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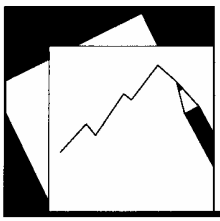

# IMF Working Paper

# Sovereign Insurance and Program Design: What Is Optimal for the Sovereign?

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# Sovereign Insurance and Program Design: What Is Optimal for the Sovereign?

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## Abstract



The design of the optimal sovereign insurance contract is analyzed when: the sovereign chooses the contract; effort is not contractible; shocks are of uncertain magnitude; the sovereign can save; and the sovereign can default. Under these conditions: i) an ex ante premium leads to higher coverage; ii) the premium increases with the sovereign's incentive to take risks; iii) a deductible is chosen to limit moral hazard; iv) the deductible-to-support ratio is decreasing with the size of the realized shock; and v) the change in the choice of savings when insurance is available is ambiguous, as there is a trade-off between inducing higher effort and increasing the likelihood of default.

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## I. INTRODUCTION

IMF-supported programs have many similarities with insurance arrangements. The opportunity cost of quotas that member countries contribute to the IMF can be interpreted as implicit premium payments, in return for which countries receive financial support in case of need. The quotas determine the amount of support that can be provided by the Fund just as an insurance premium is linked to the amount of payout. As with insurance, access to Fund resources is contingent on the occurrence of an event—in this case, balance of payments (BOP) need—and access is not automatic. Insurance contracts often impose a set of preconditions and the payment of a deductible in order to limit moral hazard; similarly, IMF programs specify conditions that need to be fulfilled before and after any transfer of resources.[2] The amount of support provided by the IMF typically does not cover the full BOP need, requiring some adjustment by the country. This is similar to an implicit "deductible."

This paper employs the analytical framework used to study insurance design in order to derive an optimal insurance arrangement and compare it with IMF programs. Using insurance as a benchmark is valid given the aforementioned similarity between insurance and IMF programs. Moreover, IMF support can be thought of as state-contingent loans, which are equivalent to the insurance arrangements studied in this paper as the insurer makes no net transfer of resources. Any resources provided by the insurer to a country during a crisis period come from contributions the country makes to the insurer in tranquil times.

Optimal design is assessed from the point of view of the sovereign. This contrasts with the more common approach of analyzing the problem from the point of view of the insurer. Sovereign moral hazard is introduced by having a shock whose likelihood depends on the level of costly sovereign effort. Effort is not contractible, and so the insurance contract needs to be designed in order to provide incentives for an adequate level of effort. In addition, the sovereign has the alternative of self-insurance through savings, and savings can be contracted upon in order to incorporate the policy conditionality that is a part of IMF programs. Finally, any distortions arising from insurer altruism are also analyzed.

The optimal insurance arrangement has important differences from IMF programs. Optimally, an initial premium is risk-adjusted according to the probability of a shock. A riskier sovereign is required to pay a higher premium for a given amount of support. Equivalently, a given initial contribution leads to smaller support to riskier sovereigns. This

[2] Unlike insurance, IMF support programs for middle-income countries do not imply a clear transfer of resources to the country. While the interest rate associated with the use of Fund resources is typically smaller than the one at which countries are able to obtain private financing at a time of BOP need, the lower rate is justifiable by the higher seniority of the IMF's claims. An exception is the support provided to low-income countries when some of the financing has preferential terms.

is not the case under the IMF quota system.[3] Higher premia—commonly observed in insurance arrangements, including deposit insurance—are chosen by riskier sovereigns because they provide access to a larger amount of resources in the event of large shocks. In addition, an increase in the premium in response to risk-taking behavior is used as a disciplining device by the sovereign to limit moral hazard.

In the case of insurance, the total amount of coverage is not fixed but chosen by the insured. This reduces the amount of inefficient self-insurance through savings. However, the ex ante premium has to increase with the coverage to limit moral hazard and maintain the resources of the insurer. Currently, the Fund's quotas can not be unilaterally increased by a country that wants to increase the potential size of future support.

Aside from a risk-adjusted premium, the optimal insurance contract addresses moral hazard in several ways. First, the insurance does not provide support equal to the size of the shock. The insured has to pay a certain amount of resources—the deductible—out of pocket. This is qualitatively consistent with IMF programs as they do not cover the full amount of BOP needs, implying a degree of domestic policy adjustment. Second, repayment of the support or the payment of a deductible should be on better terms the more quickly the insured recovers from the shock. This is analogous to the results on optimal unemployment insurance: the amount of insurance falls with the length of the unemployment spell. Finally, the amount of the deductible need not increase with the size of the shock. For example, in the case of IMF programs, this would mean that a required domestic adjustment ("deductible") of 3 percent of GDP may be enough to limit moral hazard whether the negative shock is 5 percent of GDP or 10 percent. This is optimal since the size of a shock is unknown ex ante, and this contrasts with proposals for imposing an absolute limit of IMF support.

As noted, IMF programs limit moral hazard by imposing conditionality on domestic policies. However, a risk-adjusted premium can provide stronger ex ante incentives to avoid policies that lead to a higher probability of a shock. In addition, an improvement in repayment terms in case of a faster recovery provides incentives for the country to voluntarily pursue adequate policies.

This paper is organized as follows: Section II reviews previous work on the design of international support conditional on sovereign moral hazard. Section III introduces the model used in the paper and analyzes the cases of no insurance and insurance with and without contractibility of effort and savings. Section IV discusses the case when the insurer is altruistic and the contract is renegotiable. In Section V, the sovereign has the option to default. These modifications are introduced sequentially to distinguish the effects arising from each. Section VI concludes with a comparison of the different results and discusses additional implications for the reform of the international financial architecture. Section VII includes a detailed derivation of the results discussed in the previous sections.

[3] Ostry and Zettelmeyer (2005) present a similar proposal: the IMF would rate countries and the amount of available support in case of need would depend on the rating.

## II. Moral Hazard and Sovereign Insurance

Several earlier studies have discussed the reform of the international financial architecture using analogies to insurance or to a lender of last resort. In fact, Keynes's original plans for the IMF were that it was a large lender of last resort.[4] Recent studies that look at the issue of a lender of last or final resort, or "liquidity insurer," are Fischer (1999), Mussa (1999), Mussa and others (1999), Calomiris (2000), and Cordella and Levy-Yeyati (2005). In these studies, the IMF is seen as a provider of resources to make up for temporary liquidity shortages in international financial markets.

The idea of the IMF as a lender of last or final resort has been extended to incorporate catalytic finance.[5] This is based on the idea that liquidity shortages are not purely exogenous events but can depend on what a creditor believes other creditors will do. If a creditor expects that nobody else will refinance, then she should not roll over her claims. In this case, the resources provided by the Fund are meant to generate a reversal of the negative expectations that led to the liquidity shortage by ensuring creditors that enough resources are available for repayment. The approach followed here is complementary, as shocks are assumed to arise partly due to a country's actions, rather than to those of its creditors.

