dry in equilibrium, and gets exactly the same utility whenever she is believed dry, so such a deviation doesn't exist (irrespective of whether we can find a b which makes wet worse off for sure, which is possible since very high level of b do make wet worse off). For wet, since I cannot find any level of b such that dry is worse off for sure, then, again, I cannot apply the criterion to find a profitable deviation for wet. Thus, I cannot eliminate any separating equilibria this way. If the intuitive criterion has no bite, none of the weaker ones will.

There are no pooling equilibria (for a formal demonstration, see the Appendix).[17] Without pooling Perfect Bayesian Equilibria we are just left with a range of separating equilibria, but since the dry gets the same payoff at each one (as does the wet) then they are all payoff equivalent so there is uniqueness of equilibrium payoffs.

[17] In particular, there is no pooling equilibrium in which both do not buy-back, as there was in the simplest case.

In conclusion, in this section I demonstrated that a whole set of separating equilibria does exist (i.e., wet type and dry type can be separated through the buyback) assuming beliefs are: $Prob(D \mid b \geqslant \min(b^*, RHS(14)) = 1)$, 0 otherwise.[18] The wet type chooses $b = 0$ in equilibrium, since if he chose $b > 0$ in equilibrium, a deviation to $b = 0$ must be better no matter what beliefs we use at $b = 0$. Likewise the dry doesn't gain from being thought wet as that would require a repurchase of less than min (b^*, $RHS(14)$).

4 The data

In this Section I will provide some evidence in favour of the hypothesis that the repurchase of public debt is actually perceived as a good signal by private investors, consistently with our signalling model. More specifically, I analyse series of prices of Italian and UK bonds in order to detect the presence of a structural break corresponding to the day of the buyback. I expect that the price of the bonds that are repurchased increase, since in a separating equilibrium only dry types would buy-back their debt implying that the secondary market price for debt is higher.

As Italian bonds are concerned, I also test the impact of the repurchase on the differential between the yield to maturity on the Italian and the German benchmark bond (constant 10 years maturity bond). In this case, the differential between the returns of these two benchmark bonds should decrease in correspondence of the buyback (in a separating equilibrium only dry types would buy-back their debt which is then safer).[19]

The data were provided by the *Banca d'Italia,* by the UK Debt Management Office. Data on the differential between the yield to maturity on the Italian and the German 10 years benchmark bond were kindly provided by Alessandro Missale. Data on Italian bonds prices consist of 32 series of prices of Italian medium/long-term bonds: "Buoni Poliennali del Tesoro" (BTP) and "Certificati del Tesoro a Tasso Variabile" (CCT), observed almost daily

[18] There actually are also other beliefs that will support these same equilibrium actions.

[19] Normally, the difference between two bonds rate of return reflects both the risk premium and the expectations of a devaluation. After the introduction of the Euro, the difference between European bonds returns must reflect only the country risk as the second component is null.

over the period 3/10/1995 to 30/1/1998. Italian repurchases were preferably carried out during the last months of the year (October, November and December). Overall, I obtained 22 series for the BTP bonds and 13 series for the CCT bond prices (with an average of about 90 observations for each type of bond).[20]

Data on UK bonds prices consist of 6 series of prices for UK bonds observed almost daily over the period 1/1/2000 to 1/4/2001. UK bonds were bought-back only through (six) reverse auctions, in the period between July 2000 and February 2001. Overall, I obtained 12 series with the same average of about 90 observations each.[21]

Each price series is constructed considering approximately two months observations before and after the repurchase date (the series are almost daily). I chose a quite short interval of time in order to be able to investigate the impact of the buyback on the pattern of bonds prices. Given the relatively small amount of debt that is repurchased, on average, if I considered a period of time too long, the effect of the buyback would be blurred.

Data on the differential between the return on the Italian and the German 10 years benchmark bond consist of 13 series, observed monthly over the period November 1993 to June 1998. Each series, in this case, corresponds to the month in which an Italian buyback took place, over the period November 1995-June 2001, and each series is constructed considering about two years observations before and after the repurchase date (in this case the observation period is much longer).

I test the hypothesis of the presence of a structural break due to the buyback, assuming that the break occurs on the day of the repurchase, since I can only know the day in which the repurchase occurs, but not when it was announced (if it was). Since most of the series are likely to be non-stationary, I have implemented the testing procedure suggested by Perron (1989), which allows one to simultaneously control for the presence of unit roots and breakpoints. Perron proposes three different variants of the traditional Dickey Fuller (1979) test, assuming that under the alternative hypothesis the series

[20] The total number of series rose to 35 (from 32) since three bonds were repurchased at two different dates, during this period.

