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**DEVELOPING COUNTRIES SPREADING COVARIANT RISK INTO
INTERNATIONAL RISK MARKETS: SUBSIDISED CATASTROPHE
BONDS OR REINSURANCE, OR DISASTER ASSISTANCE?**

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Abstract: Poor developing countries, faced with high levels of covariant risk ideally should spread this risk into the international risk market. How might this best be done – given that through diversification this market will tend to gain from absorbing this risk? Conglomerates of intermediate financial institutions may need to be formed in developing countries to acquire risk-transfer financial instruments. The preferred instrument is subsidised catastrophe bonds and not reinsurance or lump-sum foreign disaster assistance. Numerical analysis is employed as part of the demonstration of this point. Disaster foreign aid also should take the form of subsidising the issuing of catastrophe bonds by developing countries.

1. Introduction.

The designs of financial instruments for the management of risk have been invented and innovated upon through the centuries in order to allow evolving market systems to operate more efficiently.¹ Nevertheless, as Shiller (2003) has emphasized, there is scope for the invention and application of additional financial instruments that would allow a range of presently uninsured or underinsured risks to be mitigated at relatively low cost. And such improvements seem to be feasible or at least more likely given the considerable advances that have been made in recent decades in the technologies required for: (i) the generation of relevant information (with the aid of satellite technology) to allow certain risks to be measured; (ii) the storage, manipulation and interpretation of comparatively large amounts of relevant data – all activities that are required to allow, in particular, the accurate assessment of the level of risk attached to relevant future events - and (iii) reducing the costs of transactions associated with relevant financial instruments. These improvements should assist in reducing the costs associated with providing actuarially-fair risk-transfer financial instruments.

Despite these advances, one area where there is scope for improvements in risk markets is in the extent of the links between domestic risk markets in developing countries and international risk markets. At present developing countries, taken as a whole, have to cope with covariant risks with little or no opportunity to spread these risks into international risk markets. The urgency of this issue is emphasized by the fact that developing countries in the period 1985 through to 1999 experienced far

¹ This theme is developed, for example, by Grief (2006).

greater losses from natural disasters as a share of their combined gross domestic product (13.4 per cent) than did developed countries (2.5 per cent).² In addition there are indications that this covariant risk in developing countries is likely to become more prevalent and severe in the future due to climate change (Hoeppe and Gurenko, 2006: 609- 10; 612 - 13). And yet only one per cent of all households and businesses in poor countries are covered by catastrophe insurance whereas the coverage is thirty per cent in rich countries (Munich Re, 2005).³ What is more this situation does not seem to arise because of the lack of capacity of the international insurance market to absorb this class of risk. The annual revenue of the world insurance industry (made up of insurers and reinsurers) – some \$3.2 trillion – is equivalent to the gross domestic product (GDP) of the third largest economy in the world. And this financial capacity does not include the size of the international financial market in which certain types of risk-transfer instruments (viz. catastrophe bonds) can be acquired. It would seem, therefore, that even if a series of covariant contingent events took place in some mid-sized developing countries in a given year, the insurance industry and financial markets should be able to absorb, without any difficulties, the resulting insurance claims.

Ideally developing countries should be able to reduce the extent of the covariant risk they face by purchasing, at actuarially-fair prices some appropriate

² Because of incomplete reporting (Strömberg, 2007: 201), the relevant data for the developing countries possibly understates the situation.

³ The point made in the main text should not be taken to mean that the insurance market in developing countries currently is static. On the contrary the market in these countries for non-life premiums grew by 8.1 per cent in 2003 and 8.9 per cent in 2004 (Sigma, 2005:8).

covariant-risk-transfer financial instrument in international risk markets.⁴ Reaching this ideal would allow these countries to handle, *ex ante*, covariant shocks effectively by having access to adequate funds (indemnity payouts) in the periods immediately after these shocks occur – funds that are required to finance a prompt recovery effort. In addition, if this ideal could be satisfied then the risk-averse explicit or implicit purchasers of this (presumably actuarially-fair) index-based reinsurance/insurance⁵ in developing countries would divest themselves of downside-covariant risk and thereby experience an increase in their levels of expected utility.⁶

Since the reality falls far short of the ideal this fact makes it that more difficult to reduce the level of poverty in these countries. To explain, faced with uninsured potential economic shocks individuals view a number of economic opportunities as being too risky to take advantage of. Acquisition of some appropriate risk-transfer financial instrument, however, would encourage the exploitation of at least some of these opportunities. Indeed there is evidence to indicate that such behaviour is likely to result in a significant increase in the rate of economic growth for the community concerned (Elbers *et al.* (2007)). Such a change in turn would assist in reducing the level of poverty in these countries. (See Rozenzweig and Binswanger,

⁴ A related discussion is to be found in Shiller (2003: Ch 13) of the benefits developing countries could derive from being able to spread the risks they face into international risk markets. Shiller, however, deals with long-term contracts whereas in the main text the discussion tends to concentrate on the short- to medium-term.

⁵ While reinsurance/insurance contracts normally are based on realized losses (indemnity payments), in the main text it is assumed that these contracts allow for a suitable index to be applied - such as the level of rainfall or floods, or the severity of an earthquake and so on – to determine the level of indemnity. This is done in order to mitigate adverse selection (hidden-information) and moral hazard (hidden-action) behaviour by those insured. These matters are discussed at the beginning of Section 2 in the main text.

⁶ See Rothschild and Stiglitz (1970) and Stiglitz and Newman (1981: Ch. 6) for a statement of the relevant economic theory.

1993; Martina, 1998a; Skees, 2005: 423 – 4; Sadoulet, 2005: 387; Dercon, 2005: 439, and Hess *et al.*,2005: 23.)

On the supply side of the international risk market, those providing insurance in this market would be risk-averse profit-maximizing insurers or reinsurers (henceforth re/insurers) that are searching for ways to insure independent contingent events that are only weakly positively, or even better strongly negatively correlated with the other contingent events that they are already insuring. In other words the re/insurers would be attempting to take full advantage of the law of large numbers by attempting to pool independent random contingent events from various sources.⁷ The larger this pool, the more predictable the amount of losses will be in a given period and hence the lower the level of risk that these financial institutions face. Insuring contingent events from developing (as well as from developed) countries should assist re/insurers in the international risk market to achieve this end. What is more, this diversification process will convert the initial covariant risks, as viewed by those residing in developing countries, into part of a system of idiosyncratic risks as perceived by the re/insurers operating in international risk markets. Finally, if this diversification process is successful then, in a competitive insurance market re/insurers will need to lower the premiums charged (although still remain solvent) for a given amount of insurance provided.

