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Solving Commitment Problems in Disaster Risk Finance

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Abstract

Those at risk from natural disasters are typically under-protected, possibly because they expect benefactors such as governments and donors to come to their aid. Yet when relief comes, it is often insufficient, delayed or misallocated. Benefactors may wish to commit to provide an efficient amount of fast well-targeted relief, and leave the rest up to recipients, but such commitments are difficult. This article analyses how transferring risk to third-parties such as private insurers may help resolve these commitment problems. Using a simple model of disaster risk finance is used to identify three distinct commitment problems and then show how various properties of risk transfer schemes can help to resolve these problems. The paper illustrates how these commitment problems play out using examples from around the world, and demonstrates where risk transfer schemes seem to have helped in practice. Overall, the findings show that the benefits of such schemes depend on the relative severity of the different commitment problems.

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Solving Commitment Problems in Disaster Risk Finance*

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1 Introduction

Natural disasters are responsible for huge amounts of damage across the world, with households, businesses and local governments all at risk of suffering important losses. Most of the deaths and serious injuries resulting from these disasters are in developing countries.[1] Despite many of these disasters being relatively foreseeable, current attempts to mitigate these risks appear to be grossly insufficient. Those at risk are generally under-protected, and frequently appear to under-invest in actions that would mitigate losses. Governments and donors provide some relief, but this is often too small and inefficiently allocated.

In this context, increasing attention is turning to risk transfer instruments as a potential solution (World Bank, 2014; WHO, 2016; Clarke and Dercon, 2016; OCHA, 2016). These in-

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[1] UNISDR (2015) estimates that economic losses from extreme natural events are now reaching an average of US$250-$300 billion a year. According to Germanwatch (2015), of the ten most affected countries from 1994 to 2013, nine were in the low-income or lower-middle-income country group, while only one was classified as an upper-middle-income country.

struments, such as reinsurance, catastrophe bonds, and catastrophe swaps, essentially replace or complement ad hoc post-disaster benefactor relief with some kind of insurance, most often provided through the private sector. Critics argue that these instruments are expensive and opaque, with private financiers able to take advantage of limited competition and relatively poorly informed customers. Indeed, for all but the most extreme potential disasters, financing disaster response through savings or debt does seem to be more cost effective in the long run (Bevan and Adam, 2015; Borensztein, Cavallo and Jeanne, 2015). Yet a range of developing countries continue to purchase or subsidize these instruments with support from international institutions, despite these high costs.[2]

This paper asks whether risk transfer instruments such as insurance can provide value to governments beyond budget smoothing. In particular, it has long been recognized that major failings in disaster relief arise because governments and donors have difficulty committing. These benefactors face 'commitment problems' to the extent that they would like to promise ex-ante to undertake a certain set of actions that they may not find desirable ex-post. A well-known example of such a commitment problem is the 'Samaritan's dilemma', where those at risk deliberately under-protect themselves knowing that governments or donors will come to their rescue. Other problems include governments being unable to effectively promise to allocate disaster relief without political bias, or donors who cannot credibly commit as to who will take on which risks. Given the apparent importance of these commitment problems in explaining the weaknesses of current arrangements, it is natural to ask whether financial risk transfer products can help reduce them.

In order to answer this question, we build a simple model of disaster relief which allows us to identify several commitment problems and demonstrate how they lead to recipients being inefficiently protected. The model is then used to consider a number of ways in which governments or donors may use private finance to help mitigate the commitment problems. Throughout the paper, we draw in practical examples of the impact of risk transfer schemes across the world.

[2]Governments purchasing such products include Mexico, India, Jamaica and Kenya (Clarke and Dercon, 2016). The Caribbean Catastrophe Risk Insurance Facility (CCRIF), established by the Caribbean Community in 2007 with support from the World Bank and a range of donors, offers parametric earthquake and tropical cyclone coverage, and more recently excess rainfall coverage, to its members. The Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), a partnership between the Pacific Community, development banks, donors, and scientists, has provided five Pacific island states with subsidized insurance against earthquakes and tropical cyclones since 2013. The African Risk Capacity, set up as a specialized agency of the African Union, provides rainfall-based parametric drought insurance, initially to four African countries in 2014.

A key contribution of the paper is therefore to formally identify how commitment problems can lead to a range of undesirable outcomes related to disaster relief. We focus on commitment problems as it is these obstacles which the parties involved are most likely to be willing to remove if presented with potential solutions. They thus contrast with other issues related to disaster relief, such as a lack of resources, voter myopia, or coordination challenges, which to resolve would require a more fundamental change in the incentives faced by institutions.

The second important contribution of the paper is then to provide a precise analysis of exactly how and when risk transfer schemes can help resolve such commitment problems. This serves two purposes. On the one hand, it draws attention to the ways that innovative finance may help to improve outcomes for countries that lack the public financial management institutions to resolve these commitment problems directly. On the other hand, it makes explicit the mechanisms through which different risk transfer arrangements can help, and hence helps to avoid the over-selling of financial products as miracle cures that are suitable for every context. In this way, we help to provide a guide to policy makers as to exactly when and where different risk transfer arrangements may help.

The paper builds on a number of papers in the literature on commitment problems and insurance. The term 'Samaritan's dilemma' was coined by Buchanan (1977) and later formalized by Lindbeck and Weibull (1988) and Bruce and Waldman (1991), among others - they all describe cases where a principal who cares about an agent causes the agent to inefficiently expose themselves to risk, knowing that he will be rescued by the principal if things turn bad. Our model most closely resembles that of Coate (1995), who adds a government into this model to create a three-tier structure of donors, government and a recipient. His paper however, only considers one potential solution to the commitment problem - namely, government providing recipients with insurance contracts. Svensson (2000) and Hagen (2006) consider an alternative solution to the Samaritan's Dilemma in foreign aid, namely delegation to other institutions. Most recently, Cordella and Levy Yeyati (2015) shows that by purchasing insurance, a government may be able to solve a commitment problem not considered in our paper - namely, a government's commitment not to default on sovereign debt.