The analysis in this paper is closest to that in Chami, Sharma, and Shim (2004), who use a principal-agent framework to analyze the provision of state-contingent IMF loans. Both papers have a level of noncontractible effort that affects the probability of a crisis and the probability of recovery after the crisis. However, they solve the problem of finding an optimal state-contingent contract from the point of view of a lender that is risk-averse and altruistic, while this paper takes the point of view of the sovereign. Other distinguishing characteristics of this paper are that the magnitude of the shock is not known ex ante; the sovereign can self-insure through saving; the level of savings can affect the probability of a crisis; and the sovereign can default on future premium payments. The insurer is introduced through a participation constraint and is assumed to be either risk-neutral or altruistic.[6]

The characteristics of the optimal insurance arrangement depend on the importance of moral hazard, and a large number of proposals for the reform of the international financial architecture have been based on the existence of moral hazard. In particular, the increase in the size of IMF support programs since the mid-1990s has been criticized for exacerbating both creditor and debtor moral hazard. Creditor moral hazard can arise if private creditors have lower incentives to appraise risks correctly as they expect that international support will be used to repay their claims. Debtor (sovereign) moral hazard can arise, even in the case of

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[4] See Boughton (2002).

[5] See Morris and Shin (2003) and Corsetti, Guimaraes, and Roubini (2003).

[6] There is an extensive literature that analyzes the problem of insurance with moral hazard. See Laffont and Martimort (2002) for an exposition of the development of this literature and an extensive review of the principal-agent problems that arise in this and other contexts.

benevolent governments, if a country has lower incentives to adjust imbalances ex ante or can gamble for resurrection knowing that international support is available to lessen the negative effects of this strategy if it is unsuccessful. The problem can be compounded in the case of nonrepresentative governments, as international support may be used to allow a select few to secure their investments while the public is left with the future obligation to service this support.[7,8]

This paper solves for the optimal insurance arrangement assuming that sovereign moral hazard exists. Nevertheless, it should be noted that empirical studies have not provided convincing evidence that larger amounts of financial support since the Mexican crisis have led to increases in moral hazard. Zhang (1999), Nunnenkamp (1999), Lane and Phillips (2000), Dell'Ariccia, Schnabel and Zettelmeyer (2002), Kamin (2002), and Zoli (2004) test if spreads on sovereign bonds fell as a result of larger support programs and if the spreads became less sensitive to changes in a set of fundamental determinants. Some of the studies find evidence in favor of such a change, but this is not a general result. Even in the presence of stronger evidence, there is a fundamental problem concerning the interpretation of such a result: the spreads could have fallen and become less sensitive to shocks due to the successful design and implementation of the new types of support programs, not because of moral hazard. Most of the studies acknowledge this problem, arguing that changes in the behavior of spreads are necessary but not sufficient evidence of moral hazard. In fact, such a response in spreads is also necessary evidence that changes in the structure of IMF support programs reduced risk in the international financial system, which is what they were designed to do. Furthermore, as argued in Mussa and others (1999) and Mussa (1999), a desirable result of efficient insurance can be that the insured takes more risk. This can arise if the insured is excessively risk-averse or if efforts to avoid risk are costly, as is the case with the results presented in Section III.[9,10]

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[7] See Calomiris (2000) and Jeanne and Zettelmeyer (2001) for expositions of this argument.

[8] As argued in the conclusions, the existence of this type of moral hazard can be dealt with by having risk-adjusted premiums.

[9] More recent studies have used alternative approaches to assess moral hazard. Haldane and Scheibe (2004) look at stock returns of U.K. banks during episodes of large IMF interventions, and Gai and Taylor (2004) analyze if countries were more likely to demand IMF support after the perceived increase in program size. However, these studies are subject to the same interpretation problems as those using spreads on sovereign debt.

[10] A car insurance analogy illustrates how higher risk-taking can be optimal in the presence of externalities. In the absence of insurance, excessively cautious driving could lead to higher congestion and transit times. Martinez, Tornell, and Westermann (2003) argue that financial liberalization can increase the probability of a crisis in the short run but leads to higher growth in the long run.

## III. Basic Model Structure and the Role of Insurance

The basic structure used to analyze the design of insurance is summarized in Figure 1. There are three time periods, and the country maximizes its expected utility of consumption taking into account the disutility of effort. In period 0, the sovereign is not in a crisis, having a level of income $y$, and choosing levels of initial effort ($e_0$) and savings ($s_0$). In period 1, the sovereign can suffer from a crisis with probability $\pi(e_0)$, with $\pi(\cdot)$ being a decreasing convex function of effort ($\pi'<0$, $\pi''>0$). If there is no crisis in period 1, income in periods 1 and 2 is equal to $y$. If there is a crisis in period 1, the level of income is equal to $y-\delta_i$, where $\delta_i$ is a random variable distributed as a normal with mean $\delta^e$ and variance $\sigma_\delta^2$. In addition, the country chooses a level of effort to recover from the crisis ($e_1$) and a new level of savings ($s_1$). In the period after the crisis, the economy recovers with probability $1-\pi(e_1)$, receiving income $y$, or continues in a crisis with probability $\pi(e_1)$. In this case, the country has income $y-\delta_j$. The shock $\delta_j$ follows the same normal distribution as the shock in the first period: $\delta_j \sim N(\delta^e, \sigma_\delta^2)$, with associated density function $f(\delta_j)$.

### A. The Case without Insurance

In the absence of insurance, the sovereign chooses its level of effort and savings sequentially in each period, as the optimal level of effort and savings depends on whether a crisis took place and on its magnitude. The country makes an initial choice in period 0 before a crisis has occurred and contingent choices in period 1 depending on whether there was a crisis or not.

The model is solved backward starting with the case when a crisis has occurred in period 1. The sovereign solves the following problem:

$$\begin{aligned} \underset{s_{1i},e_{1i}}{Max} \quad & u(y-\delta_i+s_0-s_{1i})-\gamma v(e_{1i})+(1-\pi(e_{1i}))u(y+s_{1i}) \\ & +\pi(e_{1i})\int f(\delta_j)u(y-\delta_j+s_{1i})d\delta_j \end{aligned} \tag{1}$$

where the subscript $i$ indicates that the optimal choice of effort and savings is a function of the size of the shock $\delta_i$ in period 1. Utility is time separable with an increasing and concave instantaneous utility function $u(\cdot)$ in each period ($u'(\cdot)>0$, $u''(\cdot)<0$). The term $\gamma \cdot v(e_i)$ is the cost to the sovereign of carrying out effort, where $\gamma$ is a parameter and $v(\cdot)$ is an increasing convex function ($v'(\cdot)>0$, $v''(\cdot)>0$). In order to obtain an interior solution, it is assumed that the functions $u(\cdot)$ and $v(\cdot)$ are continuously differentiable and satisfy the following conditions:

$$u'(0)=-\infty, \quad u'(\infty)=0$$
$$v'(0)=0, \quad v'(\infty)=\infty$$

The first-order conditions are standard for this type of model:

$$s_{1i}: u'(y-\delta_i+s_0-s_{1i})=(1-\pi(e_{1i}))u'(y+s_{1i})+\pi(e_{1i})\int f(\delta_j)u'(y-\delta_j+s_{1i})d\delta_j \tag{2}$$

$$e_{1i} : \gamma v'(e_{1i}) = (-\pi'(e_{1i}))\left[u(y + s_{1i}) - \int f(\delta_j)u(y - \delta_j + s_{1i})d\delta_j\right] \quad (3)$$