While the comments in the previous paragraph have been made with respect to the acquisition of re/insurance in international insurance markets, similar remarks could be made with respect to index-based catastrophe bonds that are available in

⁷ This law states that if an event has a probability α of occurring then, over a large number of independent repetitions, the ratio of the observed events to the total number of repetitions will converge to α .

international financial markets. This class of bonds is defined as a financial instrument whereby the investor receives an above-market rate of return when a designated catastrophic event does not occur, but should this event occur then immediately after the investor shares the insured's (viz. bond issuer's) losses by forgoing interest payments and possibly also part or all of the principle. The contingent event occurs when the relevant index rises above (falls below) an agreed level – for example flood levels rise above an agreed specified level. No proof of loss is required. The contract for catastrophe bonds of interest here also includes the condition that the coupon payments resume exactly one year after the date when a particular contingent event occurred.⁸

As for the size of the market for catastrophe bonds (henceforth cat bonds), after its inception in 1996 initially this market grew comparatively slowly until 2005 when, from the end of that year until the end of 2007 there was a 2.8 fold increase in the amount of capital outstanding in this market (Cardenas et al., 2007: 48; Guy Carpenter, 2008: 6). At the end of 2007 this market still only accounted, however, for 8 per cent of the reinsurance market (Guy Carpenter, 2008: 6). Nevertheless, given that currently this market is expanding comparatively rapidly, the question posed is this: in the instance of developing countries are indexed-based cat bonds to be preferred to re/insurance in the task of assisting these countries cope with the comparatively severe burden that covariant risks imposes on these countries?

The answer to be provided here is that for a number of reasons cat bonds are to be preferred. The broad reason lies with a number of dimensions concerning the

⁸ A detailed description of cat bonds and the market for these bonds is to be found in Guy Carpenter (2007: Appendix 1).

timing of various payments into and, in particular, out of the risk-transfer financial instrument when sizable payments need to be paid when the contingent event occurs. This implies that cat bonds are a superior instrument for smoothing out risk over time.⁹ This is a very important property as far as developed countries are concerned. Much, but not all of the argument employed in arriving at this explanation is based upon a numerical, as distinct from a mathematical analysis. This numerical analysis also indicates, however, that both cat bonds and re/insurance will need to be subsidised in order to just cover, or nearly so, the level of covariant risk to be found in a representative developing country. Nevertheless it is shown that the use of a given amount of subsidy, to allow *ex ante* disaster assistance to be provided in the form of purchasing reinsurance, or of the payment of the interest owed on cat bonds issued by the developing country ensures the provision of a significantly higher level of indemnity cover against covariant risk than that provided by expending this subsidy on *ex post* disaster assistance.

We are not just concerned, however, with answering the question posed earlier. Some attention also is given to considering how the institutional framework in developing countries may need to be modified in the hope that this will allow these countries to take greater advantage of international risk markets. What is more, while developing countries may wish to issue (supply) cat bonds on the international risk market, do potential investors have the incentive to purchase (demand) these bonds? In attempting to answer this question we generate simulated empirical results that suggest an investor, who invests in cat bonds (issued by a developing

⁹ This theme also is developed by Jaffee and Russell (1997) albeit only within the context of a developed country.

country) as part of the strategy of diversifying her balanced portfolio of other risky assets, is likely to reduce by a significant amount the level of risk (viz. variance) attached to this portfolio. This result implies that there is the potential for cat bonds issued by developing countries to be demanded, and possibly in significant amounts, by well-informed risk-averse investors in international financial markets.

In the next section the main thrust of the argument is concerned with identifying institutions that can replace micro-insurance institutions since these latter institutions are unsuited for providing covariant-risk insurance. It is suggested that conglomerates of financial intermediaries or the governments of developing and/or developed countries operate between the international risk market and the individuals in the developing country that these institutions serve. Part of this discussion also has implications for how foreign aid, given solely as disaster assistance to developing countries, may be more effectively provided. (This theme is also taken up in part of the discussion in Section 6.) In Section 3 the properties of re/insurance and cat bonds begin to be compared within the context of attempting to provide, immediately after a catastrophe, assistance to a poor community in a developing country. Given this context, and bearing in mind other considerations, cat bonds appear to possess certain particularly desirable properties that re/insurance does not. Above all the use of cat bonds ensures that it is certain that indemnities will be paid when they are needed most. Reinsurance does not possess this property. The discussion in Section 4 deals with the diversification properties of reinsurance and especially cat bonds. In Section 5 the discussion turns to begin to consider in some detail the efficiency of cat bonds relative to reinsurance in

mitigating covariant risk in a developing country. Besides setting out a range of reasonable assumptions, the model specified is an actuarial inter-temporal deterministic valuation model. This model is applied to data concerning flood damage in India over the period 1962 – 2006. As emphasized in Section 5, this is rather an important special case. Presented in Section 6 are the empirical results generated by the model. Concluding comments are made in Section 7.

1.1 Some related literature

There are those who believe that reinsurance should be used to mitigate covariant risk in developing countries. Morduch (2006: 347) for instance states that: 'Moving to insurance against catastrophic [and hence covariant] events requires that the insurer have a way to handle potentially large losses. The best way to do that is by reinsuring through arrangements with other insurers (paying another company to share some of the risk).' (Also see Morduch (2006: 348.). Sadoulet (2005: 407) holds a similar point of view.

Some support for this position is provided in the theory of finance literature where it is reasoned that a cat bond cannot provide, at a given price, a higher level of insurance cover against covariant risk than a well-designed reinsurance contract (Lakdawalla and Zanjami, 2006: 1). This proposition is open to doubt, however, when considered within the context of a representative poor developing country where covariant risk is prevalent and the timing of relevant payments are vitally important for those afflicted by a natural disaster. Within this not unrealistic context it would seem that cat bonds are to be preferred. (See the relevant discussion in Section 3.)

Late in the writing of this paper – the initial draft was written in late 2006 – we became aware that Cardenas *et al.* (2007) had addressed a similar set of issues as we consider in Sections 5 and 6. They also came to a similar conclusion regarding the relative benefits of the use of cat bonds to mitigate covariant risk, although they employed quite different methods of analysis in arriving at their conclusions. The model we employ, for example, is far simpler and more transparent than the stochastic model employed by Cardenas *et al.* (2007) and, consequently, makes clearer why certain central results are arrived at. We also extend our argument to cover *ex post* disaster assistance. That said our main results could be viewed as an independent confirmation of their findings – and *vice versa*. [Within the context of the discussion in Section 5.3, in Appendix B the model and assumptions applied by Cardenas *et al.* (2007) are compared with what is assumed in Sections 4 and 5.]

2. A proposed institutional arrangement for the provision of covariant-risk-transfer financial instrument in a developing country

We are mainly concerned with the provision of index-based covariant-risk insurance by comparatively large economic/social/political entities in developing countries that supply various types of services (other than insurance) to firms, individuals or households in these communities – entities such as the central government, microfinance institutions and commercial banks. The implication is that these entities are assumed to act as financial intermediaries between international risk markets and citizens of the developing country. The benefits that these intermediaries gain by acquiring index-based covariant-risk insurance in the international risk markets in turn are passed on, in one way or another, to the clients

they serve. One, but only one way these benefits may be transferred is through the provision of microinsurance. Before turning to consider these matters, however, first there is a need to consider why risk-transfer financial instruments should be index-based.