A number of papers have looked at the relative benefits of private and public insurance when it comes to disaster relief. Picard (2008) for example, argues that obliging recipients to purchase private insurance encourages risk-mitigation, since premiums are based on risk. On the other hand, Shavell (2014) and Charpentier and Le Maux (2014) argue that governments, through their greater ability to borrow, have the advantage of being able to cover risks that are so large private insurance companies would go bankrupt. When it comes to public-private partnerships in disaster insurance, most papers have considered a context where private insurers sell to recipients, but may then purchase insurance from governments (Kunreuther and Pauly, 2006; Carter, Galarza and Boucher, 2007; Jametti and von Ungern-Sternberg, 2010). Here, the advantage of the private sector is generally assumed to be its better ability to price contracts, while roles for the government include encouraging consumer learning, increasing equity among consumers ex-ante, and reinsuring risks that private insurers are unwilling to take. As far as we are aware, none of these papers has considered how public-private partnerships may interact with commitment problems.

Finally, the paper draws on a literature considering privatization and public-private partnerships in infrastructure, which is somewhat more developed than that on insurance, and contains many parallels. Much of this work is synthesized in the models of Martimort (2006) and Estache, Serebrisky and Wren-Lewis (2015), with both papers noting the importance of commitment problems in explaining the relative virtues of involving the private sector.

2 A basic model of disaster relief

In this section, we set out a basic model of disaster relief with $N \geq 2$ altruistic benefactors providing aid to a vulnerable recipient.[3] This combination could represent governments and donors providing relief to households, national governments providing support to local governments, or international donors sending post-disaster aid to national governments. The game essentially has two phases - a pre-disaster phase where benefactors and recipient may make decisions to cover the recipient in the event of disaster, and a post-disaster phase where uncertainties are revealed and payoffs accrue.

The recipient is risk averse and subject to losses from a disaster. In particular, he has a base income of y and risks suffering a disastrous loss of L with probability π. He can protect himself through paying $m\pi z$, where $0 \leq z \leq L$ is the amount paid out if he suffers a loss and $m > 0$ is a parameter representing the cost of self-protection. Here self-protection may either represent some risk mitigation strategy or private insurance, with $m = 1$ corresponding to actuarially fair insurance. The recipient receives aid $a_j \geq 0$ from benefactor j and has utility function $u(x)$, where x is a recipient's consumption, with $u'(\cdot) > 0$ and $u''(\cdot) < 0$.

The benefactors care about the recipient's utility and make transfers after the loss has been realised. To keep the model simple, we model benefactors as being 'altruistic in that they

[3]Throughout the paper we use the word relief as a shorthand for post-disaster expenditures on relief, reconstruction, and other emergency costs.

care directly about recipient's welfare, but obviously in reality this concern may be generated from political or strategic concerns. Benefactor j has the following objective function:

$$V_j = \mathbb{E}\left[\delta u(x) - a_j\right]$$

where δ denotes the degree to which benefactors care about the recipient's utility relative to the cost of transfers. We assume that $0 < \delta < 1/u'(y - \pi m L)$ - i.e. benefactors value the recipient's utility sufficiently lowly that they do not provide aid to a recipient when he does not suffer a loss.

3 Baseline solution with commitment

In this baseline model, we assume that all information is public - in particular, benefactors observe whether a recipient has suffered a loss. The timeline of play is as follows:

- Time 0: Pre-disaster
  - First, each benefactor commits to the aid a_j they will transfer to the recipient in the event of a loss
  - Second, the recipient chooses z
- Time 1: Post-disaster
  - Disasters potentially occur
  - Benefactors disburse aid $a_j, \forall j$

We now solve for the equilibrium to provide a baseline result where benefactors do not suffer from commitment problems. This then forms the basis for the next section where we consider alternative assumptions and extensions that demonstrate how commitment problems may generate inefficiency. Consider the decision of the recipient in choosing self-protection z. Let $a = \sum_j a_j$ be the total relief they will receive in the event of a loss, and $z(a)$ the amount of self-protection the recipient will invest in when anticipating aid a. Then the recipient aims to maximize the following expected utility function:

$$(1-\pi)u\left(y - m\pi z\right) + \pi u\left(y - L + a + (1 - m\pi)z\right)$$

If $m \leq 1$, then the recipient will invest in self-protection such that they are fully protected (i.e. $z(a) = L - a$). If $m > 1$, then let z^* be the solution to the following equation:

$$u'(y - L + a + (1 - m\pi)z^*) = \frac{m - m\pi}{1 - m\pi}u'(y - m\pi z^*) \tag{1}$$

The recipient will invest in protection $z(a) = z^*$ if $0 \leq z^* \leq L$ and will not invest in any protection (i.e. $z(a) = 0$) if $z^* < 0$.

Now let us consider benefactor j's choice of a_j. The benefactor's best response function when they anticipate the other benefactors will give total aid a_{-j} is zero or the solution to the following expression:

$$u'(y - L + a_j + a_{-j} + (1 - \pi m)z(a)) = 1/\delta$$

Define $x(\delta)$ as the level of consumption that gives such a marginal utility, i.e. $u'(x(\delta)) = 1/\delta$. Then, in equilibrium, the recipient will never consume less than this level - benefactor aid essentially creates a consumption floor. Due to benefactor free-riding, the recipient is not affected by how many benefactors care about his utility. Collectively, benefactors would like the recipient to consume more, but none of them are willing to pay more. From our previous assumptions on δ, a recipient who does not suffer a loss will not receive aid.

If $y - L + (1 - m\pi)z(0) \geq x(\delta)$, then a recipient who protects themselves optimally will not require aid, and hence benefactors will commit to $a^* = 0$.