Condition (2) implies that the sovereign saves to equalize the marginal utility of consumption in period 1 with the expected marginal utility in period 2, while condition (3) states that effort is chosen so that the expected marginal benefit of a reduction in the probability of a crisis is equal to the marginal cost of effort. In addition, it can easily be shown that first period effort and savings respond in opposite directions to initial period savings, $s_0$, and the magnitude of the shock in the first period, $\delta_i$:

$$\frac{de_{1i}^*}{ds_0} < 0, \frac{ds_{1i}^*}{ds_0} > 0, \frac{de_{1i}^*}{d\delta_i} > 0, \frac{ds_{1i}^*}{d\delta_i} < 0$$

where the superscript * indicates the optimal choice of a variable. A higher level of initial savings allows the country to transfer more resources to smooth consumption in period 2. In consequence, effort can be smaller. The response to the size of the shock in period 1 is the opposite, as the sovereign uses a larger amount of initial savings for consumption in that period, leading to higher effort and lower savings in period 1.

When there is no crisis in the first period, the country only needs to choose the level of savings in a context of certainty:

$$\underset{s_{1n}}{Max} \quad u(y + s_0 - s_{1n}) + u(y + s_{1n}) \quad (4)$$

The solution in this case is to divide the resources saved from the initial period between periods 1 and 2. Therefore:

$$s_{1n}^* = \frac{s_0}{2} \quad (5)$$

In period 0, the sovereign chooses $s_0$ and $e_0$ to maximize its expected utility, taking into account the choices of effort and savings it knows it will make in period 1:

$$\underset{s_0, e_0}{Max} \quad u(y - s_0) - \gamma v(e_0) + (1 - \pi(e_0))2u(y + s_0/2) + \pi(e_0)[\int f(\delta_i)\{u(y - \delta_i + s_0 - s_{1i}) - \gamma v(e_{1i})$$
$$+ (1 - \pi(e_{1i}))u(y + s_{1i}) + \pi(e_{1i})\int f(\delta_j)u(y - \delta_j + s_{1i})d\delta_j\}d\delta_i]$$
$$s.t. \quad (2) \text{ and } (3)$$

The restrictions are the first-order conditions from the decision in period 1 when there is a crisis. Condition (5) for savings in the case of no crisis has been included directly in the objective function.[11]

[11] The discount rate is assumed to be equal to zero for simplicity.

The first-order conditions for $s_0$ and $e_0$ are:

$$s_0 : u'(y - s_0) = (1 - \pi(e_0))u'(y + s_0/2) + \pi(e_0)[\int f(\delta_i)u'(y - \delta_i + s_0 - s_{1i})d\delta_i] \quad (6)$$

$$\begin{aligned} e_0 : \gamma v'(e_0) = (-\pi'(e_0))[2u(y + s_0/2) - [\int f(\delta_i)\{u(y - \delta_i + s_0 - s_{1i}) - \gamma v(e_{1i}) \\ + (1 - \pi(e_{1i}))u(y + s_{1i}) + \pi(e_{1i})\int f(\delta_j)u(y - \delta_j + s_{1i})d\delta_j\}d\delta_i]] \end{aligned} \quad (7)$$

These equations have the same structure as those arising from the first period choice when there is a crisis (conditions 2 and 3). Savings are set at a level that equalizes the marginal utility of initial consumption with the expected marginal utility of consumption in period 1, and effort is chosen so that its marginal benefit is equal to its marginal cost. These choices of savings and effort are used as a benchmark to assess the effect of introducing insurance.

### B. Insurance without Moral Hazard: Contractibility of Effort and Savings

The multilateral insurance institution is initially assumed to be risk-neutral and willing to sign a contract specifying any kind of contingent payments to and from the sovereign as long as the net expected value of the resources it receives from the country is equal to or greater than an opportunity cost *C*. Payments to the sovereign are referred to as transfers, denoted by *t*, and payments from the sovereign are called premia, denoted by *p*. It is assumed that the sovereign can credibly commit to present and future levels of effort and savings through the insurance contract. The modified structure of the problem is shown in Figure 2. The full modified model and analytical results are presented in Section VII.

The assumption of contractibility of effort and savings implies that there is no moral hazard, and so full insurance is feasible and is the optimal solution: the sovereign contracts for premia and transfers that lead to the same utility in all periods and under all shocks. Without any restrictions on the level of savings, premia, and transfers, only the sum of savings and transfers or premia is determined in the optimum as premia and transfers are adjusted to compensate for any change in the level of savings. If savings are assumed to be zero in both periods, the premia are all identical, transfers are $t_k = \delta_k - p$, for $k=i,j$, and consumption is always equal to $y - p$.

The choice of effort by the country takes into account that lower effort leads to higher premia paid to the insurer in order to compensate for higher expected transfers. Therefore, the marginal cost of effort is equalized with the marginal loss in utility of consumption due to higher premium payments. This implies that the optimal level of effort is higher in the initial period, $e_0 > e_1$. In the optimal contract, the initial level of effort is larger because it helps to avoid the first period crisis and its continuation.

How do savings and effort change as the availability of insurance increases, i.e., as the opportunity cost of insurance falls? As mentioned, savings are not determined in this case and so they depend on how the country decides to structure the insurance contract. Effort is reduced as the availability of insurance increases, but this response is not due to moral hazard as effort is perfectly contractible. Given that effort is costly, it is optimal for the country to

distribute the benefits from increased availability of insurance between lower premia and lower effort.

These results confirm the identification problems, discussed in Section II, that arise in empirical studies of sovereign moral hazard. A reduction in the risk perception implicit in spreads and changes in the behavior of sovereigns when the availability of multilateral support increases is not sufficient evidence of a moral hazard problem: the same qualitative response is observed as the optimal result in a context without market failures. What constant spreads and no behavioral changes would imply is that the support is not useful.

Countries with higher costs of undertaking effort, higher $\gamma$, choose contracts with lower levels of effort and higher premia, $p$. This result is consistent with the practice in deposit insurance.[12] Banks are allowed to take risks in spite of the existence of deposit insurance. However, the fee charged for the insurance should respond to the characteristics of a bank's portfolio in order to avoid excessive risk-taking.[13]

### C. Insurance with Moral Hazard: Noncontractible Effort

After signing a contract with full consumption smoothing, the sovereign has no incentives to undertake any effort ex post unless it is forced to do so by a contract or other means. In turn, the ex post reduction in effort leads to an increase in the probability of a crisis, which can make any contract with full consumption smoothing inconsistent with the opportunity cost constraint of the insurer. In this case, effort may need to be induced after the insurance contract has been signed through a structure of contractible pay-offs with only partial smoothing of consumption.[14] Therefore, the previous model is solved without any contractibility in order to find the structure of pay-offs that provides incentives for adequate savings and effort. When savings and effort are noncontractible, the country chooses the structure of the insurance contract subject to the fact that the insurer knows about the incentives of the sovereign to adjust its savings and effort.[15] Subsequently, the results allowing for contractibility of savings are discussed to show how partial contractibility modifies the results and because IMF support programs typically include conditionality in terms of levels of public savings and accumulation of international reserves.