[21] The total number of bonds series is greater (double) than the number of bonds types since some bonds were repurchased more than once.

is stationary around a segmented trend, rather than a linear one. Under the alternative, the segmented trend can show a change in the intercept (Model A), in the slope (Model B) or in both (Model C):

$$H_0 : y_t = a_0 + y_{t-1} + \mu_2 D(TB)_t + \varepsilon_t \qquad \text{(Model (A))}$$

$$H_1 : y_t = a_0 + a_1 y_{t-1} + a_2 t + \mu_1 DU_t + \varepsilon_t$$

$$H_0 : y_t = a_0 + y_{t-1} + \mu_1 DU_t + \varepsilon_t \qquad \text{(Model (B))}$$

$$H_1 : y_t = a_0 + a_1 y_{t-1} + a_2 t + \mu_3 DT^*{}_t + \varepsilon_t$$

$$H_0 : y_t = a_0 + y_{t-1} + \mu_2 D(TB)_t + \mu_1 DU_t + \varepsilon_t \qquad \text{(Model (C))}$$

$$H_1 : y_t = a_0 + a_1 y_{t-1} + a_2 t + \mu_1 DU_t + \mu_4 DT_t + \varepsilon_t$$

where t_B is the break-point and:

$$DU = 1 \qquad if \quad t > t_B,\ 0 \qquad \text{otherwise}$$

$$D(TB) = 1 \qquad if \quad t = t_B + 1,\ 0 \qquad \text{otherwise}$$

$$DT^* = t - t_B \qquad if \quad t > t_B,\ 0 \qquad \text{otherwise}$$

$$DT = t \qquad if \quad t > t_B,\ 0 \qquad \text{otherwise}$$

The three tests are carried out following the procedure in Perron, which requires the regression of the dependent variable on a constant, a time trend, the lagged dependent variable, DU and augmented differences lag in order to remove autocorrelation (according to Model A); on a constant, a time trend, the lagged dependent variable, DT^* and augmented lagged differences (according to Model B); on a constant, a time trend, the lagged dependent variable, DU, DT and augmented lagged differences (according to Model C).[22]

I chose the third testing equation (Model C), which allows for both a change in the intercept (DU) and for a change in the slope (DT) of the trend, under the alternative. Analysing the pattern of all the series it seemed appropriate to have a model that captures both a very short-term break (associated to the date of the repurchase/breakpoint t_B) and a longer-term behaviour. However, to explain the pattern of bonds prices, as the period of time increases, we should probably model better all the factors that might

[22] For more details see Perron (1989), p. 1373; Enders (1995), p. 247.

affect them, not only taking into account their break-points. This is why I am more interested here in analysing the very short-term break, that is the sign (and the significance) of the coefficient of DU. However, DT is important as well since it gives an indication of the "order of magnitude" of the initial impact (how long it lasts).

The detailed results of my tests are presented in the Appendix. Tables 6, 7 and 8 describe the impact of buybacks on Italian and UK bonds prices, while Table 9 presents the impact of buybacks on the differential between the yield to maturity on the Italian and the German 10 years benchmark bond. As Italian bonds prices are concerned, almost all series are non-stationary at 5% level of significance. The coefficient of DU is generally significant and positive (while the coefficient of DT is generally significant and negative). Thus, as the coefficient of DU is positive, the initial impact of the repurchase is to make the prices of the remaining bonds rise.

For the series on BTP this result holds in most cases (Table 6). There are only few cases in which the coefficient of DU does not have the "expected" signs (I12675, I12678, I12686, I36675) or it is not significant at 5% level of significance (I36607, I12686bis, I36674, I36682, I36675). For the series on CCT (Table 7) slightly similar conclusions hold: in three cases the coefficient of DU does not have the expected signs (I13097, I13204, I36690) and in other few cases it is not significant at 5% level of significance (I13096, I13097, I13204, I36612, I36685, I36690bis, I36694). The increase in bonds prices can be interpreted as a signal that the buyback has positively affected the credibility of a government. In fact, being thought to be a safer government implies that the buyback takes place at a higher price, which just reflects the reduced risk. For both BTP and CCT the average duration of the buyback impact is about 50 periods (days).

These results are confirmed after examining the impact of the repurchase on the differential between the yield to maturity on the Italian and the German 10 years benchmark bond (Table 9). Almost all series are non-stationary at 5% level of significance and the coefficient of DU is generally significant and negative (when positive it is not significant at conventional levels). The opposite holds for the coefficient of DT (i.e., generally significant and positive). Thus, the impact of the repurchase is positive for the credibil-

ity of the country that undertakes it, since the return of its bond decreases with respect to the return of the German one (Germany represents here an example of credible, dry type, country). In this case the average duration of the impact is about 28 periods (months).