Now, define $\overline{\delta}$ such that:

$$\overline{\delta} = \frac{1 - m\pi}{(m - m\pi)u'(y)}$$

Then we arrive at the following lemma:

Lemma 1. If $\delta < \overline{\delta}$, then in an equilibrium where benefactors commit there will be self-protection. If $\delta \geq \overline{\delta}$, there will be no self-protection in equilibrium.

Proof. From (1), the recipient will invest in no self-protection if and only if $u'(y - L + a) \leq \frac{m - m\pi}{1 - m\pi}u'(y)$. In an equilibrium with no self-protection, aid a is set such that $u'(y - L + a) = \frac{1}{\delta}$ - combining these equations gives us our result. □

4 Identifying commitment problems

Let us now consider various problems that may arise due to an inability of benefactors to commit. We begin with the classic Samaritan's dilemma, and then consider problems relating to aid misallocation, and delay in benefactor disbursements.

4.1 The Samaritan's dilemma

The classical idea of the Samaritan's dilemma is that a well-intentioned 'Samaritan' who cares about a recipient but cannot commit essentially provides them with implicit insurance against risk (Buchanan, 1977). This insurance is directly beneficial for the recipient, but since receiving it is dependent on the recipient being in a bad situation, it can create a moral hazard problem, since the recipient now faces a reduced incentive to avoid such a bad situation. This leads to two potential problems. First, even if the implicit insurance provided by the Samaritan is only partial, then recipients may forgo more complete insurance, even if it is actuarially fair (Coate, 1995). Second, if the recipient has access to a technology that reduces the expected risk, he may choose not to use such a technology because this would result in a smaller expected transfer from the Samaritan (Bruce and Waldman, 1991).

In the baseline model, we assumed that benefactors committed to the aid they would give at the beginning of the game, and importantly before households made decisions about self-protection. In reality, this is often not the case because of the way that many benefactors finance relief. Pre-financed contingency budgets or disaster funds may be able to offer guaranteed funding, assuming that they aren't spent on other things before disaster strikes, but once a benefactor has reserved fiscal space for disaster relief it is very difficult to commit to not use these funds, for example when a minor disaster occurs. Yet this is what they must do to avoid the Samaritan's dilemma - a benefactor needs to commit to not give any more than she promised even if recipients are worse off than expected, a particularly difficult commitment to make. As such, it is reasonable to consider the case where benefactors instead set a_j after z has been chosen.

To consider when benefactors' lack of commitment leads to inefficiency, define z^* to be the value of self-protection that maximizes the recipient's expected payoff were they to anticipate no aid. Then, we can define $\underline{\delta}$ as the value of δ where the recipient is indifferent between on the one hand investing in no self-protection and receiving aid, and on the other hand investing optimally in self-protection and receiving no aid. $\underline{\delta}$ is the therefore given by the following equation:

$$(1-\pi)u(y)+\pi u(x(\underline{\delta}))=(1-\pi)u(y-\pi m z^*)+\pi u(y-L+(1-\pi m)z^*)$$

The following proposition then states that benefactors' lack of commitment will lead to inefficiently low self-protection unless benefactors' generosity is either very high or very low.

Proposition 1. If benefactors cannot commit, and $\underline{\delta} \leq \delta < \overline{\delta}$, then the recipient will not invest in any self-protection even when it is efficient to do so.

Proof. If a recipient does not invest in self-protection, they get utility $(1-\pi)u(y)+\pi u(x(\delta))$. Clearly it is not in the recipient's interest to invest in an amount of self-protection that would still mean they receive aid in the event of a loss. So the alternative is to invest in a sufficient amount of self-protection that he will not receive aid - by definition, he will only do so when $\delta < \underline{\delta}$. This is inefficient whenever the recipient would wish to invest in some self-protection even after accepting the money given by the benefactors, which from Lemma 1 is when $\delta < \overline{\delta}$. So inefficiency occurs if both of these equations hold.

□

If benefactors are very generous, i.e. $\delta \geq \overline{\delta}$ then even ex-ante they would like to give such a high level of aid that self-protection would not be efficient. In this case, the Samaritan's dilemma does not cause a problem since the lack of commitment will not lead to less self-protection being undertaken. On the other hand, if benefactors care little about the recipient, i.e. $\delta \leq \overline{\delta}$, then even without commitment the recipient will prefer to pay for their own self-protection rather than rely on a very low level of aid in the event of a disaster.

It is therefore in the intermediate case that the Samaritan's dilemma can lead to inefficiently low self-protection. In this case, the recipient will anticipate that benefactors will give such that they will always reach their minimal consumption level $x(\delta)$. Though this is the same level of consumption as in the commitment case, the difference is that it will be reached no matter what the recipient does. The result is that a recipient has less incentive to take any actions that will increase post-loss consumption.

4.2 Aid misallocation

A common complaint of disaster relief is that it is misallocated. Many people who should receive aid do not, and sometimes funds are diverted to those who suffered no losses at all

(Leeson and Sobel, 2008). Aid may be allocated based on short-term political calculations, or emergency procurement procedures may provide an opportunity for politically-directed largesse. Recipients and benefactors may be tempted to exaggerate the scale of disasters, in order to motivate more giving (Bailey, 2013). Benefactors understand this and have a healthy mistrust of information that they receive.

To model this problem, we relax the assumption that benefactors observe whether a recipient suffered a loss, and instead assume that this is reported by an agency responsible for disaster relief. Since the agency may hold different preferences from the benefactors, it may misreport who suffered a loss. If the recipient does not suffer a loss, the agency will report that he did with probability η, while if the recipient does suffer a loss, there is a probability γ that the agency will report that he did not. An honest agency is therefore equivalent to the case where $\eta = \gamma = 0$. We assume that benefactors can commit to the level a that they will give in response to the agency reporting a loss.