In the current case without contractibility, premia and transfers need to vary in order to impose the correct incentives for effort and savings after the insurance contract is signed. The

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[12] See Garcia (2000), Demirguc-Kunt and Kane (2002) and Demirguc-Kunt and Detragiache (2002).

[13] Among many others, see Merton (1977), Bodie and Merton (1992), FDIC (2000), and Blinder and Wescott (2001). These studies make the case for the need to price any deposit guarantee according to risk and propose mechanisms for doing so.

[14] See Laffont and Martimort (2002) for the case without savings.

[15] See Section VII for the analytical model and derivation of the results.

sovereign decides to pay a higher premium in the first period, even if that implies a lower level of initial savings and consumption. By paying a higher premium today, the country limits its ability to increase savings that lead to more consumption smoothing in the future and reduce incentives for effort.

In order to create the incentives for effort, the premium in the case of no crisis and the transfer in the case of a crisis are such that the utility of the country has to be higher when there is no crisis. A comparison between first and second period utilities in the case of a crisis shows similar results. Transfers in the case of a crisis are limited and so the sovereign has higher incentives for first period effort (and smaller savings). In period 2, transfers and premia are such that there is a wedge in utilities between the recovery and continued crisis cases in order to have higher effort in the first period.

When there is a crisis, transfers are such that consumption is smoothed for any size of the shocks, but not enough that consumption is equal to the noncrisis and recovery cases. Consumption smoothing across crisis cases arises because what matters for effort incentives is the difference between utility in the case of no crisis and the total expected utility when there is a crisis, not each specific utility in the crisis case. Given the sovereign's risk aversion, it is willing to pay a larger initial premium in exchange for full smoothing across noncrisis episodes.

The existence of a wedge in utilities between crisis and noncrisis episodes can be interpreted as an implicit deductible, a widely observed characteristic of insurance contracts for all types of activities. In addition, full consumption smoothing across shocks during a crisis implies that the deductible falls as a proportion of the shock.[16]

In order to solve the case when savings are contractible, the model can be simplified based on the result that consumption is smoothed within crisis episodes.[17] As in the case when savings are not contractible, effort is induced by setting premia and transfers such that utility is higher in noncrisis periods than when a crisis occurs. However, in contrast with the previous case, a high initial premium is not needed in order to limit transfers of resources through savings. These are explicitly contracted downward with respect to the level that the country would choose ex post given this structure. The ability to commit to lower savings in the initial period and after the first crisis is used to reduce the premium in the initial period while maintaining the desired level of effort.

The choice of a lower level of savings in order to promote effort has a precedent in the literature that explains the use of indexed, short-term, and external debt to deal with

[16] This implies that the risk-neutral insurer is taking a significant amount of risk. In the case of a risk-averse insurer, as assumed in Chami, Sharma, and Shim (2004), it may be the case that the proportion of coinsurance increases if the insurer is sufficiently risk-averse compared with the country.

[17] The results are not presented in detail, but are available from the author.

commitment problems, which includes Sachs (1984), Krugman (1985), Alessina, Prati, and Tabellini (1990), Calvo and Guidotti (1990), and Tirole (2003), among others. In this literature, a country self-disciplines by choosing a more vulnerable financial structure which includes higher levels of indexed, foreign, and short-term debt. The country cannot inflate the indexed and foreign debt and will have problems refinancing the short-term debt if economic performance is unfavorable. The robustness of this result is analyzed in the following sections under two conditions: if the insurer is altruistic and if the country has the option to default.[18]

Finally, the results that transfers have to be smaller in period 2 in order to promote effort in period 1 after a crisis has happened is similar to that obtained in the analysis of unemployment insurance: insurance payments should be reduced gradually as the unemployment period increases.[19]

## IV. An Altruistic Insurer

International support is based partly on the intercountry effects of shocks and adjustment policies, but also on concerns about welfare in the affected countries. In the case of international financial institutions, potentially affected countries are represented in the decision-making process, which presumably leads to additional responsiveness to the welfare of each member country. In consequence, international financial institutions have been described as partly altruistic, the implications of which have been analyzed in several studies such as Azam and Laffont (2003), Mourmouras and Rangazas (2004), and Chami, Sharma, and Shim (2004).

Therefore, the problem of Section III.C is modified to allow for altruism of the insurer. This is introduced by incorporating the utility of the country into the participation constraint of the insurer (when the utility of the country is lower, the insurer is willing to charge less for the insurance), and by focusing only on contracts that are renegotiation proof, as commitment to a contract may be affected by altruism. Contracts for which a deviation at any point in time would lead to higher ex post utility of the insurer and the country are not considered feasible. The technical details are discussed in Section VII.

The problem has two distinct solutions depending on the level of altruism. When altruism is very strong, the optimal solution for the country leads to an extreme case of moral hazard. The country chooses not to pay any initial premium but rather to transfer an extremely large amount of resources to the initial period through negative savings or loans (or a negative

[18] In addition, the optimal choice of savings was analyzed in the case when these have a direct effect on the probability of a crisis assuming that higher savings reduce the likelihood of a crisis. The optimal amount of savings is larger under this assumption, but it is still the case that, in order to induce more ex post effort, savings would be contracted downward with respect to the level they would have when effort is also contractible.

[19] See Wang and Williamson (1996) and Hopenhayn and Nicolini (1997).

initial premium if this is allowed). As it would have to repay the loans in the case of no crisis, the country has no incentives to undertake any effort. In fact, the country is hoping for a crisis to occur so that it can receive transfers from the insurer in order to repay its loans and to smooth any shocks. However, this is a case that implies a very large ex ante exposure by the insurer as it transfers an increasing amount of resources to the country. In this case, the assumption of a risk-neutral insurer seems much less plausible. It is likely that risk aversion of the insurer would rule out such a result.[20]

In the case of intermediate levels of altruism, the structure of the solution reverts gradually toward the autarky case. Given the possibility of ex post renegotiation, the initial premium increases so that altruistic transfers can be made in the subsequent periods. Consumption smoothing is reduced with respect to the case without altruism, though the transfers from the insurer increase, and at higher rates, with the size of the negative shock so that the implicit ratio of co-insurance to the size of the shock is still decreasing with the magnitude of the shock. In the case of autarky, the initial resources for smoothing are first period savings, which similarly provide only partial smoothing of consumption in subsequent periods. As in the results of Section III.C., the country chooses a contract that reduces its ability to increase the level of savings in order to promote higher effort. This is done by choosing a higher level of initial premium.