Finally, the results of the test concerning UK bonds repurchases are presented in Table 8. All the series are non-stationary at 5% level of significance. The coefficient of DU is positive in about half of the cases while positive and significant only twice. These results are definitely "weaker" respect to those concerning Italian bonds: here a buyback can generally be associated, almost with the same probability, either to an increase or to a decrease in bonds prices.

In conclusions, considering these two countries, a buyback does actually have the role of a signal only in the case of the more indebted country (in Italy the fraction of Central Government Debt to GDP is about 110% while in the UK the same ratio is about 45%). In this respect, it could be very useful to have access to the same kind of data for some other countries, possibly with a high value of debt as a percentage of their GDP.

5 Conclusions

Many developing countries have been keen to repurchasing part of their international debt on the secondary market at lower prices, as they considered the reduction in the price of their liabilities an attractive opportunity. In the case of domestic debt, buybacks can be used to reduce the costs of debt service, since they can both enhance liquidity and efficiency in the secondary market and eliminate an unjustified risk premium (which may result either from a government's credibility problem or from market imperfections).

In this paper a model is developed in which public debt repurchases is a signal of a government's type. Asymmetry of information between the government and private investors is assumed, where a government can be of two types, a dry type and a wet type, according to its willingness to implement a stabilisation plan. In particular, interest rates are assumed to incorporate a risk premium which reflected the expectation that the inability to implement

the stabilisation programme may result in more inflation, taxation or debt default. Thus, a dry type who has to finance some new spending might want to signal her resolution in order to lower her interest costs and one way to do that would be to repurchase a fraction of the outstanding debt. Actually, the wet type could also decide to buy-back some of his debt in order to pretend to be a dry type and to (possibly) lower his interest payments. We show that a critical amount of buyback exists such that the two types can be separated.

Finally, some evidence is provided in favour of the hypothesis that the repurchase of public debt is actually perceived as a good signal by private investors, consistently with the theoretical model. I analysed series of prices of Italian and UK bonds and series of the differential between yield to maturity of the Italian and the German 10 years benchmark bond, in order to detect the presence of a structural break corresponding to the date of the buyback. In the Italian bonds case, the main finding is that the initial impact of the repurchase is to increase the bonds prices and to make the Italian/German benchmark bond differential decrease. This is consistent with the theory as, in a separating equilibrium, only dry types would buy-back their debt implying that the secondary market price for debt is higher (and its rate of return is lower).

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Appendix

Pooling

I want to examine whether pooling equilibria may exist. Let's define b^P as the general, putative, pooling buyback and let's assume that both types now choose the same value $b^P > 0$, so the risk premium is the average one. Beliefs at $b = b^P$ are just the initial prior beliefs (i.e., π is the prior probability of the dry type and $(1-\pi)$ is the prior probability of the wet type). Then let's suppose beliefs are $Prob[W \mid b < b^P] = 1$.[23] Then, in order to find a critical value of b^P, let's compare the interest costs the wet type would pay under pooling with his interest costs under his best deviation ($b = 0$).

More specifically, in the case of pooling, the price per unit of debt repurchased will be:

$$q^P = \frac{\overline{i}(1-p^P)}{(i^*)^2},$$

where:

$$p^P = \pi p^D + (1-\pi)p^W,$$

Correspondingly, the two levels of the interest rate become:

$$i_1^P = \frac{i^*}{(1-p^P)},$$

and:

$$i_0^P = \frac{i^*}{(1-s^P)},$$

where:

$$s^P = (1-\pi)s.$$

Let's define $R_{b^P}^W$ as the interest costs that correspond to b^P.

$$\begin{aligned} R_{b^P}^W &= b^p q^P i_0^P i_1^W + (1-\overline{b})\overline{i} + F i_0^P i_1^W \qquad (15) \\ &= b^p \frac{\overline{i}(1-p^P)}{(i^*)^2}\frac{i^*}{(1-s^P)}\frac{i^*}{(1-p^W)} + (1-\overline{b})\overline{i} + F\frac{i^*}{(1-s^P)}\frac{i^*}{(1-p^W)} \\ &= b^P\overline{i}\frac{(1-p^P)}{(1-s^P)(1-p^W)} + (1-\overline{b})\overline{i} + F\frac{(i^*)^2}{(1-p^W)(1-s^P)}. \end{aligned}$$

[23] Let's exclude the possibility that $Prob[W \mid b > b^P] = 1$ as there exist for sure a high enough value of b such that the dry type is better off deviating to $b > b^P$ (and being believed wet) rather than choosing the pooling value of b (see Figure 3).