Misallocation leads to two negative consequences. First, benefactors will give less aid, since aid is effectively 'taxed' through misallocation - if the benefactor gives aid when the agency reports a loss, there is only a $\frac{\pi(1-\gamma)}{\pi(1-\gamma)+(1-\pi)\eta}$ probability that the recipient really did suffer a loss. Indeed, if this probability is sufficiently high, benefactors will give no aid. Second, recipients may self-protect even when the cost of doing so is very high. This is because they cannot rely on relief to come to their rescue, and is particularly acute for the most risk averse recipients, for whom the threat that relief may not arrive is sufficiently concerning to merit investing in their own self-protection. In practice, therefore, fear of relief misallocation may partly explain why recipients choose to protect themselves from risk even in ways that appear very expensive - for example, through crop diversification. Though such strategies typically coexist with governments and benefactors who spend money on disaster relief, recipients may not trust that they will receive disaster relief when they need it.

Altruistic benefactors clearly have a strong interest in forcing the agency to report truthfully and thereby getting rid of misallocation. Let us consider that, for a certain cost, benefactors can learn the truth about whether the recipient suffered from a loss. This cost may, for instance, represent the costs involved in rigorous auditing, or providing the agency with sufficiently strong incentives to be able to ignore other influences. The following proposition shows that benefactors' willingness to pay is greater prior to the disaster than afterwards. Hence benefactors may like to commit themselves in advance to remove misallocation.

Proposition 2. If without commitment the recipient anticipates misallocation, then benefactors are willing to pay more to prevent misallocation before the disaster than afterward.

Proof. If the agency reports truthfully, benefactors will give aid as before - let us label this level of aid as a^*. They will then get utility $\delta\left((1-\pi)u(y-\pi m z(a^*))+\pi u(x(\delta))\right)-a^*/N$.

If the agency doesn't report truthfully, then let us first consider the optimal self-protection decision for a recipient expecting total aid a. He chooses z to maximize his expected utility, which leads to the following first order condition:

$$\begin{aligned}&(1-\gamma)u'(y-L+(1-m\pi)z+a)+\gamma u'(y-L+(1-m\pi)z)\\=&\frac{m-m\pi}{1-m\pi}\left((1-\eta)u'(y-\pi m z)+\eta u'(y-\pi m z+a)\right)\end{aligned} \tag{2}$$

Let $\tilde{z}(a)$ be the optimal amount of self-protection here, then comparing (2) with (1) we have $\tilde{z}(a)>z(a)$, and greater misallocation risk leads to greater self-protection.

Considering benefactors, in total they will give aid a such that

$$\frac{\pi(1-\gamma)u'(y-L+(1-m\pi)\tilde{z}(a)+a)}{\pi(1-\gamma)+(1-\pi)\eta}+\frac{(1-\pi)\eta u'(y-\pi m\tilde{z}(a)+a)}{\pi(1-\gamma)+(1-\pi)\eta}=\frac{1}{\delta}$$

and hence it is clear that they will give less aid the greater the misallocation. Let us label this level of aid $\tilde{a}$, and the aid level given in the baseline case as a^*.

Then, the cost of misallocation to benefactors ex-post is:

$$\begin{aligned}&\delta\left[(1-\pi)(1-\eta)u(y-\pi m\tilde{z}(\tilde{a}))+\pi(1-\gamma)u(y-L+(1-m\pi)\tilde{z}(\tilde{a})+\tilde{a})\right.\\&\quad\left.+(1-\pi)\eta u(y-\pi m\tilde{z}(\tilde{a})+\tilde{a})+\pi\gamma u(y-L+(1-m\pi)\tilde{z}(\tilde{a}))\right]-\tilde{a}\\&-\delta\left[(1-\pi)u(y-\pi m\tilde{z}(\tilde{a}))+\pi u(y-L+(1-m\pi)\tilde{z}(\tilde{a})+a^*)\right]+a^*\end{aligned}$$

On the other hand, the cost of misallocation to benefactors ex-ante is:

$$\begin{aligned}&\delta\left[(1-\pi)(1-\eta)u(y-\pi m\tilde{z}(\tilde{a}))+\pi(1-\gamma)u(y-L+(1-m\pi)\tilde{z}(\tilde{a})+\tilde{a})\right.\\&\quad\left.+(1-\pi)\eta u(y-\pi m\tilde{z}(\tilde{a})+\tilde{a})+\pi\gamma u(y-L+(1-m\pi)\tilde{z}(\tilde{a}))\right]-\tilde{a}\\&-\delta\left[(1-\pi)u(y-\pi m z(a^*))+\pi u(y-L+(1-m\pi)z(a^*)+a^*)\right]+a^*\end{aligned}$$

Since $z(a)$ is chosen optimally when misallocation is not anticipated, and $a^*>\tilde{a}$, which is already below optimal, the ex-ante cost is clearly greater than the ex-post cost. □

In reality, committing that aid will not be misallocated may be difficult. In situations where electronic cash transfers are a cost-effective way to support disaster-affected people, investing before the disaster in a transparent biometric identification system, and pre-registering the bank accounts of potential recipients may increase the cost of post-disaster misallocation (Dercon, 2005; ODI, 2015). However, where aid is in the form of physical goods, such as food, committing before a disaster that aid will be well distributed is more challenging. It is therefore not surprising that citizens do not necessarily believe governments when they promise corruption free aid dispersion and hence behave accordingly. Then, once everyone has assumed that aid will be misallocated, it is clearly much more tempting for governments and other benefactors to let this occur after a disaster.

4.3 Disbursement delay

A further common complaint of disaster relief is that it frequently arrives too late. Clarke and Hill (2013) estimate that responding early in an extreme slow-onset drought is approximately three times more cost-effective than responding late. Yet typically aid is delayed, partly because donors' decisions to respond depend on the actions of other donors. As a result, there may be a waiting game where each donor is scared to move first and 'where responsibility for action is diffuse, delay is more likely' (Bailey, 2013, p. 10). This is particularly the case when donors are relatively symmetric and there is no 'lead' donor (Steinwand, 2015).