2.1 The virtues and reservations concerning index-based insurance

A well chosen and carefully designed parametric-index-based risk-transfer financial instrument will mitigate the difficulties of adverse selection and moral hazard behaviour by those insured. The reasons are that the indemnity provided by an insurance contract, for instance, is only paid or 'triggered' if the agreed parametric index falls below (or rises above) a certain agreed level, while the premium charged for this insurance is based on the probability that the index falls below (rises above) this 'trigger' level of the index. It follows that the particular characteristics of an economic entity covered by such a contract will have no influence on the amount of the premium charged or the indemnity paid – except that this entity possesses some general characteristic (such as residing in a particular geographic region) that is possessed by many others. Hence such an entity gains no advantage by hiding relevant information (which gives rise to the adverse selection problem) – such as being an inefficient farmer in the instance of weather insurance - or by altering its actions after the insurance contract has been entered into – such as farming less diligently after taking out weather insurance. What is more, if an indexed trigger is transparent this allows transactions to be settled and verified quickly, whilst also reducing transaction costs.

There are situations, however, where, if the index is not well designed, an index-based risk-transfer instrument will not eliminate moral hazard behaviour. For instance the provision of insurance against flood or earthquake damage, based on a poorly designed index, will tend to encourage those covered by this insurance not to take actions to reduce the level of relevant risk that is avoidable at reasonable cost. (Examples are the building of a dwelling on a flood plane, or building a dwelling not capable of withstanding comparatively low-intensity earthquakes.) To counter this possibility the trigger point for the index needs to be set at a level such that indemnity begins to be paid after the flood (or earthquake) has inflicted damage *only* on those who have *not* taken appropriate risk-avoidance action. The risk of being exposed to this damage – which acts as an implicit co-payment - should provide the incentive for those insured to reduce their moral hazard behaviour by taking appropriate action to eliminate this avoidable risk.

An alternative route to take to mitigate this moral hazard behaviour is to allow some random basis risk to exist - risk that is created by indemnity being triggered but the insured are not fully compensated for the losses incurred. Again the presence of this risk should induce a household to take appropriate action to eliminate avoidable risks.

Applying a more refined index would reduce the extent of basis risk but this action also would tend to increase the level of the transaction costs (associated with monitoring claims in the attempt to reduce moral hazard behaviour (although this

problem can be mitigated in the way indicated earlier).¹⁰ Hence a balance needs to be struck between the level of basis risk (and the associated benefit of tending to mitigate moral hazard behaviour) and the level of transaction costs that are associated with applying a more refined index. Such a balance also would need to take account of equity considerations. (For example in the instance of public action directed at mitigating moral hazard behaviour, how much flood damage should be borne by poor communities before indemnity begins to be paid – poor communities that, through no fault of their own, have to live on a flood plain?)¹¹

These introductory remarks apply throughout the subsequent discussion with respect to the various types of explicit or implicit index-based risk-transfer contracts to be considered.

2.2 Avoiding attempts to create microinsurance institutions

There are a range of reasons why the use of microinsurance institutions (MIs) should be avoided in the attempts to provide covariant risk insurance to firms, households and individuals in developing countries. First attempting to provide an efficient index-based insurance contract at this disaggregated level creates a range of administrative transaction costs associated with attempting to supply insurance

¹⁰There may well be significant practical difficulties associated with devising an acceptable index for a developing country. In some instances improvements in technology may assist in this matter. For instance advances in automating weather stations and satellite technology should assist in reducing the cost of monitoring the extent of a drought or a flood in a particular region. This matter is touched on in Hess *et al.* (2005: 16 and 17) and Zimmerli (2003: 24).

¹¹In the attempt to mitigate the dilemma alluded to in the main text the authorities may need to undertake certain infrastructure projects, such as build flood levies, apply and police building codes directed at reducing earthquake damage and so on. This matter is returned to later in the main text.

directly to these economic entities.¹² And even if these costs could be kept within reasonable bounds, the covariant nature of the risks insured means that the microinsurer needs to hold a comparatively large stock of financial capital in reserve in order to cover extreme covariant events. This opportunity cost of capital adds yet another layer to the costs associated with providing this insurance.

[There is some evidence to support the line of argument presented in the previous paragraphs. A trial of an index-based insurance program in Andhra Pradesh in India was begun in 2003. It consisted of the largest microfinance institution in India, Krishi Bima Samruddhi purchasing weather-indexed insurance policies from the Mumbai-based insurer ICICI Lombard General Insurance Company. ICICI Lombard was responsible for selling weather-indexed policies directly to individual farmers. It turned out, however, that ICICI Lombard found this type of insurance business unprofitable because of, not surprisingly, the comparatively high administrative costs associated with selling insurance directly to farmers. ICICI Lombard, however, has expressed an interest in entering comparatively large (wholesale) index-based insurance contracts with state governments or financial institutions.¹³ The matter of insurance companies being willing to insure comparatively large economic entities is returned to later within a slightly different context.]

Assuming for the present that it is possible to reinsure this risk on international markets, this capital cost could be shifted on to the reinsurer. The

¹² Morduch (2006: 339), Sadoulet (2005: 407) and Trommershäuser *et al.* (2006: 508) all mention the comparatively high administrative costs associated with providing any type of insurance at the level of the household or individual in developing countries.

¹³ See Kelkar (2007: 665 and 666 – 67) for more details.

difficulty here, however, is that there are likely to be significant economies of scale associated with administering insurance contracts written in international risk markets. Consequently these contracts need to be written for relatively large sums before they become profitable for international re/insurers to enter into. A nascent MI will be unable to satisfy this requirement, however, since the aggregate value of the contracts it is able to sell domestically is too small for these contracts to be sold on to reinsurers.¹⁴

Besides this economies-of-scale constraint causing the market for re/insurance market to be incomplete in developing countries, there is a set of information problems that also tend to contribute towards weaknesses in this insurance market. On the supply side of the market re/insurers are likely to lack the relevant information that allows them to make accurate assessments of the risks associated with the insurance provided by microinsurers in developing countries. Reinsurers, therefore, prudently will set premiums at levels to incorporate this lack of relevant information. On the demand side of this market poor households probably do not possess the information and skills required to assess the complex problem of accurately evaluating the infrequent covariant risks that they face and hence tend not to insure.¹⁵ Each of these information problems, therefore, tends to reduce the size of the market for re/insurance in developing countries.

It follows that MIs in developing countries tend not to come into existence, or if they do they tend not to survive. This is evidenced by the fact that it has been

¹⁴ See Morduch (2006: 349).

¹⁵ Hess *et al.* (2005: 10) and the references cited there discuss this matter of the failure of the market for covariant risk in developing countries. Also see Goes and Skees (2003). Kunreuther and Pauly (2004) discuss this matter within the context of developed countries.

difficult to attract commercial insurers into establishing microinsurance enterprises that provide covariant-risk insurance.¹⁶ In particular insurers based in developed countries are unwilling to become involved in this class of insurance. The reasons were pithily put in 2005 by Hans-Jurgen Schinzler, Chairman of the Board of Trustees of the Munich Re Foundation:¹⁷ 'Premium income is low, administrative costs are relatively high, and infrastructure for insurance is lacking; that's why commercial insurers have not taken more interest in this market.'

Given this situation, can some way be found that at least partially fills this void in the market system regarding the provision of covariant-risk financial instruments in developing countries?