The interest costs that correspond to the wet type best deviation (i.e., $b = 0$) are R^W and they are reported in (7). $R^W_{b^P} \geqslant R^W$ if:

$$b^P \overline{i} \frac{(1-p^P)}{(1-s^P)(1-p^W)} + (1-\overline{b})\overline{i} + F\frac{(i^*)^2}{(1-p^W)(1-s^P)} \geqslant \overline{i} + F\frac{(i^*)^2}{(1-s)(1-p^W)} \tag{16}$$

that simplifies to:

$$b^P \overline{i} \left[\frac{(1-p^P)}{(1-s^P)(1-p^W)} - 1\right] \geqslant F(i^*)^2 \left[\frac{1}{(1-p^W)(1-s)} - \frac{1}{(1-p^W)(1-s^P)}\right]$$

that means:

$$\begin{aligned} b &\geqslant b^P = b^{**} \equiv F(i^*)^2 \left[\frac{(1-s^P)-(1-s)}{\overline{i}(1-p^W)(1-s)(1-s^P)}\right] \left[\frac{(1-s^P)(1-p^W)}{(1-p^D)-(1-s^P)(1-p^W)}\right] \\ &= \frac{F(i^*)^2(s-s^P)}{[(1-p^D)-(1-s^P)(1-p^W)]\overline{i}(1-s)}, \end{aligned} \tag{17}$$

where b^{**} is smaller than b^S (see Figure 2 and 3). Now, if $b^P \leq b^{**}$ the wet type prefers a pooling equilibrium to his best deviation $b = 0$ (Fig. 3.2). But when $b^P \leq b^{**}$, the dry can profitably deviate to any $b > RHS(14)$, no matter what beliefs are at this high level of b (see Fig. 3) and so this is not an equilibrium. If $b^P > b^{**}$, then the wet must again be better off at $b = 0$, no matter what beliefs are, so that is again a profitable deviation. So I can conclude that a pooling equilibrium cannot exist.

Table 1: Answers of 19 OECD countries

Countries	**Y/N**	**Description**
Australia	Y	Bond conversion. 1990-91. RAMS since 1993
Austria	Y	No information
Belgium	Y	RAMS 1991-92. Bond Conversion since 1991
Canada	N	
Denmark	Y	RAMS since 1990
Finland	Y	RAMS since 1994
France	Y	RAMS since 1991
Greece	N	Only some issues between 1991-95 were repurchased
Iceland	Y	RAMS planned to start in 1997
Ireland	Y	RAMS since 1990
Italy	Y	RAMS since 1995
Netherlands	Y	RAMS only at the end 1994
New Zealand	Y	RAMS since 1990
Norway	Y	2 RAMS. The first since 1995
Spain	Y	RAMS since 1995
Sweden	Y	RAMS since 1989
Switzerland	N	
United Kingdom	Y	RAMS since 1988
United States	N	

Table 2: Reasons for the repurchase programme

Countries	**Description** (*)
Australia	(4) Poor liquidity (2) Smoothing
Austria	(3) DSC (2) Smoothing (1) Debt reduction
Belgium	(2) Smoothing (4) Poor liquidity (5) Old certificates
Denmark	(2) Smoothing (6) FT (4) Poor liquidity (3) DSC
Finland	(2) Smoothing (7) Short liquidity (5) Old certificates
France	(2) Smoothing (4) Poor liquidity (3) DSC
Greece	(1) Debt reduction (2) Smoothing (3) DSC (4)Poor liquidity
Iceland	(2) Smoothing
Ireland	(4) Poor liquidity (3) DSC (2) Smoothing
Italy	(1) Debt reduction (2) Smoothing (4) Poor liquidity (3)DSC
Netherlands	(4) Poor liquidity (8) Extend debt maturity (3) DSC
New Zealand	(2) Smoothing (4) Poor liquidity
Norway	(2) Smoothing (3) DSC (4) Poor liquidity
Spain	(4) Poor liquidity (2) Smoothing
Sweden	(4) Poor liquidity (2) Smoothing
United Kingdom	(9) Money market management (2) Smoothing

(*) (1) Reduction of outstanding debt; (2) Smoothing of the maturity profile; (3) Reduction of debt servicing costs (DSC); (4) Elimination of securities with poor liquidity; (5) Elimination of old physical certificates; (6) Fine Tuning of the government borrowing in accordance with the borrowing requirement (FT); (7) Elimination of securities with short liquidity; (8) Extend the debt maturity; (9) Money market management.