## V. Default by the Country

The final analysis corresponds to the case when effort is noncontractible and the country has the option to default on its premium payments to the insurer.[21] The insurer is no longer altruistic, in order to focus solely on the effect of the option to default. The decision to default depends on a simple comparison of the net benefits of repayment versus default. The benefit of default is the avoidance of present and future premium payments. The costs of defaults most extensively discussed are the loss of future financing and any direct (or indirect) costs imposed by the insurer (or creditor).

When insurance is only sustained by the loss of future financing, there is a simple solution in the current framework with a final period. The insurer knows that the country would default on its premium payments when there is a recovery after a crisis or when the crisis does not happen. Therefore, the country can only commit to payment of the initial premium in exchange for a transfer that helps it smooth consumption across crisis scenarios. The results are qualitatively similar to the case when the country cannot default. There is complete smoothing across crisis events in each period, though not across periods. As before, the country chooses an insurance contract that drives a wedge in consumption between crisis and

[20] A similar case with an altruistic, risk-averse lender is solved by Chami, Sharma, and Shim (2004).

[21] Obstfeld and Rogoff (1996) has an extensive analysis of insurance default in sovereign markets.

noncrisis periods and commits to a lower level of savings than would be chosen ex post in order to induce higher effort.

The case with a direct cost of default is analyzed by specifying a cost function $d(c_t)$, which increases in a convex way with the level of consumption of a country, i.e. $d'(\cdot)>0$ and $d''(\cdot)>0$. This structure of the cost function implies that a country tends to default when the level of consumption is lower, and it has been used in several studies of sovereign defaults such as Giavazzi and Pagano (1990), Cole and Kehoe (2000), and Detragiache and Spilimbergo (2001).

In the case of the current insurance problem, default is not desirable at the lowest levels of consumption as that is when the country has a crisis and expects to receive a transfer from the insurer. Therefore, the option of default is only relevant when the sovereign has to pay a premium. This implies that any premium must be smaller than the cost of default at that given premium, establishing an upper bound on the premium that can be committed credibly in the insurance contract. In the case of the premium in the second period after recovery, this bound is given by:

$$p_{2ri} \leq d(y + s_1) \tag{8}$$

A similar upper bound holds for the case when the country avoids the crisis:

$$p_n \leq d(y + \frac{s_0}{2}) \tag{9}$$

The upper bound in the case of the initial premium differs from those above in that by defaulting on the initial premium, the country foregoes any future transfers during the crisis period. Therefore, it is equivalent to a participation constraint and is assumed not to be binding for the current exercise. The other two upper bounds are assumed to be binding in order to assess the effect of the option to default. If they are not binding, the results are the same as in the case of noncontractible effort without default. The sovereign's problem is then solved subject to the previous bounds on premia payments, the participation constraint of the insurer, and the conditions for ex post choice of effort.

As in the case of noncontractible effort without the option to default, the sovereign chooses a contract that promotes ex post effort by keeping a wedge in the level of utility between crisis and noncrisis periods. In addition, effort is promoted by contracting for a lower level of savings than would arise ex post.

The default option implies that the premium charged in the events of no crisis and of recovery is smaller than otherwise, increasing the wedge between crisis and noncrisis episodes that was necessary to promote effort. This also leads to a front-loading of the premium in the initial period. Finally, the effect of the default option on savings is the opposite to that generated by the noncontractibility of effort. Higher savings reduce the incentives to default as they lead to a larger amount of available resources to pay the premium in the case of no crisis and recovery. In turn, this permits higher future premia to be

credibly committed in the insurance contract, leading to greater consumption smoothing between noncrisis episodes as the initial period premium is reduced.

## VI. CONCLUSIONS

This paper analyzed the design of an optimal sovereign insurance contract from the point of view of the sovereign. The main results of the analysis are: i) part of the benefits of the optimal insurance contract arise from lower effort by the country, even in the absence of moral hazard; ii) payment of an initial premium allows the country to contract more insurance and leads to greater consumption smoothing; iii) the premium increases with the incentives of the country to undertake risky behavior; iv) a deductible limits moral hazard;[22] v) the ratio of the deductible to the size of the shock is decreasing in the magnitude of the shock as exposure to extreme shocks is not necessary to reduce moral hazard;[23] and vi) there are two opposite effects on saving—the sovereign would choose a lower level of savings in order to induce a credibly higher ex post effort, but would like to save more to avoid a default.

The analysis has several implications for the reform of the international financial architecture and the design of support programs in the presence of moral hazard.[24] The insurance arrangement allows for better opportunities for consumption smoothing compared with self-insurance through savings. Initial contributions before a crisis occurs are optimal in all the cases that were analyzed, as they lead to an increase in the amount of resources available through the insurance arrangement. They are particularly important in the case of an altruistic insurer or if the sovereign can default. In both cases, an initial payment by the sovereign before a crisis occurs is important to make sure that the insurer is willing to provide sufficient resources in the case of a crisis. The contributions need to be risk-adjusted in order to provide initial incentives to the country and to cover the opportunity cost of the insurer.

Previous proposals for providing incentives before a crisis include some form of preconditions for access to IMF resources and making the interest rates charged on Fund resources contingent on the policies followed by a country before a crisis.[25] Contingent rates

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[22] The deductible can be implicit, in the form of a payment by the insurer that is smaller than the size of the shock.

[23] This result can vary if the magnitude of the crisis depends on the level of effort by the sovereign. More generally, the specific design of the deductible will depend on the underlying structure of the random component of the shock and on the cost function of effort.

[24] This paper does not address the additional role played by the IMF in international surveillance. For a discussion of how an international institution compares favorably with domestic institutions in the provision of information see Feltenstein and Lagunoff (2005).

[25] For an example of preconditions, see IFIAC (2000). Among those proposed are freedom of entry and operation for foreign financial institutions and an unspecified "proper fiscal requirement." Interest rate differentiation depending on policy efforts and on the type of

(continued…)

are consistent with the risk-sensitive insurance premium discussed above. However, penalty rates proposed in order to provide incentives for faster repayment can end up reducing recovery effort and can increase the possibility of a default. Regarding the conditions proposed for prequalification, these are discrete, may be overly restrictive, and are subject to time consistency problems.[26] The time consistency problem is lessened with initial risk-adjusted contributions as they lead to an increase in the support available when a crisis occurs.

The use of deductible payments, possibly implicit, is an additional mechanism through which moral hazard is reduced. There has to be a difference in utility between normal and crisis periods for the country to have incentives to undertake effort. However, the proportion of deductible to transfers is not constant but falls with the size of the shock. A sovereign does not need to be exposed to an extremely large shock in order to have incentives to undertake effort. In contrast, proposals for imposing an ex ante limit on the amount of resources available for support imply an increasing deductible payment so that a sovereign receives proportionally smaller support when a crisis is large.[27] A constant limit of support is optimal when there is no uncertainty about the magnitude of the shocks, as in Chami, Sharma, and Shim (2004). Something closer to an absolute limit may also be adequate if effort affects the magnitude, in addition to the probability, of the shock. This case is left for future work.