2.3 Elements of a possible answer

Part of a possible solution that seems to be worth investigating would be to ignore MIs and concentrate attention on forming conglomerates of financial intermediaries that are in a position, possibly with financial assistance provided by developed countries, to purchase index-based covariant-risk-transfer financial instruments in international risk markets. A financial intermediary in a developing country may take the form of the central government, or groups of microfinance institutions or groups of commercial banks – and possibly other forms.¹⁸ Due to their size, a conglomerate is assumed to have access to adequate funds, although some financial assistance provided by developed countries may be required, to

¹⁶ See Brown and Churchill (2000): 90) and Skees (2003).

¹⁷ Cited by Dror and Wiechers (2006: 524).

¹⁸ The general point made in the main text was touched upon by Skees et al. (2005: 430) albeit only within the particular context of agricultural cooperatives. Relevant institutional forms, other than those discussed in the main text are also discussed by Linnerooth-Bayer and Mechler (2006) – institutional forms concerned with creating overarching international institutions essentially concerned with mitigating covariant risk in developing countries.

finance purchases of risk-transfer financial instruments in the international risk market such that the economies-of-scale problem is overcome. These conglomerates in turn pass on the benefits they derive from these instruments to those they serve in the community concerned - and who are adversely affected by covariant risk. Examples of how this may be done are considered soon.

If public funds are required to achieve this end, this action can be rationalized on a number of grounds. The first is that, as indicated in the previous sub-section, for a number of reasons the market for re/insurance to cover covariant risk in developing countries fails to operate efficiently. Appropriate public assistance is required to mitigate this inefficiency. The other reason concerns the matter of economic justice. Certainly it is not difficult to construct an argument that would justify a system of economic justice that entails providing public assistance solely for the purpose of insuring poor households in developing countries against economic uncertainty caused by covariant risk. This matter is not explored further here, however.¹⁹

2.4 The government of a developing country.

Ideally the government of a developing country, faced with a natural disaster, should be able to finance prompt assistance directed at those adversely affected – by say funding an assistance-for-work program. The finance required will be available if this government had acquired a suitable index-based covariant-risk-transfer

¹⁹ The theory of justice alluded to in the main text is based on a Rawlsian notion - viz. Rawls's (1993) first (not second) principle of justice - that in a situation of complete uncertainty a community will decide that each individual in this community should be provided with a basic level of income. There is some empirical evidence, based on the results derived from game-theoretic experiments performed in a developing country that does not contract this notion. This and other related matters are examined in dela Cruz-Dofia and Martina (2000).

financial instrument that paid indemnity immediately after the contingent event occurred (in the case of flood for instance) or even during a disaster (in the case of drought). Relying on alternative sources of finance, however, possibly will result in this finance arriving with a significant delay. And this delay may impose, as emphasized in Martina (1998b: 307 – 311), considerable short- and longer-term economic costs on the poor community concerned. (This theme of the delayed response to a natural disaster is returned to on a number occasions below.)

In addition, the promptly provided assistance-for-work program, if carefully designed and implemented would mitigate adverse selection and moral hazard behaviour at the level of the household. Thus the assistance provided would be directed, at relatively low cost, mainly to those who are most in need.²⁰

This use of risk-transfer financial instruments to fund assistance to poor groups afflicted by natural disasters has been recognized recently by a number of governments. For instance the government of Ethiopia, with the assistance of the World Food Program, set up a pilot project in 2005 aimed at exploiting international risk markets to insure against covariant weather risk. The financial benefits derived from this program – which entailed index-based cat bonds being issued by this government – are to be used to fund the assistance given to households adversely affected by this weather risk.²¹ Similarly the Fund for Natural Disasters (FONDEN) – which was established by the Mexican government in 1996 - for the first time, in

²⁰ The matter of the effective design of assistance-for-work programs in developing countries is discussed in Martina (1998a, b) and Barrett *et al.* (2005) and the references cited in these sources.

²¹ See World Food Program (2006).

2006, issued index-based cat bonds to cover covariant-risk damage caused by earthquakes for the period 2007 to 2009 (Cardenas *et al.* (2007: 51).

While this behaviour of these two governments reveal that they are risk averse, some may infer that this behaviour is at variance with the Arrow-Lind theorem (Arrow and Lind, 1970) – which states that a public project financed out of a balance government budget imposes no social risk on a large community if certain independence assumptions are satisfied (Foldes and Rees, 1977). It would appear, therefore, that there is no need for these two countries to purchase cat bonds. Such an inference is incorrect, however, once assessed within the context of the comparatively small developing countries of interest here – countries that are faced with catastrophic covariant risk. This fact implies that these countries do not satisfy certain independence assumptions that need to be applied in order to derive the Arrow-Lind theorem. [One of these assumptions, for instance, requires that the tax revenue per head, used to finance a public project is independent of the benefit each individual receives from this project (Foldes and Rees, 1977: 191 - 193). Also see Cardenas *et al.* (2007: 41).]

2.4.1 The central government of a developed country – an implication for the way foreign aid is financed

The government of a developed country, which provides emergency assistance to particular developing countries, alternatively may act as the intermediary that purchases index-based risk-transfer financial instruments in international risk markets in order to mitigate the covariant risk that each of these countries face. Again the indemnity paid, when the contingent event insured against

occurs can be used to finance the appropriate emergency assistance provided to the relevant developing country (countries). Amongst other things this method of financing disaster assistance would reduce the need for this developed country to always have on hand adequate funds to finance, promptly, emergency assistance – which most likely is not always the case. (This failure to provide this assistance promptly may be considered an implicit form of credit risk. This class of risk is considered in the next section.) The developing countries receiving this assistance, in turn, presumably would be obliged to ensure that the funds provided were effectively directed at meeting the needs of those households adversely affected by the insured contingent event(s). Should this obligation not be met in the country concerned then some alternative method(s) will need to be found for mitigating covariant risk in this country.

This organizational approach would seem to be a comparatively efficient method of providing disaster foreign aid to developing countries since the developed country could achieve economies of scale when purchasing risk-transfer financial instruments in international risk markets. Certainly this approach would seem to be more efficient than just providing lump-sum transfers to each relevant developing country that, in turn, use them to purchase a suitable risk-transfer financial instrument. And certainly this approach would be more efficient than just providing lump-sum transfers that are *not* used by the developing country concerned to purchase an appropriate index-based risk-transfer financial instrument – even though there is a clear social need for the developing country to make such an acquisition.

The particular case of providing subsidies for the acquisition of a covariant-risk-transfer financial instrument is returned to in sub-Section 6.2.

2.5 Microfinance organizations

Microfinance institutions (MFIs) tend to find it difficult to provide their services effectively within the context of a covariant shock that results in significant falls in the levels of the incomes received by most, if not all of its clients.²² A conglomerate of MFIs that could find ways to insure against this downside covariant risk in international risk markets should be in a much better position to allow each of the MFIs in the conglomerate to finance assistance to its clients in times of economic stress. This assistance could take the form, for instance, of the interest rate charged to borrowers by a MFI being reduced in size during this stressful period thereby converting these loans into contingent loans where the current interest rate charged is contingent on the size of the current level of the income received by the borrower. (This general idea of income-based interest rates is not new as indicated by Shiller (2003; Ch. 10).) Alternatively the size of the loan to be repaid could be varied during periods of distress.²³ In order to reduce the potential for moral hazard behaviour associated with these contingent loans, the variable loan and/or interest rate charged also would need to be linked to some relevant index that is applied within a

²² A similar point was made by Sadoulet (2005: 407).