To consider this problem, we extend our model by adding an extra period. Times 0 and 1 remain as before, but in addition we add time 2 where donors can again give money to the recipient. We can think of giving money at time 1 as giving money 'immediately' after the disaster has struck, while giving at time 2 is giving money 'later'. We assume that money given later is less effective than money given immediately - giving the recipient a dollar immediately costs benefactors a dollar, but giving him a dollar later costs the benefactor $\kappa > 1$ dollars.

Let us assume that all information about the disaster is known immediately, but that benefactors cannot commit in advance to aid they will give (as in Section 4.1). The advantage to benefactors of giving later is therefore simply that they can observe how much other benefactors gave immediately.

Then we arrive at the following proposition:

Proposition 3. A symmetric subgame perfect equilibrium exists whereby benefactors give all aid later rather than earlier if the number of donors N is sufficiently large, i.e.

$$N \geq \frac{\kappa(x(\delta/\kappa) - x_L)}{\delta\left[u(x(\delta/\kappa)) - u(x(\delta))\right] + x(\delta) - x_L}$$

Proof. Consider a potential equilibrium whereby other donors give a^1_{-j} immediately and a^2_{-j} later. Since we require the equilibrium to be subgame perfect, we first consider the best response of benefactor j in the 'later' stage. To maximize their payoff, donor j will give aid a^2_j such that

$$u'(y - L + (1 - m\pi)z + a^1_j + a^2_j + a^1_{-j} + a^2_{-j}) \leq \frac{\kappa}{\delta}$$

If this requires giving no aid, she will do so - otherwise she will give whatever aid is required to make this equal. Hence, in any subgame perfect equilibria, benefactors will either give no aid later or will give aid such that $u'(x) = \frac{\kappa}{\delta}$. As before, let us label this level of consumption as $x(\delta/\kappa)$

Now let us consider the decision over how much aid to give immediately when such later behavior is anticipated. If the benefactor gives aid a^1_j such that $u'(y - L + (1 - m\pi)z + a^1_j + a^1_{-j}) > \frac{\kappa}{\delta}$, then at the margin giving aid at time 1 reduces the amount of aid she gives at time 2 by κ/N. If $\kappa \neq N$, it is therefore optimal for the benefactor to give no aid immediately or to give a^1_j such that $u'(y - L + (1 - m\pi)z + a^1_j + a^1_{-j}) \leq \frac{\kappa}{\delta}$. If the benefactor gives a^1_j such that $u'(y - L + (1 - m\pi)z + a^1_j + a^1_{-j}) \leq \frac{\kappa}{\delta}$, then no further aid will be given later. In this case, the benefactor will give aid such that $u'(y - L + (1 - m\pi)z + a^1_j + a^1_{-j}) = \frac{1}{\delta}$.

There are therefore two potential symmetric subgame perfect equilibria. Let $x_L = y - L + (1 - \pi m)z$ be the amount the recipient would consume without aid. Then the first equilibrium involves benefactors each giving $(x(\delta) - x_L)/N$ immediately, while the second involves benefactors each giving $\kappa(x(\delta/\kappa) - x_L)/N$ later.

For the 'giving later' equilibrium to be subgame perfect, we require that no benefactor wishes to deviate by giving $x(\delta) - x_L$ immediately, which requires:

$$\delta u(x(\delta/\kappa)) - \kappa(x(\delta/\kappa) - x_L)/N \geq \delta u(x(\delta)) - (x(\delta) - x_L)$$

Rearranging this gives the expression for N in the proposition. □

This is a commitment problem in the sense that each benefactor would be better off unilaterally committing not to give later. If all benefactors did this, we would arrive at the equilibrium whereby they all gave immediately. However, promising not to give is difficult, and without such a promise and with enough benefactors, all benefactors giving later is an equilibrium. In other words, the problem is one of coordination, but could be solved through unilateral commitments if this was possible.

5 Solving commitment problems with risk transfer

The previous section set out three problems that arise in disaster relief due to the inability of benefactors to commit. To a certain extent, commitment problems can be solved by building generalist institutions - more developed countries may find commitment easier, for instance, because they have built a reputation for keeping their word, or a separation of powers ensures it is technically difficult to renege on commitments. Benefactors with sufficiently strong institutions can then make commitments to provide a pre-agreed amount of relief and no more, backed by well-disciplined public financial management systems, and hence avoid the problems discussed above. In practice, however, building generalist commitment institutions and better public financial management takes time and political will, and it is therefore worth asking whether there are intermediary solutions that might mitigate commitment problems without the need for massive institutional development.

One type of solution that has appeared to sometimes meet with success is to invest in systems that transfer risk to third parties. Often this is seen under the guise of 'bringing in private finance' or a 'public-private partnership', but this may also involve schemes that only involve public actors. Of course, these schemes may be valuable for purely financial reasons, for example if diversifying risks globally can be done more cheaply than retaining them in country, but we wish to concentrate here on the idea that they can help to solve some of the commitment problems which plague disaster relief.

Transferring disaster risk to third-parties can be done in a number of different ways. For instance, benefactors may encourage recipients to protect themselves by subsidizing private insurance, or the benefactor herself may purchase an insurance policy. Benefactors who care about one set of recipients may pool risk directly with those who care about others, bypassing the private sector. Relief systems may be based on direct measures of losses or proxy indices. Different risk-transfer schemes will have different implications for the commitment problems outlined above.