Table 3: Techniques adopted in the repurchase

Countries	**Description**
Australia	Buyback operations for stock nearing maturity (CB holding)
Austria	Unannounced buyback operations
Belgium	Bond Conversion (into longer maturity bonds)
Denmark	Continuous buyback operations
Finland	Debt exchange techniques
France	OTC. Larger amounts: reverse auctions or public exchange
Greece	Buyback of extraordinary issues (at interest payments)
Iceland	Buyback operations and bond conversions
Ireland	Switching programme and direct buybacks (rarely)
Italy	Reverse auctions (illiquid assets) and buybacks
Netherlands	Bond conversion and buyback operations
New Zealand	Buyback and bond exchange (greater volume in a new bond)
Norway	Buybacks (on the stock exchange), fixed-price offers
Spain	Debt exchange auctions and buybacks
Sweden	Bond conversion
United Kingdom	Purchases of "next maturities", "small"/"index-linked" stocks (*)
	Reverse auction and bond conversion

(*) "Next maturities": Bank of England bids daily a price for bonds maturing within the next three months; "small stocks": Bank of England repurchases issue with extremely low outstanding amount; "index-linked" stocks: sometimes the Bank of England is asked by primary dealers to do so in order not to reduce the volume of such bonds in the market.

Table 4: Source of financing used

Countries	**Description**
Australia	(2) credit facilities (1) new issues
Austria	(3) budget surplus
Belgium	(1) new issues
Denmark	(1) new issues
Finland	(1) new issues
France	(1) new issues (4) special Fund
Greece	
Iceland	(1) new issues
Ireland	(1) new issues
Italy	(4) special Fund
Netherlands	(1) new issues
New Zealand	(1) new issues (initially short term)
Norway	(1) new issues (2) credit facilities
Spain	(2) credit facilities
Sweden	(1) new issues
United Kingdom	Since 1993 Gilt Edged Official Operations Account (GEOOA) (*)

(*) It is an account through which all official transactions in Gilts passe (sales and purchase). It is managed by the National Debt Commissioners under the authority of the Treasury.

Table 5: Repurchases in 1999 and 2000

Countries	**Buyback (*)**	**Exchange**	**Buyback**	**Exchange**	**Buyback**	**Total**
	Auction		**Auction**		**Secondary market**	
	1999		**2000**			
Belgium			11.99			11.99
France			7.07		5.28	12.35
Italy	3.69		2.63		8.64	11.28
Ireland	12.27	16.63				
Netherlands	27.20	29.10				
Spain	5.60	7.37	2.26	2.50		2.26
UK			3.10		0.84	3.94
US			30			30

(*) Nominal values in billion of Euro.

Table 6: Structural break test (BTP)

BTP	**Buyback**	**Model (C):**								**Euro**
		$\mathbf{y}_{t-1}$	**const.**	**trend**	**DU**	**DT**	**lags**		$\boldsymbol{\lambda}$	**(mill.)**
I12675	30/11/1995	-0.243	24.819	0.003	-0.326	0.007	5	NS	0.50	277
		(-3.672)	(3.666)	(1.949)	(-2.040)	(2.125)				
I12678	30/11/1995	-0.162	16.604	0.002	-0.350	0.007	0	NS	0.50	204
		(-2.575)	(2.572)	(1.927)	(-2.398)	(2.375)				
I12686	30/11/1995	-0.195	19.704	0.001	-0.174	0.003	1	NS	0.50	1077
		(-3.678)	(3.676)	(1.424)	(-2.336)	(2.208)				
I36607	12/12/1995	-0.139	14.225	0.008	0.681	-0.009	0	NS	0.50	191
		(-2.220)	(2.227)	(1.329)	(1.935)	(-1.413)				
I12675bis	31/10/1996	-0.216	22.572	0.004	0.397	-0.008	0	NS	0.50	41
		(-3.427)	(-3.427)	(2.857)	(3.551)	(-3.538)				
I12686bis	31/10/1996	-0.157	15.729	-0.002	0.028	-0.001	0	NS	0.50	26
		(-2.269)	(2.268)	(-2.293)	(1.055)	(-1.395)				
I36606	31/10/1996	-0.186	18.917	-0.0002	0.159	-0.003	0	NS	0.50	10
		(-3.147)	(3.147)	(-0.527)	(2.935)	(-3.068)				
I36622	31/10/1996	-0.175	18.229	0.004	0.310	-0.006	3	NS	0.50	31
		(-2.284)	(2.290)	(1.844)	(2.467)	(-2.494)				
I36631	31/10/1996	-0.195	20.326	0.006	0.368	-0.007	0	NS	0.50	41
		(-3.201)	(3.205)	(2.887)	(3.232)	(-3.275)				
I36635	31/10/1996	-0.157	16.436	0.006	0.329	-0.007	0	NS	0.50	2
		(-2.757)	(2.763)	(2.517)	(2.659)	(-2.786)				
I36641	31/10/1996	-0.156	16.309	0.005	0.333	-0.006	4	NS	0.50	46
		(-2.844)	(2.857)	(2.145)	(2.715)	(-2.527)				
I36650	31/10/1996	-0.181	18.623	0.009	0.472	-0.009	0	NS	0.50	16
		(-3.121)	(3.130)	(2.770)	(3.101)	(-3.060)				
I36674	31/10/1996	-0.148	14.785	7.09E-05	0.015	-0.0004	1	NS	0.50	21
		(-2.090)	(2.091)	(0.261)	(0.723)	(-0.909)				
I36676	31/10/1996	-0.144	14.135	0.020	1.001	-0.016	0	NS	0.50	13
		(-2.697)	(2.739)	(2.084)	(2.619)	(-2.210)				
I36682	31/10/1996	-0.168	16.855	0.001	0.072	-0.002	4	NS	0.50	67
		(-2.382)	(2.386)	(1.508)	(1.747)	(-1.775)				