There is a trade-off in the choice of the optimal amount of savings. A higher amount of savings reduces the incentives to undertake effort as the difference in consumption between crisis and no-crisis periods is reduced. This increases the fair price of insurance as the probability of a crisis increases. However, if a sovereign has the option to default on future premium payments, it is more likely to do so if it lacks the resources to pay them.

Finally, the results confirm the difficulty of identifying sovereign moral hazard. If support is of any use, it should reduce the risk exposure of the sovereign. In addition, insurance should allow countries to reduce effort, when this is costly, compared with the level when no insurance is available. Therefore, studies based on changes in risk perception and effort in response to an increase of support are more directly testing if the additional expected support is having the desired effect or is irrelevant. Tests of moral hazard need to identify if any observed reductions in risk perceptions and effort are excessive.

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support is proposed by De Gregorio and others (1999), CFR (1999), IFIAC (2000), and Williamson (2001), among others.

[26] The discreteness of access to the Contingent Credit Line developed by the IMF was criticized by potential users in emerging markets; see Ortiz (2002).

[27] The Central Banks of Canada and England adopted this as a formal proposal; see Haldane and Kruger (2001).

## VII. Derivation of the Results

### A. The Case of Contractibility of Effort and Savings

The problem of the sovereign has the following form:

$$\begin{aligned} &\underset{p_0,p_n,p_{2i},t_i,t_{ij},e_0,e_{1i},s_0,s_{1i}}{Max} \quad u(y-s_0-p_0)-\gamma v(e_0)+(1-\pi(e_0))2u(y+s_0/2-p_n) \\ &+\pi(e_0)[\int f(\delta_i)\{u(y-\delta_i+s_0-s_{1i}+t_i)-\gamma v(e_{1i})+(1-\pi(e_{1i}))u(y+s_{1i}-p_{2ri}) \\ &+\pi(e_{1i})\int f(\delta_j)u(y-\delta_j+s_{1i}+t_{ij})d\delta_j\}d\delta_i] \end{aligned} \tag{10}$$

*s.t.*

$$\begin{aligned} &p_0+(1-\pi(e_0))2p_n+\pi(e_0)\int f(\delta_i)(1-\pi(e_{1i}))p_{2ri}d\delta_i- \\ &\pi(e_0)[\int f(\delta_i)\{t_i+\pi(e_{1i})\int f(\delta_j)t_{ij}d\delta_j\}d\delta_i]\geq C \end{aligned} \tag{11}$$

where equation (10) is the participation constraint of the risk-neutral insurer. The opportunity cost of the insurer, *C*, is assumed to be sufficiently low so that the expected utility of the sovereign is higher than that obtained in the case of no insurance.

As noted in Section III.B, there is no moral hazard with contractibility of effort and savings, and there is full smoothing of consumption across all scenarios. If savings are assumed to be zero in both periods, the premia are all identical, $p_0=p_n=p_{2r}=p$, transfers are $t_k = \delta_k - p$, for $k=i,j$, and consumption is always equal to $y - p$. The level of the premium $p$ is:

$$p=\frac{C+\pi(e_0)\delta^e+\pi(e_0)\pi(e_1)\delta^e}{3} \tag{12}$$

The choice of effort is obtained by substituting the results for premia and transfers into the first order conditions for $e_0$ and $e_1$:

$$e_0: \gamma v'(e_0)=(-\pi'(e_0))[\gamma v(e_1)+u'(y-p)\delta^e(1+\pi(e_1))] \tag{13}$$

$$e_1: \gamma v'(e_1)=(-\pi'(e_1))u'(y-p)\delta^e \tag{14}$$

These conditions imply that $e_0 > e_1$ as $v(\cdot)\geq 0$, $\pi(\cdot)\geq 0$ and either one has to be larger than zero.

Conditions (12) and (13) are used to obtain the response of effort to changes in the availability of insurance, after substituting for the level of the premium from equation (12):

$$\frac{de_0^*}{dC}=\frac{(\gamma v_1''+u'\delta^e\pi_1'')(1+\pi_1)\pi_0'u''\delta^e/3}{\Omega} \tag{15}$$

$$\frac{de_1^*}{dC} = \frac{(\gamma v_0'' + (\gamma v_1 + u'\delta^e(1+\pi_1))\pi_0'')\pi_1' u''\delta^e/3}{\Omega} \tag{16}$$

where

$$\Omega = (\gamma v_1'' + u'\delta^e \pi_1'' - \pi_0 u'' \pi_1'^2 \frac{\delta^{e2}}{3})(\pi_0''(\gamma v_1 + u'\delta^e(1+\pi_1)) + \gamma v_0'')$$
$$-(\gamma v_1'' + u'\delta^e \pi_1'')(1+\pi_1)^2 u'' \pi_0'^2 \frac{\delta^{e2}}{3} \tag{17}$$

Equations (15)-(17) are positive given *u''<0, v''>0* and *π''>0*.

### B. The Case with Noncontractible Effort

When savings and effort are noncontractible, the country chooses the insurance contract subject to the fact that the insurer knows about the ex post incentives of the sovereign to adjust its savings and effort. Therefore, the country's problem is:

$$\underset{p_0, p_n, p_{2ri}, t_i, t_{ij}}{Max} \quad u(y - s_0 - p_0) - \gamma v(e_0) + (1-\pi(e_0))2u(y + s_0/2 - p_n)$$
$$+ \pi(e_0)[\int f(\delta_i)\{u(y - \delta_i + s_0 - s_{1i} + t_i) - \gamma v(e_{1i}) + (1-\pi(e_{1i}))u(y + s_{1i} - p_{2ri})$$
$$+ \pi(e_{1i})\int f(\delta_j)u(y - \delta_j + s_{1i} + t_{ij})d\delta_j\}d\delta_i] \tag{18}$$

*s.t.*

$$p_0 + (1-\pi(e_0))2p_n + \pi(e_0)\int f(\delta_i)(1-\pi(e_{1i}))p_{2ri}d\delta_i -$$
$$\pi(e_0)[\int f(\delta_i)\{t_i + \pi(e_{1i})\int f(\delta_j)t_{ij}d\delta_j\}d\delta_i] \geq C \tag{11}$$

$$u'(y - s_0 - p_0) = (1-\pi(e_0))u'(y + \frac{s_0}{2} - p_n)$$
$$+ \pi(e_0)[\int f(\delta_i)u'(y - \delta_i + s_0 - s_{1i} + t_i)d\delta_i] \tag{6'}$$

$$\gamma v'(e_0) = (-\pi'(e_0))[2u(y + \frac{s_0}{2} - p_n) - [\int f(\delta_i)\{u(y - \delta_i + s_0 - s_{1i} + t_i) - \gamma v(e_{1i})$$
$$+ (1-\pi(e_{1i}))u(y + s_{1i} - p_{2ri}) + \pi(e_{1i})\int f(\delta_j)u(y - \delta_j + s_{1i} + t_{ij})d\delta_j\}d\delta_i]] \tag{7'}$$

$$u'(y - \delta_i + s_0 - s_{1i} + t_i) = (1-\pi(e_{1i}))u'(y + s_{1i} + p_{2ri})$$
$$+ \pi(e_{1i})\int f(\delta_j)u'(y - \delta_j + s_{1i} + t_{ij})d\delta_j, \quad \forall \delta_i \tag{2'}$$

$$\gamma v'(e_{1i}) = (-\pi'(e_{1i}))\left[u(y + s_{1i} - p_{2ri}) - \int f(\delta_j)u(y - \delta_j + s_{1i} + t_{ij})d\delta_j\right], \quad \forall \delta_i \tag{3'}$$

Equation (11) is the opportunity cost constraint of the insurer, and the next four restrictions are the conditions determining the optimal choice of ex post effort and savings. Their structure is the same as those obtained in the case of sequential choice without insurance, with payoffs modified to incorporate premia and transfers. The respective multipliers associated with each of the five restrictions are $\mu$, $\psi$, $\kappa$, $\xi_i$, $\tau_i$.