In this section we therefore proceed by considering four potential properties of schemes undertaken by benefactors that transfer risk to third parties. First, benefactors may encourage greater risk transfer from recipients to third parties in ways such that recipients then receive payouts directly from the third party. We label this as when benefactors provide 'recipient insurance subsidies', though it may also include mandating or outright purchase. Second, benefactors may purchase 'benefactor insurance', whereby they transfer risk from themselves to third parties. Third, benefactors may ensure that there are 'common payout triggers' across their relief efforts and those of the third-party. Fourth, benefactors may construct 'disaster loss indices' that are robust to moral hazard, by gathering and publishing statistics on proxies for disaster losses.

5.1 Recipient insurance subsidies

The standard solution to the Samaritan's dilemma, as outlined in Coate (1995), is for the Samaritan to 'give in kind', rather than give cash. In particular, the idea is that providing the recipient with an efficient amount of relief, delivered through fully subsidized insurance established in a contract with a third-party, means that the Samaritan will not wish to bail the recipient out any further. We can formalize this in the following proposition if we now allow benefactors to purchase recipient insurance at a premium:

Proposition 4. If benefactors cannot commit and $\underline{\delta} < \delta < \overline{\delta}$, then there exists a critical premium level $\tilde{m} > 1$ such that benefactors would like to purchase recipient insurance at a premium $m \leq \tilde{m}$.

Proof. First, note that if benefactors could purchase insurance for recipients at actuarially fair rates - i.e. $m = 1$ - then it would clearly be welfare enhancing to do so. This follows directly from Coate (1995) and is straightforward when we consider that, given benefactors are risk neutral over cash payments, purchasing actuarially fair insurance for recipients is equivalent to committing to giving a minimum level of aid regardless of the recipients actions. Hence benefactors could purchase insurance equivalent to what they would give in the full commitment case and then be strictly better off because the recipient would then undertake further self-protection, from Proposition 1.

Second, it is straightforward to see that the value of doing this is continuous and decreasing in the premium m. Indeed, for large m benefactors would rather suffer the individual undertaking no self-insurance than pay such a premium. Hence there must exist a critical value $\tilde{m}$ as given in the proposition. □

Some benefactors, in particular governments, may have the power to mandate insurance purchase. One advantage of mandating over subsidizing or purchasing may arise if recipients have more than one way in which they can self-protect, the government can only observe insurance purchase, insurance is a fairly inexpensive way to self-protect, and insurers are able to implement risk-based pricing, whereby recipients pay a premium that is increasing in the expected claim payment from the insurance. In this case, by forcing recipients to purchase private insurance at a price that reflects their uninsured risk, the recipient receives an appropriate incentive to protect themselves in the relatively more efficient way. Benefactors may also be able to improve on the no commitment equilibrium through partial subsidies to insurance, although the effectiveness would depend on the structure of such subsidies. For example, offering subsidies that cap the insurance premium, such as under the Government of India's new crop insurance program Pradhan Mantri Fasal Bima Yojana, will not improve on the no commitment equilibrium, as the beneficiary has no incentives to invest in self-protection beyond the capped insurance premium. In this case the benefactor is using their subsidy structure to institutionalise the Samaritan Dilemma. However, proportional premium subsidies or capped premium subsidies, where the benefactor covers a fixed part of the premium and the marginal cost of risk is born by the recipient, could mitigate the Samaritan's Dilemma.

Subsidizing insurance may also help to mitigate the strategic delay problem identified in Section 4.3 if benefactors are able to coordinate more easily over such a subsidy than over immediate relief. This may well be true if coordination is simply time consuming - it may be possible to spend years negotiating who will contribute how much to the purchase of an insurance product, when clearly an equivalent amount of time cannot be devoted to coordinating immediate relief. For example a range of donors have provided partial premium subsidies for Pacific Island governments to purchase parametric catastrophe insurance coverage against major tropical cyclones and earthquakes since 2013.

5.2 Benefactor insurance

We have so far abstracted from how benefactors finance the relief they disburse. Since the number of recipients who may suffer losses is unpredictable, and money is needed quickly, this is not a trivial matter. Typically, money is often reprogrammed from other budgets, but such an exercise can be expensive. Benefactors have a number of means by which they may be able to reduce the cost of financing relief. For instance, they may set up 'disaster funds' that save precisely for such events, or may ask for credit lines to be made available.

If benefactors can commit to how much aid they will spend, then clearly they should choose financing arrangements that minimize the cost. However, if donors cannot commit, then the choice of financing is more subtle. In particular, if a benefactors faces the Samaritan's dilemma, then reducing the marginal cost of ex-post financing can be damaging. To see this, suppose that the benefactor j's payoff function is

$$V_j = \mathbb{E}\left[\delta u(x) - \lambda a_j\right]$$

where λ represents the cost of financing aid. Then we arrive at the following proposition:

Proposition 5. If benefactors cannot commit, then their payoffs may be increasing in the cost of aid, λ.

Proof. From proposition 1 we know that if $\delta > \underline{\delta}$ the recipient will not self-protect, but if $\delta < \underline{\delta}$ they will self protect. A reduction in the cost of finance λ is essentially equivalent to an increase in δ, so clearly at this boundary increasing δ will reduce the expected payoff of the benefactor, since her financing cost has only been reduced marginally but the large decrease in self-protection will lead to a large increase in the amount of aid spent by benefactors. $\square$

Given this proposition, benefactors may be unwilling to save or negotiate credit lines that reduce their marginal cost of spending. Note that it is lowering the *marginal* cost of finance that is potentially damaging - if a benefactor would be willing to commit to spend a certain amount of aid, then the benefactor is only made better off by decreasing the cost of this lump sum. The problem comes therefore because the size of the amount the benefactor would like to spend is unknown - if many recipients suffer losses, the benefactor will need a large amount of money, but if few do, having access to the extra finance reduces the marginal cost of spending more than the benefactor would ex-ante wish to.