Notes: Lags refer to the augmented form of the regression in the presence of serial correlation. S and NS refers to the stationarity and non stationarity of the series, respectively. λ is the proportion of observations occurring before the structural change. t ratios are reported in parenthesis. The critical value, for Model C and for λ=0.50, is -4.24 at 5% (*) and -3.96 at 10% (**). The asympotic distribution of the other coefficients' t statistic is standardised normal.

Table 6 ctd.: Structural break test (BTP)

BTP	**Buyback**	**Model (C):** $\mathbf{y}_{t-1}$	**const.**	**trend**	**DU**	**DT**	**lags**		**λ**	**Euro (mill.)**
I36691	31/10/1996	-0.186	18.602	0.003	0.156	-0.003	4	NS	0.50	77
		(-3.025)	(3.030)	(2.380)	(2.593)	(-2.578)				
I36707	31/10/1996	-0.188	19.023	0.005	0.289	-0.006	4	NS	0.50	57
		(-3.140)	(3.146)	(2.585)	(2.978)	(-2.923)				
I36715	31/10/1996	-0.181	18.690	0.006	0.362	-0.007	4	NS	0.50	62
		(-2.676)	(2.687)	(2.006)	(2.6127)	(-2.431)				
I36727	31/10/1996	-0.213	22.019	0.009	0.521	-0.010	0	NS	0.50	88
		(-3.387)	(3.395)	(2.996)	(3.331)	(-3.274)				
I36740	31/10/1996	-0.188	19.649	0.009	0.546	-0.010	4	NS	0.50	28
		(-2.905)	(2.921)	(2.285)	(2.992)	(-2.737)				
I36747	31/10/1996	-0.217	22.256	0.0139	0.747	-0.014	0	NS	0.50	15
		(-3.585)	(3.597)	(3.197)	(3.596)	(-3.476)				
I36675	3/11/1997	-0.171	17.680	-0.001	-0.127	0.003	2	NS	0.50	1067
		(-2.870)	(2.879)	(-1.306)	(-1.717)	(1.925)				

Notes: Lags refer to the augmented form of the regression in the presence of serial correlation. S and NS refers to the stationarity and non stationarity of the series, respectively. λ is the proportion of observations occurring before the structural change. t ratios are reported in parenthesis. The critical value for Model C for λ=0.50 is -4.24 at 5% (*) and -3.96, at 10% level of significance (**). The asympotic distribution of the other coefficients' t statistic is standardized normal.