The first-order conditions with respect to the structure of payoffs are:

$$p_0 : u_0' = \mu - \psi u_0'' \tag{19}$$

$$p_n : u_n' = \left(\mu + \psi u_n''\right)\left(1 - \kappa \frac{\pi_0'}{(1-\pi_0)}\right)^{-1} \tag{20}$$

$$t_i : u_{1i}' = \left(\mu + \psi u_{1i}'' - \frac{\xi_i u_{1i}''}{f(\delta_i)\pi_0}\right)\left(1 + \kappa\left(\frac{\pi_0'}{\pi_0}\right)\right)^{-1} \tag{21}$$

$$p_{2ri} : u_{2ri}' = \left(\mu + \frac{\xi_i u_{2ri}''}{f(\delta_i)\pi_0}\right)\left(1 + \kappa\left(\frac{\pi_0'}{\pi_0}\right) - \frac{\tau_i \pi_{1i}'}{f(\delta_i)\pi_0(1-\pi_{1i})}\right)^{-1} \tag{22}$$

$$t_{ij} : u_{2ij}' = \left(\mu + \frac{\xi_i u_{2ij}''}{f(\delta_i)\pi_0}\right)\left(1 + \kappa\left(\frac{\pi_0'}{\pi_0}\right) + \frac{\tau_i \pi_{1i}'}{f(\delta_i)\pi_0\pi_{1i}}\right)^{-1} \tag{23}$$

The assumptions on $u(\cdot)$ and $v(\cdot)$ imply that all the multipliers are positive.

Condition (19) shows that the multiplier on initial savings, $\psi$, leads to an increase in the marginal utility of consumption in period 0 with respect to those in period 1, conditions (20-21). The sovereign pays a higher premium in the first period.

The factor $\kappa$ in (20) and (21) shows that ex post effort is encouraged by specifying premium and transfers such that the utility of the country is higher when there is no crisis. The same is observed between first and second period utilities in the case of a crisis (equations 19-21). Transfers in the case of a crisis are limited to have higher incentives for first period effort (and lower savings), as indicated by the terms including $\xi_i$. In period 2, transfers and premia are such that there is a wedge in utilities between the recovery and continued crisis cases in order to have higher effort in the first period (captured by $\tau_i$).

### C. The Case with an Altruistic Insurer

The new initial participation constraint of the insurer is:

$$p_0 + (1-\pi_0)2p_n + \pi_0 \int_i f(\delta_i)\left[-t_i + (1-\pi_{1i})p_{2ri} - \pi_{1i}\int_j f(\delta_j)t_{ij}d\delta_j\right]d\delta_i \geq$$
$$c_0 + \varepsilon C(u_0 + (1-\pi_0)2u_n + \pi_0[\int f(\delta_i)\{u_{1i} + (1-\pi_{1i})u_{2ri} \qquad (24)$$
$$+ \pi_{1i}\int f(\delta_j)u_{ij}d\delta_j\}d\delta_i])$$

where $c_0$ is a fixed cost, ε is an altruism parameter which is larger or equal to zero, and the function $C(\cdot)$ captures insurer altruism with $C'(\cdot)\geq 0$ and $C''(\cdot)\leq 0$.

As noted in Section IV, the problem is solved backward in order to obtain non-renegotiable premia and transfers. It is assumed that the parties do not renegotiate when no ex post pareto improvement is available. In the two crisis cases, the country is only willing to renegotiate a contract that leads to a larger transfer. The situation of the insurer is more complex due to two effects. The lower utility of the country given a crisis could make the insurer increase the transfer. However, the insurer has lost the premium it would have received in the cases of no crisis or recovery, with a consequent deterioration in its financial condition. If the effect of the deterioration in the insurer's financial condition is high compared with the altruistic motive, no renegotiation is feasible and the solution is the same as in the previous case without contractibility of effort.

In the cases of no crisis or recovery, the country is only willing to renegotiate for a lower premium. As in the case of a crisis, the insurer is affected by two changes. The absence of a crisis or the recovery from one imply that the insurer's expenditures are smaller but, on the other hand, the country's utility is larger so that the altruism motive is weaker. The two effects on the insurer's utility in the cases of crisis and noncrisis imply that there are sets of transfers and premia that are credibly non-renegotiable. In addition, they imply that altruism by itself need not lead to commitment problems in this case. It has to be a sufficiently high altruism.

In what follows, the altruism motive is assumed to be sufficiently strong such that the previous solution is no longer feasible. The renegotiation proof transfers and premia in t=2 after an initial crisis are:

$$\overline{p_0} - \overline{t_i} - t_{ij} =$$
$$c_0 + \varepsilon C(u(\overline{y - s_0 - p_0}) + u(\overline{y - \delta_i + s_0 - s_{1i} + t_i}) + u(\overline{y - \delta_j + s_{1i}} + t_{ij})) \qquad (25)$$

$$\overline{p_0} - \overline{t_i} + p_{2ri} = c_0 + \varepsilon C(u(\overline{y - s_0 - p_0}) + u(\overline{y - \delta_i + s_0 - s_{1i} + t_i}) + u(\overline{y + s_{1i}} - p_{2ri})) \tag{26}$$

where, compared with the ex ante condition in (24), the income structure and the altruistic component of the insurer participation constraint have been updated to reflect the crisis in the first period and subsequent developments.