²³ As for the matters of moral hazard and adverse selection relating to MF loans, that are not contingent on any particular event, they are mitigated by either one of the standard lending techniques employed by MFIs. One of these is to make use of a dynamic loan system where, initially, a small loan is provided to an individual. The size of each subsequent loan is increased only when the previous loan is repaid in full and on time. If this loan is not repaid no further loans are provided to the defaulter. (Reinker (1998) provides a discussion of an example of this dynamic loan system. The administrative costs associated with managing these loans are reduced by the use of modern information technology.) The other technique, that is better-known and which is widely-discussed, is the use of the group-lending system. See for instance de Aghion and Morduch (2005) for a discussion of this lending technique.

given geographic region to measure the extent of the contingent risk.²⁴ This index, which would need to be free from any manipulation, would be applied in some appropriate formula to determine how much interest rates and/or the size of loans are varied for all loans provided to all (not just some individuals) living in this region. It follows that the behaviour of any individual (or group) would not influence the amount by which the interest rate, or size of loan is varied on the loan this person (or group) has received.

The index employed to determine the rate of interest charged on these contingent loans would need to be very similar (if not identical) to that used in the index-based risk-transfer financial instrument acquired by the conglomerate of MFIs. If this is not the case then any indemnity paid (in response to some contingent event covered by an index-based international insurance contract) will suffer from basis risk (that was discussed in sub-Section 2.1).

This use of index-based contingent loans system in fact is being experimented with in Malawi (Hess et al. 2005: 47, and Linnerooth-Bayer and Mechler, 2006: 627 – 8), although the precise institutional arrangement employed there varies a little from that just outlined.

Drawing on the argument set out in the previous sub-section, there also is a potential rôle for developed countries to provide assistance to MFIs to mitigate covariant risk. The assistance provided to MFIs may take the form of the developed country acting as the financial intermediary for the MFIs by purchasing covariant-

²⁴ This index may measure, for instance, the severity of the weather – such an agreed rainfall index, or the number of frost-free days - or the damage caused by a seismic event with the Modified Mercalli Intensity scale.

risk-transfer financial instrument in international risk-markets. The rest of the relevant argument is the same as that presented earlier.

2.6 Commercial Banks

A similar line of argument applies to commercial banks (that may or may not form themselves into a conglomerate to purchase risk-transfer financial instruments) that operate in developing countries. The customers for these banks equally could be faced with sharp and covariant declines in income. If a bank could insure against this downside risk it would be in a better position to finance variable-interest-rate contingent loans, or vary the size of the loan provided. The provision of such loans should give this bank an edge over its competitors (who do not provide contingent loans) in the loans market. This is so since in the longer term this commercial bank would tend to benefit from this assistance by its customers being in a better financial position to contemplate taking on more risky and profitable ventures. Hence customers would be more inclined to borrow from the bank, compared to the situation where these contingent loans were not provided.

Similar remarks made with respect to MFIs regarding the use of some suitable index apply here.

3. Some of the properties of reinsurance and catastrophe bonds compared

Here some the properties of reinsurance are compared with those for cat bonds – as they were defined in the introduction.²⁵ These comparisons are continued later in Sections 4 and 6.

An initial important point of difference in that reinsurance is provided in the insurance market, whereas cat bonds are issued in the much larger and more diverse financial market – a market that has a far greater capacity than the international insurance market to absorb losses due to natural disasters. This fact has a number of implications. One is that it raises the possibility that there is more scope for investors in cat bonds to diversify risk (that is present in an overall balanced portfolio of assets held by investors in cat bonds) than is the case for reinsurers. (This matter is returned to in the next section.) Another implication is that cat bonds will tend to be a cheaper source of risk transfer, compared to reinsurance since the relatively larger size of the international financial market will result in the cat bond market being more competitive than that for re/insurance. (In fact the level of competition in the cat bond market appears to have increased in recent years (Guy Carpenter, 2008: 19).) Cat bonds characteristically also have lower transaction costs than reinsurance.²⁶ Furthermore, these bonds are able to provide multi-year (often a 3 to 5 year term) protection against natural disasters.²⁷ Reinsurance contracts, on the other hand, have to be re-negotiated every year which creates an additional element of risk and additional transactions costs associated with this risk-transfer financial instrument. Taken as a whole these points

²⁵ The cat bond has long antecedents (Jaffee and Russell, 1997: 207) in that this financial instrument closely resembles the maritime insurance contract that was called bottomry in London in the seventeenth century – a contractual form that goes back to the Greeks and Phoenicians.

²⁶ Goes and Skees (2003: 13).

²⁷ See for example Dubinsky and Laster (2004).

imply that cat bonds, since they make use of the capital market whereas reinsurance does not, have a far greater capacity to transfer covariant risk through time.

Within the context of developing countries being faced with covariant risk an important property that cat bonds possess is that they do not expose issuers of these bonds to credit risk, whereas re/insurance does. To begin to explain, the funds raised by issuing cat bonds have to be deposited in an account managed by a separate entity called a special purpose vehicle. This entity in turn invests the funds under its control in risk free securities with the returns on these investments, along with additional periodic interest payments made by the issuer of the bonds, being paid to the investors in these bonds. The funds in this account can only be drawn upon when indemnities have to be paid. These administrative arrangements imply, therefore, that there is no credit risk attached to cat bonds. In addition payment of the indemnity begins immediately after the occurrence of a contingent event. This is so since coupon payments cease immediately once the contingent event occurs while the principle is drawn down, if required, if the parametric index falls (rises) by a large enough amount.

In contrast in the instance of reinsurance it is possible that a reinsurer becomes insolvent and, therefore, is unable to meet all, if any of its contractual obligations should an insured contingent event occur. (This possibility arises since the limits on how much risk a reinsurer is capable of insuring are low compared to the size of the costs caused by this event (Jaffee and Russell,1997: 217).) This

implies that the insured are exposed to credit risk - or at best there is an extended delay in the payment of indemnity.

This difference in the speed with which indemnity payments are likely to be made after a contingent event takes on special significance in a poor community in a developing country attempting to cope with the consequences of a natural disaster. Any extended delay in the payment of indemnities in such circumstances almost certainly will impose considerable costs on these communities. For instance this delay will tend to force poor households, which are near to the margin of existence to dispose of, or not invest in valuable assets in order to survive the disaster – such as the sale of farm equipment and land and curtailing investments in the education of children. The need to employ such survival strategies, as emphasized in Martina (1998b: 307 – 311), will make it more difficult for this community to recover from a severe economic shock. What is more any delay in the payment of indemnities may well result in lives being lost. An implication of these observations is that members of these poor communities are likely to be highly risk averse and, consequently, will tend to prefer cat bonds, which do not expose them to credit risk, to re/insurance, which does.