Table 7: Structural break test (CCT)

CCT	**Buyback**	**Model (C):**								**Euro**
		$\mathbf{y}_{t-1}$	**const.**	**trend**	**DU**	**DT**	**lags**		$\boldsymbol{\lambda}$	**(mill.)**
I13096	31/10/1996	-0.237	23.887	0.002	0.039	-0.002	1	NS	0.35	10
		(-1.925)	(1.923)	(0.603)	(0.543)	(-0.655)				
I13097	31/10/1996	-0.026	2.612	0.0003	-0.027	0.0003	1	NS	0.35	10
		(-0.585)	(0.584)	(0.266)	(-0.885)	(0.272)				
I13204	31/10/1996	-0.029	2.901	0.0001	-0.027	0.0003	1	NS	0.35	5
		(-0.665)	(0.665)	(0.182)	(-1.027)	(0.293)				
I36612	31/10/1996	-0.126	12.741	0.001	0.040	-0.001	1	NS	0.35	31
		(-2.072)	(2.070)	(0.514)	(1.148)	(-0.899)				
I36690	31/10/1996	-0.229	23.040	0.006	0.195	-0.007	2	NS	0.35	36
		(-3.562)	(3.561)	(2.849)	(3.243)	(-3.081)				
I36611	31/12/1996	-0.151	15.437	-0.001	0.124	-0.002	1	NS	0.54	155
		(-3.368)	(3.369)	(-1.630)	(2.618)	(-2.355)				
I36629	31/12/1996	-0.165	16.806	-0.001	0.154	-0.003	0	NS	0.54	170
		(-2.816)	(2.816)	(-0.989)	(2.510)	(-2.525)				
I36685	3/11/1997	-0.180	18.111	0.001	0.004	-8.38E-05	2	NS	0.50	759
		(-3.091)	(3.093)	(1.305)	(0.135)	(-0.156)				
I36690bis	3/11/1997	-0.144	14.472	0.001	-0.018	0.0001	0	NS	0.50	418
		(-2.597)	(2.597)	(1.986)	(-0.641)	(0.232)				
I36694	3/11/1997	-0.175	17.630	0.001	0.006	-0.0002	1	NS	0.50	1164
		(-3.010)	(3.101)	(1.752)	(0.233)	(-0.329)				
I36726	19/12/1997	-0.425	42.806	0.003	0.149	-0.004	1	S	0.50	413
		(-4.432)*	(4.432)	(4.033)	(3.177)	(-3.634)				
I36746	19/12/1997	-0.359	36.201	0.003	0.140	-0.004	1	NS	0.50	1033
		(-3.909)	(3.909)	(3.657)	(2.938)	(-3.334)				

Notes: Lags refer to the augmented form of the regression in the presence of serial correlation. S and NS refers to the stationarity and non stationarity of the series, respectively. λ is the proportion of observations occurring before the structural change. t ratios are reported in parenthesis. The critical value for Model C for λ=0.3 is –4.17 at 5% (*) and -3.87 at 10% (**). The critical value for Model C and for λ=0.4 is -4.22 at 5% (*) and -3.95 at 10% (**). For λ=0.5, the critical value is -4.24 at 5% (*) and –3.96 at 10% (**). The asympotic distribution of the other coefficients' t statistic is standardized normal.

Table 8: Structural break test (UK)

	Buyback	**Model (C):**								**£**
		$\mathbf{y}_{t-1}$	**const.**	**trend**	**DU**	**DT**	**lags**		$\boldsymbol{\lambda}$	**(mill.)**
10TY03	20/7/2000	-0.119	13.803	0.0002	-0.300	0.005	0	NS	0.51	357
		(-1.942)	(1.950)	(0.082)	(-2.581)	(2.086)				
8TY03	20/7/2000	-0.159	18.430	0.006	0.344	-0.006	0	NS	0.51	381
		(-2.377)	(2.378)	(2.178)	(1.623)	(-1.791)				
7TTY06	21/9/2000	-0.207	22.938	0.001	-0.101	0.002	0	NS	0.51	130
		(-3.322)	(3.316)	(1.218)	(-1.464)	(1.460)				
8HTY07	21/9/2000	-0.190	19.917	0.002	-0.092	0.002	0	NS	0.51	464
		(-3.260)	(3.256)	(2.649)	(-1.541)	(1.441)				
9TY08	21/9/2000	-0.118	13.495	0.003	-0.080	0.001	0	NS	0.51	180
		(-2.338)	(2.326)	(2.171)	(-0.771)	(0.298)				
10TY03	11/10/2000	-0.212	23.540	-0.005	-0.372	0.011	0	NS	0.5	381
		(-2.883)	(2.880)	(-1.857)	(-1.984)	(2.492)				
8TY03	11/10/2000	-0.215	25.193	-0.006	-0.438	0.0133	0	NS	0.5	221
		(-2.891)	(2.887)	(-1.943)	(-1.962)	(2.483)				
9HCV05	11/10/2000	-0.226	27.863	-0.007	-0.541	0.017	0	NS	0.5	38
		(-3.034)	(3.028)	(-2.114)	(-1.980)	(2.568)				
8HTY07	23/11/2000	-0.219	24.425	0.001	0.077	-0.003	0	NS	0.53	592
		(-2.882)	(2.889)	(0.633)	(0.776)	(-1.268)				
9HCV05	18/1/2001	-0.202	21.282	0.0014	0.0421	-0.002	0	NS	0.5	430
		(-2.713)	(2.720)	(0.917)	(0.495)	(-1.021)				
7TTY06	22/2/2001	-0.084	9.533	-0.001	0.348	-0.004	1	NS	0.53	13
		(-1.595)	(1.599)	(-0.568)	(1.858)	(-1.032)				
8HTY07	22/2/2001	-0.047	5.608	-0.003	0.548	-0.007	0	NS	0.53	411
		(-0.932)	(0.940)	(-0.915)	(2.606)	(-1.629)				