The same changes in the insurer's incentives arise in t=1. Therefore, the renegotiation proof levels of transfers and savings are given by the first period constraint of the insurer:

$$\begin{aligned}&\overline{p_0} - t_i + (1-\pi(e_{1i}))p^*_{2ri} - \pi(e_{1i})\int_j f(\delta_j)t^*_{ij}d\delta_j \geq \\ &c_0 + \varepsilon C(u(\overline{y - s_0 - p_0}) + u(\overline{y - \delta_i + s_0} - s_{1i} + t_i) \\ &+ (1-\pi(e_{1i}))u(y + s_{1i} - p^*_{2ri}) + \pi(e_{1i})\int f(\delta_j)u(y - \delta_j + s_{1i} + t^*_{ij})d\delta_j)\end{aligned} \tag{27}$$

Finally, the maximum premium payments feasible in the case of no crisis are:

$$\overline{p_0} + 2p_n \geq c_0 + \varepsilon C(u(\overline{y - s_0 - p_0}) + 2u(y + \frac{s_0}{2} - p_n)) \tag{28}$$

The initial period choice of the country is obtained by solving the same type of initial period problem as in previous sections:

$$\begin{aligned}\underset{p_0, p_n, p_{2ri}, t_i, t_{ij}}{Max} \quad & u(y - s_0 - p_0) - \gamma v(e_0) + (1-\pi(e_0))2u(y + s_0/2 - p_n) \\ &+ \pi(e_0)[\int f(\delta_i)\{u(y - \delta_i + s_0 - s_{1i} + t_i) - \gamma v(e_{1i}) + (1-\pi(e_{1i}))u(y + s_{1i} - p_{2ri}) \\ &+ \pi(e_{1i})\int f(\delta_j)u(y - \delta_j + s_{1i} + t_{ij})d\delta_j\}d\delta_i]\end{aligned} \tag{18'}$$

These are now subject to the modified initial participation constraint of the insurer (24), the non-renegotiation conditions (25-28), and the equations determining the ex post choice of effort and savings.

### D. The Case with Direct Costs of Default

As both upper bounds on future premiums are assumed to be binding, the sovereign solves the following problem:

$$\begin{aligned}\underset{p_0, p_n, p_2, t_1, t_2, s_0, s_1}{Max} \quad & u(y - s_0 - p_0) - \gamma v(e_0) + (1-\pi(e_0))2u(y + s_0/2 - p_n) \\ &+ \pi(e_0)[u(y - \delta^e + s_0 - s_1 + t_1) - \gamma v(e_1) + (1-\pi(e_1))u(y + s_1 - p_{2r}) \\ &+ \pi(e_1)u(y - \delta^e + s_1 + t_2)]\end{aligned}$$

*s.t.*

$$p_0 - \pi(e_0)\{t_1 + \pi(e_1)t_2\} \geq C$$

$$\wp'(e_0) = (-\pi'(e_0))[2u(y + s_0/2) - [u(y - \delta^e + s_0 - s_1 + t_1) - \wp(e_1)$$

$$+ (1 - \pi(e_1))u(y + s_1) + \pi(e_1)u(y - \delta^e + s_1 + t_2)]$$

$$\wp'(e_1) = (-\pi'(e_1))\left[u(y + s_1) - u(y - \delta^e + s_1 + t_2)\right]$$

and the upper bounds (8) and (9), with multipliers $\mu$, $\kappa$, $\tau$, $\lambda$ and $\eta$, respectively. The first-order conditions are:

$$p_0 : u'_0 = \mu \tag{29}$$

$$t_1 : u'_{1c} = \frac{\mu}{(1 + \kappa\pi'_0/\pi_0)} \tag{30}$$

$$p_n : u'_{1n} = \frac{\mu}{(1 - \kappa\pi'_0/(1 - \pi_0))} - \frac{\lambda}{2}\left(\frac{1 + d'_n}{(1 - \pi_0) - \kappa\pi'_0}\right) \tag{31}$$

$$p_{2r} : u'_{2r} = \frac{\mu}{(1 + \kappa\pi'_0/\pi_0 - \tau\pi'_1/(\pi_0(1 - \pi_1)))} - \eta\left(\frac{1 + d'_{2r}}{(1 - \pi_1)(\pi_0 + \kappa\pi'_0) - \tau\pi'_1}\right) \tag{32}$$

$$t_2 : u'_{2c} = \frac{\mu}{(1 + \kappa\pi'_0/\pi_0 + \tau\pi'_1/(\pi_0\pi_1))} \tag{33}$$

$$s_0 : u'_0 = (1 - \pi_0)u'_n + \pi_0 \int_i u'_{1i} + \kappa\pi'_0 \left(\int_i u'_{1i} - u'_n\right) + \lambda d'_n \tag{34}$$

$$s_1 : u'_{1c} = (1 - \pi_1)u'_{2r} + \pi_1 \int_j u'_{ij} + \frac{\tau\pi'_1 \left(\int_j u'_{ij} - u'_{2r}\right) + \eta d'_{2r}}{1 + \kappa\pi'_0} \tag{35}$$

The default option leads to a smaller premium in the events of no crisis and of recovery (equations 31-32, terms with λ and η). This also leads to a front-loading of the premium in the initial period. The default option also leads to higher savings, as these reduce the incentives to default given a larger amount of available resources to pay the premium in the case of no crisis and recovery (equations 34-35, terms with λ and η).

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**Figure 1. Choice and Shock Structure**

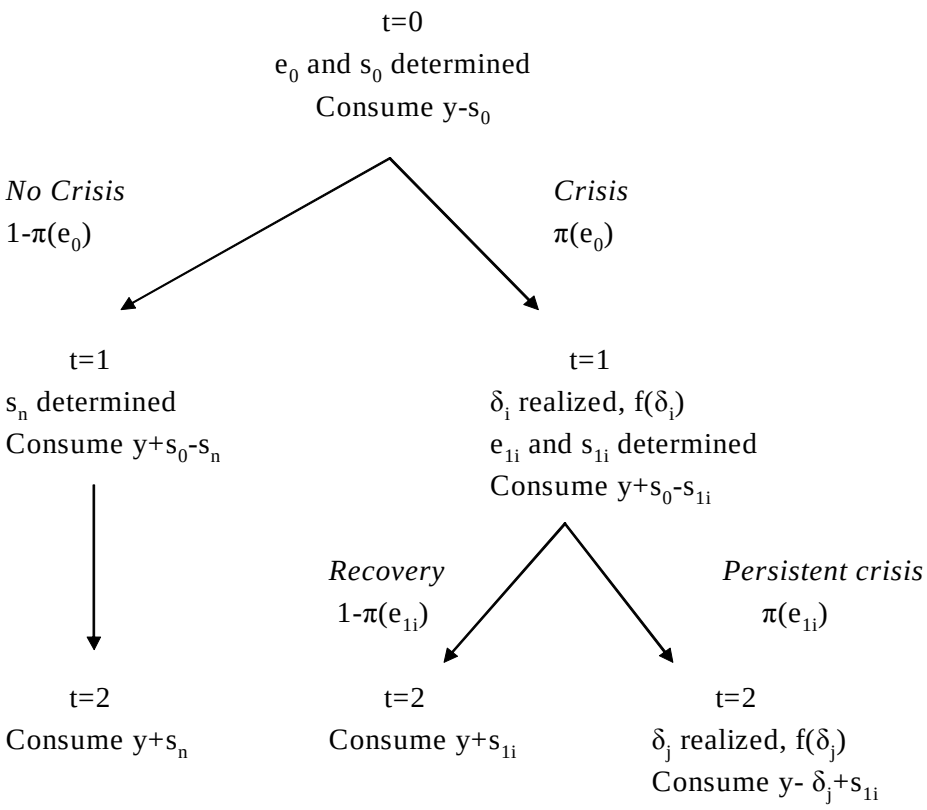

**Figure 2. Structure Insurance**