This line of argument is emphasized since (as mentioned sub-Section 1.1) an argument to be found in the theory of finance literature is that cat bonds cannot offer a better level of insurance against covariant risk than that provided by a well-designed reinsurance contract (Lakdawalla and Zanjami, 2006: 1). This may be so in developed countries where those insured can cope with credit risk or the delayed payment of indemnities. But even in these circumstances, theoretical models can be

constructed that suggest that, because of the presence of credit risk cat bonds may be preferred to re/insurance (Lakdawalla and Zanjami, 2006) and Brandts and Laux (2007: 19). The supposed superiority of re/insurance is even more questionable within the context of a developing country faced with a disaster. As indicated in the previous paragraph, members of a poor less developed country are likely to view credit risk as the fatal flaw in re/insurance and, hence, have good reason to employ cat bonds instead of reinsurance to insure against covariant risk.

Finally, these various observations apply *a fortiori* in the instance of the comparison of cat bonds with *ex post* disaster assistance provided by the government of a developing country and/or the governments of developed countries. In the instance of disaster assistance there is no absolute certainty that it will be provided in a timely manner, if at all. In short implicit credit risk applies to *ex post* disaster assistance. This potential delay or absence of disaster assistance only adds to the burden inflicted by the natural disaster on the inhabitants of the developing country concerned.²⁸

4. Gains from diversification

It was pointed out in the introduction that re/insurers gain by diversifying their portfolio of insurance contracts. This matter is examined further here by concentrating attention on the potential for diversifying risk by investing in cat bonds. The argument developed here is essentially concerned with considering a major factor that is likely to positively influence the decision of risk-averse investors to

²⁸ This matter is also touched upon in Hess *et al.* (2005: 32 – 33) and the references cited there.

invest in cat bonds issued by developing countries with a rate of return little more than that for risk-free securities.

The point of departure begins by noting that Swiss Re (2004: 6) provided an illustration of how insurers in developed countries experience a lower variance of income streams by transferring covariant risk to reinsurers. Investors in cat bonds issued by developing countries are likely to gain even more, however (by experiencing a lowered level of variance of the overall income stream from diversification). This is due to the fact that these investors have scope to invest in a wider range of international securities, than have insurers in reinsurance, whose returns are poorly correlated with those for cat bonds.²⁹

In order to provide an illustration of this point, the following simulations are used to demonstrate the impact on an investor's portfolio following the purchase of a cat bond for a developing county instead of an Australian bond.³⁰ It is assumed initially that the investor invests in international bonds, Australian bills (cash) and then, alternatively, in Australian bonds or cat bonds for a developing country. The following assumptions are used for the returns, standard deviation and correlations between these investments. All the returns are assumed to follow normal distributions.³¹

Table 3.1: Assumptions for investment simulation

Investment	Mean	Standard deviation
------------	------	--------------------

²⁹ See Dubinsky and Laster (2004: 17 – 18).

³⁰ Naturally bonds for any mature financial market could be employed in the exercise discussed in the main text.

³¹ The initial data cited in the main text is derived from data extracted from Towers Perrin Asset returns database for years 1988-2004.

Australian bonds	6.00%	6.00%
International bonds	6.00%	5.50%
Bills (cash)	5.00%	1.50%

Table 3.2: Correlation matrix for investment simulation

	Australian bonds	International bonds	Bills (cash)
Australian bonds	1	0.9	0.5
International bonds	0.9	1	0.5
Bills (cash)	0.5	0.5	1

For the purposes of comparison it will be assumed that the cat bond issued by a developing country has the same mean return and standard deviation (for these returns) as that for an Australian bond.

The first set of Monte Carlo simulations demonstrates the effects on returns and variance (of these returns) for an investment portfolio where an Australian bond is replaced by a cat bond issued by a developing whose returns has a zero correlation with those for the other assets in the portfolio.³² The simulation carried out produced a set of 10 simulations consisting of 500 iterations, thereby requiring 5000 calculations.

Table 3.3: Results of an investment portfolio without, and with a cat bond with zero correlation

Without cat bonds		With cat bonds	
Mean	Variance	Mean	Variance

³² The assumption just made in the main text seems to be reasonable since there should be little or no correlation between, for instance, a flood in Bangladesh and the returns on international bonds.

Average	31.701	0.00430	31.701	0.00226
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These simulation results indicate that the investment in the cat bond has nearly halved the variance (or risk) of the return for the entire portfolio whilst maintaining the same return for this portfolio. Clearly this illustration indicates the considerable potential gains to be made by a risk-averse investor by increasing the level of diversification in his/her portfolio by investing in cat bonds.

This exercise is repeated, only now probably a more conservative assumption is applied; viz. there is a correlation of 22.5 per cent between the returns on cat bonds issued by the developing country and those for other assets in the portfolio. (This assumption is in the mid-range of the correlation coefficients estimated, based on actual data, by Dubinsky and Laster (2004: 16) for cat bonds for developed (not developing) countries and equity markets in these countries.) Once again the simulations demonstrate the effects on the average return and the variance in this return for the investment portfolio that replaces an Australian bond with a cat bond. Even in this case diversification benefits the risk-averse investor who invests in cat bonds instead of Australian bonds.

Table 3.4: Results of an investment portfolio with, and without a cat bond with 22.5% correlation

	Without cat bonds		With cat bonds	
	Mean	Variance	Mean	Variance
Average	31.700	0.00435	31.700	0.00290

These various results suggest that a risk-averse investor stands to gain from investing a comparatively small amount in cat bonds by reducing – and possibly by a substantial amount - the level of risk attached to this investor's portfolio of investments and still earn a competitive rate of return in this portfolio. However, the unknown value (uncertainty) regarding the likelihood of the contingent event occurring means that the rate of return for these bonds will need to be greater than that for risk-free securities in order to encourage investment in these bonds. (Jaffee and Russell (2003: 43 - 44) and the references cited there provide a more detailed discussion of this matter.) Nevertheless, knowledge of the potential gain to be derived from investing in these securities should encourage the expansion in the level of investment, by risk-averse investors, in cat bonds issued by developing countries.

5. Beginning to determine the relative efficiency of alternative covariant-risk-transfer financial instruments

Drawing on the argument Section 2, initially suppose that a conglomerate of intermediate financial institutions (COIFI) is attempting to insure against floods for the entire area of India. The reason for considering this country is because, of all developing countries, India has the longest continuous time series measuring the costs of natural disasters. India also is the second most disaster-prone country in the world (Bals *et al.*, 2006, and Kelkar *et al.*, 2007). What is more this situation is likely to deteriorate in the future since the United Nations Framework Convention on Climate Change forecasts that later in the 21st Century the changing climate of India will result in yet more extreme climatic events. (See Kelkar *et al.* (2007: 659) for more details.) Given this context the question for which the COIFI needs to find

answer is: what covariant-risk-transfer financial instrument would be the most effective at reducing the level of covariant risk caused by floods for a given amount of funds invested in acquiring this instrument? In answering this question here we abstract from the issue of credit risk.

It may be argued that concentrating attention on India is questionable. The reason is that since this country covers a comparatively large geographic area, the COIFI could reduce a good deal of the localized covariant risks that it insures by insuring flood damage across the whole country. The law of large numbers would then tend to apply in this instance. It is assumed here, however, that the COIFI could still benefit from spreading some of its covariant risk into international risk markets. Indeed this is what appears to be the case as is indicated by the empirical evidence presented in the next section.