Notes: Lags refer to the augmented form of the regression in the presence of serial correlation. S and NS refers to the stationarity and non stationarity of the series, respectively. λ is the proportion of observations occurring before the structural change. t ratios are reported in parenthesis. The critical value for Model C and for λ=0.5 is -4.24 at 5% (*) and -3.96 at 10% (**). The asympotic distribution of the other coefficients' t statistic is standardised normal.

Table 9: Structural break test (yield to maturity)

Buyback	**Model (C):**								**Euro**
	$\mathbf{y}_{t-1}$	**const.**	**trend**	**DU**	**DT**			$\boldsymbol{\lambda}$	**(mill.)**
30/11/1995	-0.281	0.792	0.038	1.425	-0.083	0	NS	0.51	1558
	(-2.675)	(2.615)	(2.184)	(1.638)	(-2.216)				
21/12/1995	-0.303	0.100	0.031	1.404	-0.080	1	NS	0.51	1298
	(-2.679)	(3.112)	(1.638)	(1.544)	(-1.988)				
24/6/1996	-0.107	2.147	-0.103	-2.731	0.112	6	NS	0.51	1109
	(-0.797)	(2.816)	(-4.633)	(-3.435)	(3.150)				
31/10/1996	-0.400	3.002	-0.083	-1.664	0.056	3	NS	0.51	736
	(-3.957)	(4.365)	(-4.931)	(-3.947)	(3.733)				
31/12/1996	-0.410	2.908	-0.086	-1.587	0.058	1	S	0.51	325
	(-4.457)**	(4.650)	(-5.081)	(-3.757)	(4.162)				
3/11/1997	-0.493	2.027	-0.074	-1.838	0.072	4	NS	0.51	3409
	(-3.672)	(2.809)	(-2.898)	(-2.942)	(3.020)				
19/12/1997	-0.503	2.045	-0.077	-1.850	0.074	3	NS	0.51	1446
	(-3.899)	(3.150)	(-3.251)	(-3.088)	(3.252)				
19/11/1999	-0.394	0.148	-0.002	-0.099	0.004	2	NS	0.57	1905
	(-4.165)	(2.763)	(-1.184)	(-1.211)	(1.583)				
22/5/2000	-0.594	0.145	0.002	0.072	-0.001	0	NS	0.53	2634
	(-2.909)	(2.796)	(1.293)	(1.672)	(-0.612)				
23/11/2000	-0.377	0.083	0.003	0.119	-0.005	0	NS	0.71	1501
	(-2.433)	(2.416)	(2.012)	(1.179)	(-1.255)				
7/12/2000	-0.369	0.081	0.003	0.114	-0.005	0	NS	0.75	7140
22/12/2000	(-2.391)	(2.379)	(2.061)	(0.939)	(-1.043)				
19/6/2001	-0.300	-0.422	0.006	1.891	-0.061	0	NS	0.94	2209
	(-2.096)	(-1.906)	(1.531)	(0.534)	(-0.545)				

Notes: Lags refer to the augmented form of the regression in the presence of serial correlation. S and NS refers to the stationarity and non stationarity of the series, respectively. λ is the proportion of observations occurring before the structural change. t ratios are reported in parenthesis. The critical value for Model C and for λ=0.5 is -4.24 at 5% (*) and -3.96 at 10% (**). The critical value for Model C and for λ=0.7 is -4.18 at 5% (*) and -3.86 at 10% (**). The critical value for Model C and for λ=0.8 is -4.04 at 5% (*) and -3.69 at 10% (**). The critical value for Model C and for λ=0.9 is -3.80 at 5% (*) and -3.46 at 10% (**). The asympotic distribution of the other coefficients' t statistic is standardised normal.