In this way, access to finance that is contingent on the size of the disaster helps to reduce the cost of finance without worsening the Samaritan's dilemma. Indeed, once benefactors know they will have access to finance that is contingent on disaster, they may be able to avoid the Samaritan's dilemma by increasing the marginal cost of additional financing. This may be achieved, for instance, by reducing the size of contingency funds and budget lines, opting out of lines of contingent credit that can be drawn down at the recipient's discretion, and making budget reallocations slower and more difficult bureaucratically, for example for international donors to not allow post-disaster budget reallocations between countries.

Insurance may also be able to help problems of strategic delay if benefactors are able to coordinate more easily over jointly purchasing such a policy compared to coordinating over post-disaster aid. This may well be true if a large cost of coordination is simply time - even if it takes several years to coordinate among benefactors, this may be feasible for agreeing to purchase insurance policies, when clearly it is not possible for post-disaster aid to wait such a long time. For example, in 2015 Nicaragua paid the premium for earthquake and tropical cyclone insurance through a concessionary loan from the International Development Association (IDA), the World Bank fund for the poorest countries, which itself is financed by a range of donors.

5.3 Common payout triggers

The misallocation problem identified above involved difficulties in benefactors committing to collect or reveal accurate information that would then feed into relief efforts. Typically, this is not a problem that is associated with private insurance. Indeed, profit maximizing private insurers have a much larger incentive than benefactors not to pay out to recipients that did not make a loss, since they do not care about the recipient's utility.[4] One potential advantage of involving the private sector within public relief programs may therefore be as a way for benefactors to commit to providing accurate information on losses.

A simple way to model the integration of public and private information systems in or model is to assume that a recipient must receive both z and a, or neither. We then assume that information on recipient's losses is observed by the private company responsible for paying out z, in addition to the appropriate government agency and/or benefactors. Moreover, we assume that any misreporting of this information requires the consent of the private insurer. We do not need to assume that the private insurer will automatically enforce truthful information revelation, but instead that, if a government agency or benefactor wishes to distort information, they must compensate the private insurer for any payouts she will then have to make.

If misallocation results in higher expected payouts (i.e. an expected payout with probability greater than π) then clearly the private sector has a strong incentive to collect truthful information. If, on the other hand, the expected payout is the same with or without misallo-

[4] We may worry that this means private insurers are too willing not to pay out, and indeed this may be a concern in countries where insurance companies care little about their reputations or are badly regulated. This may provide an additional reason why combining public and private sectors in verifying information is optimal.

cation, in the short-term the private insurance agency would not suffer any expected losses. However, crucially the private insurer receives revenues from recipients who purchase insurance, and if the recipient expects payouts to be misallocated he will be less willing to pay for private insurance. Hence misallocation will lead to a reduction in future expected profits for the private insurer, which they must be compensated for.

An example of integration of information systems can be seen in agricultural insurance in India, for example (Government of India, 2014). Since 1985 the Government of India has been supporting crop insurance, where claim payments are linked to area average estimates of crop yield. Until 2010 this program (originally the Comprehensive Crop Insurance Scheme, then the National Agricultural Scheme, the Modified National Agricultural Scheme, and currently Pradhan Mantri Fasal Bima Yojana) was implemented solely by the public sector, but since 2010 it has been implemented in partnership with private insurers and reinsurers, and this has led to significant additional investments in accurate, timely data. Since the private sector insurance triggers were an aggregate of the standard agricultural insurance triggers, this forced the program to build capacity and strengthen their auditing systems, protecting against misallocation. A similar example comes in the case of disaster insurance in Mexico, where the government has purchased private reinsurance based on aggregate losses in its public disaster relief program (Mahul, Ángel Villalobos and Yi, 2013).

Integration of the information systems used by relief programs and private insurance also decreases the commitment problem identified in Section 4.2 directly. The reason why benefactors were willing to pay less ex-post to reduce misallocation than they were willing to pay ex-ante is that ex-post those that would suffer from misallocation had already self-protection in anticipation. However, if self-protection is at least partially in the form of insurance, and if private insurance schemes must go along with any misallocation of relief, then this removes a channel through which recipients can self-protect. In the extreme, where the only form of self-protection is private insurance, then the benefactor's ex-post and ex-ante willingness to reduce misallocation will be identical.

If private insurance is relatively cheap, the most attractive way for benefactors to effectively integrate information systems may be simply purchasing or subsidizing private insurance for recipients (see Section 5.1). However, if private insurance is relatively expensive, then private sector involvement could be limited to private insurers taking only part of the total risk. For instance, a public insurance company could take the insurance risk on and then pass part of it to private insurers or reinsurers, as the Agricultural Insurance Company of India does, or government could provide insurance to private insurers, as Agroasemex does for agricultural insurance in Mexico.

Note that a similar logic might apply to other information besides information on losses. In particular, if the disaster insurance scheme involves some kind of index - see Section 5.4 - then committing not to manipulate the index may be more credible if the private sector is involved.

5.4 Disaster indices

Many of the recent financial products which have been promoted to help increase recipients' protection against disasters involve the use of indices. These are basically statistics, often based on relatively objective data such as satellite data on wind speed or rainfall, or monitoring station readouts of ground acceleration, that are correlated with recipients losses from disasters such as tropical cyclones, drought or earthquakes. Basing financial products on indices, rather than losses directly, holds a number of attractions. It is typically less expensive to collect and less vulnerable to manipulation than loss information, and since it does not depend on recipients' losses, basing insurance on it avoids problems of moral hazard or adverse selection.

In our model, we can introduce a basic index $\hat{L}$, which takes the value 1 or 0 and is correlated with whether a recipient suffers a loss. In particular, we can specify that, if a recipient suffers a loss, then $\hat{L} = 1$ with probability $1 - \mu$, and if a recipient does not suffer a loss then $\hat{L} = 1$ with probability

$$\frac{\mu\pi}{1-\pi}$$

. The parameter $\mu \leq 1 - \pi$ here represents the amount of basis risk in the index, such that a perfect index would therefore have $\mu = 0$, and deviations from this represent 'basis risk'. Note that our parameter μ is comparable to η and γ in Section 4.2, and hence to a certain extent we can directly compare the risks of misallocation to basis risk.