5.1 The data

The Indian disaster data for various classes of disasters is compiled by the Office of the United States Foreign Disaster Assistance (OFDA) and the Centre for Research on the Epidemiology of Disasters (CRED) and is to be found in the Emergency Disasters Data-Base (Em-DAT).³³ The deterministic model developed here utilise the historic economic loss data from floods occurring in India for the period 1962 - 2006. The economic loss data in Em-DAT refers to the damage level at the time of the event. It includes direct (e.g. damage to housing) and indirect damage (market destabilisation, unemployment).³⁴ The combined amount of losses is employed here. To ensure that the model is easy to understand, the economic

³³ See OFDA/CRED

³⁴ The Em-DAT glossary is available at <http://www.em-dat.net/glossary.htm>.

loss data provided by the data in Em-DAT prior to 2006 is adjusted, using the consumer price (CPI) index, so that all this data is set at United States (U.S.) 2006 prices. In order to simplify the calculations the US dollar/Indian rupee exchange rate is assumed to be constant. (Allowing for variations in this exchange rate would not influence the thrust of the argument being developed here.)

Economic and demographic data is obtained from the World Bank's World Development Indicators (WDI) database (World Bank, 2008). The data collected includes the Indian population, percentage of the population living on less than (U.S.)\$2 a day, inflation rates, gross domestic product (GDP) and real interest rates.

5.2 Assumptions

The point of departure is that it is assumed that the COIFI provides affordable microinsurance. As indicated in Section 2 this insurance may be provided in various implicit forms. It remains for the COIFI to determine how best to spread the covariance risk it faces into international risk markets.

The following additional assumptions are applied throughout the model. The spread between lending and borrowing rates is assumed to be 1 percentage point.³⁵ The lending rate or risk free rate is based on an historic average of the real interest rate.

Table 5.1: Economic assumptions

Inflation rate	Borrowing rate	Lending rate
0%	8.06%	7.06%

³⁵ The net value of the insurance provided at the end of the period is sensitive to the spread when the net value falls below zero.

The COIFI is assumed to offer flood insurance to individuals living on less than (U.S.)\$2 a day. From this population it is assumed 1% will purchase this insurance. Sensitivity testing indicates that the shape of the model is not responsive to the proportion of the population that purchase this flood insurance. This is because of the assumption that claim losses are directly proportional to the number of people covered by this COIFI insurance system.

Data is intermittent concerning the percentage of the population living on less than (U.S.)\$2 a day. The average of the four years of data is used throughout the model.

Table 5.2: Proportion of the population of India living on (U.S.)\$2 or less per day

Year	1987	1993	2000	2003	Average
% of the population living on (U.S.)\$2 or less per day	87.29%	85.67%	81.3%	79.9%	83.54%

The insurance program covers all losses suffered by the COIFI system. These losses are based upon a proportion of the total of all natural disaster economic losses. These losses are distributed pro rata throughout those covered by the COIFI. To simplify calculations, losses will be paid at the end of the year.

Figure 5.1 below illustrates the time series of disaster losses, at current prices, suffered by those insured by the COIFI. These losses are equivalent to the claims made over time. Figure 5.2 illustrates these losses when valued at 2006 (U.S.)\$ prices.

It is assumed that an insurance premium is charged by the COIFI for those covered by catastrophe insurance based on affordability rather than the actuarial risk

premium.³⁶ The premium is assumed to be (U.S.)\$1.07 p.a. to reflect a ratio of premiums to claims at 0.0229. This lies within the range of premiums to claims for the life microinsurance industry (0.005 - 0.03) and, therefore, indicates that the suggested premium is affordable. It is not possible, however, to check the validity of

Figure 5.1: Disaster losses suffered by those insured by the COIFI

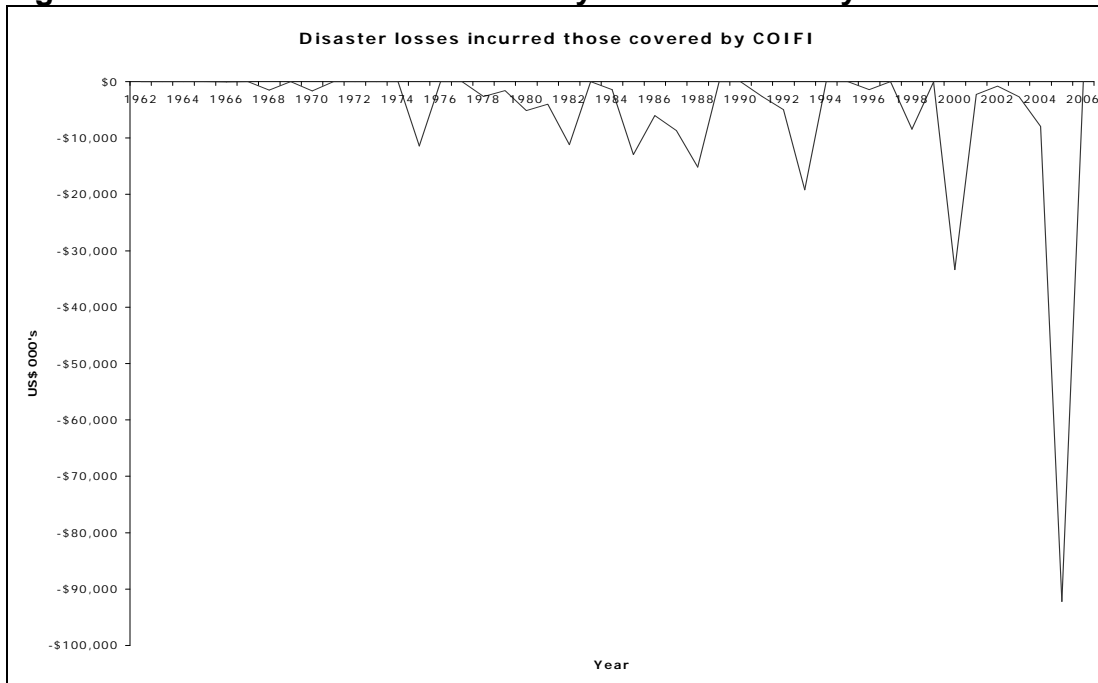
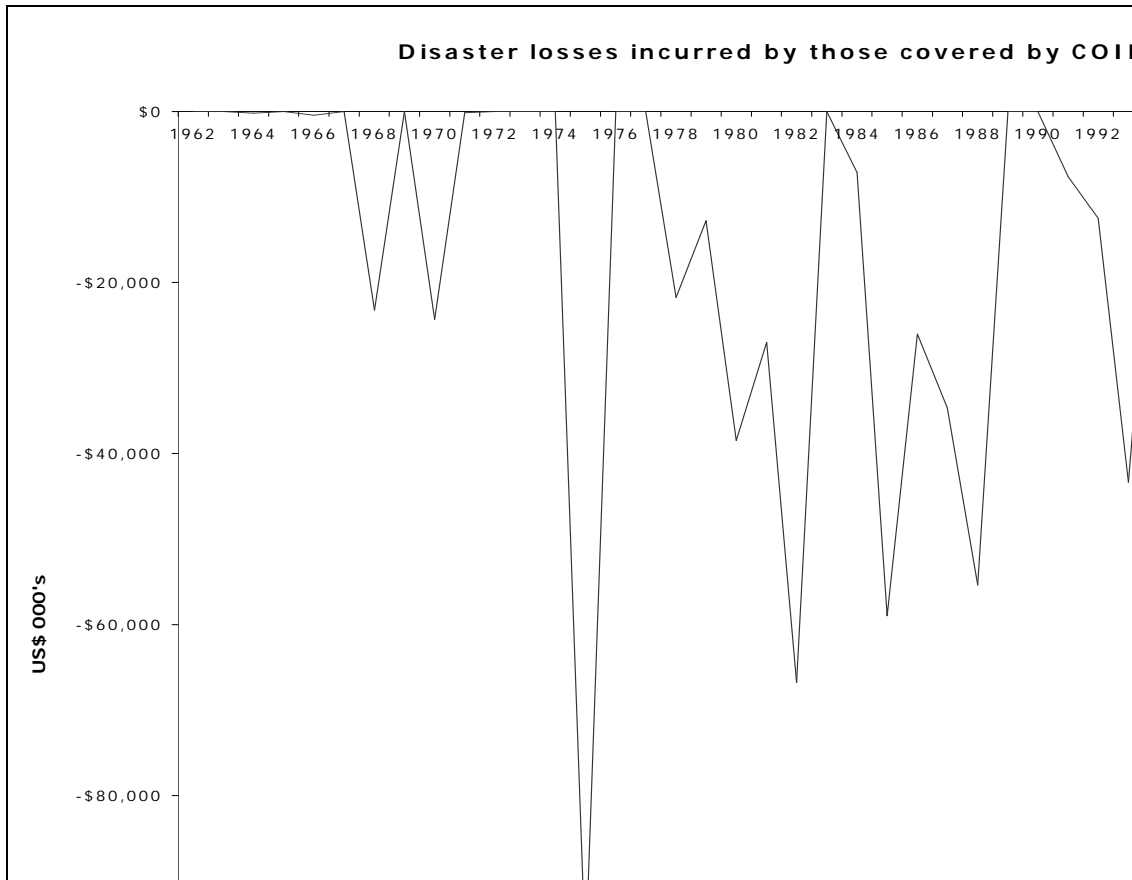