Does the simple act of building an index help with any of the commitment problems previously identified? In terms of the Samaritan's dilemma, building an index does not help if true losses are freely observed by benefactors - they will simply ignore the index, as they have better information on recipient's utility. However, if observing losses is relatively expensive compared to observing the index (or the cost of collecting the index has already been committed to), then ex-post a benefactor may choose not to pay to learn the true loss, and instead rely on the index when it comes to allocating relief. In this case, she avoids the Samaritan's dilemma problem, because she does not observe net losses, and hence recipients' self-protection decisions do not impact the relief they receive.

Indeed, if a benefactor knows that she has the index available, she may even take actions ex-ante to increase the cost of observing true losses (i.e. by disbanding the agency in charge of collecting such information), making it all the more credible that she will not pay to observe true losses ex-post. In particular, indices typically produce results relatively quickly. Even though true losses may be observed later on, this may be when budgets are already committed or opportunities are missed, and hence the Samaritan's dilemma is less severe.

To the extent that the index has basis risk, there will clearly be a trade-off here when deciding whether to build one. An index with basis risk may help in reducing the Samaritan's dilemma, but compared to observing true losses it will result in misallocation. This will have negative consequences both directly and indirectly, as identified in Section 4.2.

Proposition 6. If benefactors cannot commit, and $\underline{\delta} \leq \delta \leq \overline{\delta}$, then there exists a critical amount of basis risk $0 < \tilde{\mu}$ such that benefactors ex-ante would prefer to commit to observe the index rather than true losses if $\mu \leq \tilde{\mu}$.

Proof. If benefactors cannot commit and $\underline{\delta} \leq \delta \leq \overline{\delta}$ then Proposition 1 tells us that recipients will not self-protect when they anticipate that benefactors will observe their losses. It is straightforward to see therefore that benefactors would strictly prefer to commit to observing an index if there was no basis risk, i.e. if $\mu = 0$. This is because observing the index instead of actual losses serves as a way for the benefactors to commit not to respond to self-protection and hence avoid the Samaritan's dilemma. Note also that, if benefactors commit to only observing the index, their payoff is weakly decreasing in μ since any aid given becomes less well targeted. □

Building an index also has the potential to reduce two of the other commitment problems identified. If basis risk is lower than the misallocation arising from agency reporting, then it will be preferable to use it to allocate aid and remove the government agency, or potentially use a combination of both. This will reduce the misallocation problems identified in Section 4.2.

Of course, for index building to solve both of these two latter commitment problems that stem from misreporting information, we have to assume that the index is less susceptible to manipulation than information on losses. There are two potential reasons why this may be the case. First, the technology of the index may simply make it more difficult to falsify - if collecting the information is cheaper, verification is also likely to be cheaper. Second, it may be easier to bear much of the cost of building a reliable index up-front and thus solve the commitment problems which are behind misreporting. For instance, investing in satellite data or computer systems for processing information can be paid for prior to a disaster, whereas rewarding uncorrupted bureaucrats or making important politicians unhappy has to be done after the fact.

6 Conclusions

Using the model built in this paper, we have been able to analyze a number of commitment problems arising in disaster risk finance. One important result to note from this analysis is that the effects of these various commitment problems differ. For instance, while the Samaritan's dilemma causes recipients to protect themselves too little, fear of aid misallocation may result in them protecting themselves too much. As a result, we cannot recommend a single solution as being appropriate for all situations. Instead, it is important to diagnose which commitment problems are most severe and then choose the system of disaster risk finance that is most adapted.

Table 1 provides a first attempt to try to categorize how policies involving private risk finance may interact with various commitment problems. Pluses represent cases where a policy should mitigate a commitment problem, minuses cases where the policy may worsen such a commitment problem, and zeros mean it is not clear there would be any impact.

Table 1: **Private finance solutions for commitment problems**

Commitment problem	**Recipient insurance subsidies**	**Benefactor insurance**	**Common payout triggers**	**Disaster index**
Samaritan's dilemma	+	+	0	+
Aid misallocation	+	0	+/-	+/-
Delayed disbursements	+	+	0	0

The Samaritan's dilemma can be mitigated by both recipient insurance and benefactor insurance. Recipient insurance decreases the need for discretionary aid, while benefactor insurance allows benefactors to reduce their access to more discretionary contingency funds and lines of credit, hence increasing the *marginal* cost of post-disaster finance. Disaster indices may also help, though only if they are sufficiently accurate that benefactors are then not sufficiently motivated to learn the true needs of recipients.

A simple way to reduce aid misallocation is through subsidizing recipient insurance, assuming that the private sector is reliable enough not to misallocate. Combining payout triggers across public and private programs may also reduce misallocation through a similar mechanism, but here there is a risk that if the incentive to misallocate is strong enough, this may contaminate previously well-functioning insurance systems. Disaster indices may also be less vulnerable to political misallocation, though of course if basis risk is high enough misallocation may worsen.

Finally, insurance subsidies and benefactor insurance may mitigate the problem of delayed disbursements if it is easier for benefactors to coordinate over payment into these products than disaster relief ex-post. Even if free-riding is not reduced, delays over the purchase of insurance products are likely to be less costly than delays in relief disbursement.

Overall, Table 1 makes clear that there are several reasons why involving the private sector in each way may be beneficial for governments and benefactors who suffer commitment problems. Placed alongside this, of course, it should be noted that these kinds of private finance are typically expensive. This can be due to lack of competition, poor insurance regulation, high administrative costs or ambiguity averse pricing from regulated insurance companies. These costs should obviously be weighed against the potential benefits that have been the focus of this paper.

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