Figure 5.2: Disaster losses suffered by those insured by the MI (in 2006 (U.S.)\$)

³⁶ The premium charged by a government for covariant-risk insurance may take the implicit form of imposing a special general tax. In the instance of a conglomerate consisting, say, of microfinance institutions the premium charged may take the implicit form of being incorporated into bank charges.



this assumption since the market for disaster microinsurance does not exist. That said the assumption made here seems to be reasonable.

Finally the assumption is imposed that the transaction costs incurred by the COIFI in managing the microinsurance system make up 50 per cent of the premium revenue. This assumption may be on the high side since one of the reasons for the formation of the COIFI is the reduction of the transaction costs associated with providing covariant insurance. That said the net value of the COIFI system is highly sensitive to the level of transaction costs. This fact implies that further research is necessary in order to achieve a more accurate estimate of these transaction costs.

These various assumptions are summarized in the following table.

Table 5.3: Flood microinsurance assumptions

Average population living on < US\$2 a day	Insurance penetration	Premium	Costs as a percentage of premium revenue
83.54%	1%	(U.S.)\$ 1.07	50%

5.3 The model

The objective of the model is to compare various risk management techniques based upon six variations of the standard insurance model. The variations depend upon two sets of options:

1. Insurance option: use of reinsurance, or cat bonds, or *ex post* disaster assistance, or no international risk-transfer instrument;
2. Subsidy option: use of direct subsidies, or indirect subsidies, or no subsidies. (The distinction between direct and indirect subsidies is defined in the next section.)

The arguments supporting the social need to provide these subsidies were considered earlier in Section 2. Here it is assumed that the present value of the subsidies provided is held constant for both direct and indirect subsidies. Also, the present value cost of reinsurance for the COIFI is assumed to be (U.S.)\$3.48 million and the present value cost of the cat bond is assumed to be slightly less at (U.S.)\$3.28 million. Despite this lower cost for cat bonds as will be indicated later cat bonds provide a great level of cover (than does reinsurance) against covariant risk.

The methodology used to determine the net value of the COIFI insurance system provided over time is a series of present value calculations. The present value is calculated as that at the end of 2006. This implies that all values are comparable once their present values have been calculated to this date.

At the end of each year the accumulated net value of the COIFI insurance provided is calculated by employing the following equation:

$$NV_t = NV_{t-1} \times I \times (1 + l) + ((1 - I) \times NV_{t-1} + P_t + SS_t - RE_t - TC_t) \times (1 + r)^{1/2} - CB_t - IC_t + SE_t + COIFIR_t + COIFIC_t \times (1 + r)^{1/2}.$$

In this equation the following definitions apply:

NV_t = Accumulated Net Value at time t ;

I is an indicator variable, $I = \{0,1\}$ where $I = 0$ when NV_{t-1} is positive and $I = 1$ otherwise;

l is the lending rate, that is the rate at which money is lent to the COIFI;

r is the risk free rate or borrowing rate, that is the return the COIFI receives when it invests its money;

P_t is the premium revenue that the COIFI receive in calendar year t ;

RE_t is the reinsurance expense or premium that the COIFI must pay in calendar year t to receive reinsurance;

TC_t are the transaction costs the COIFI incurs by running its business (e.g. administration costs, claims costs, staff);

CB_t is the coupon on the cat bond that the COIFI must pay as the beneficiary of the cat bond;

IC_t are the individual claims the COIFI must indemnify when a flood damages an insured area;

SS_t is the total subsidies given to the COIFI at the start of the period;

SE_t is the total subsidies given to the COIFI at the end of the period;

$COIFIR_t$ is the indemnity returned to the COIFI from reinsurance; and $COIFIC_t$ is the indemnity returned to the COIFI from cat bonds in the event of a flood.

A detailed explanation of equation (1) is provided in the Appendix A. Here a few additional remarks are provided. First the adjustments of interest rates reflect the fact that certain transactions take place at the beginning of the period – the transactions being premiums paid, reinsurance expense, transactions costs and some subsidy transactions. The unadjusted amounts are subsidies at the end of the period. Indemnities paid to the COIFI from reinsurers or investors in cat bonds also occur at the end of the year. Coupon payments are not made in the twelve months immediately following the date when a contingent event occurred. However, coupon payments resume immediately thereafter. The net value amount at the end of each year is the accumulated amount and thus it is the balance from the previous year that needs to be brought forward. The interest adjustment on this amount depends on whether the balance is positive or negative.

As noted earlier at the end of the introduction Cardenas *et al.* (2007) applied a stochastic model to analyse a similar problem as is being considered here. In Appendix B the approach taken by Cardenas *et al.* is compared with the deterministic model that has just been sketched out.

6. Empirical results

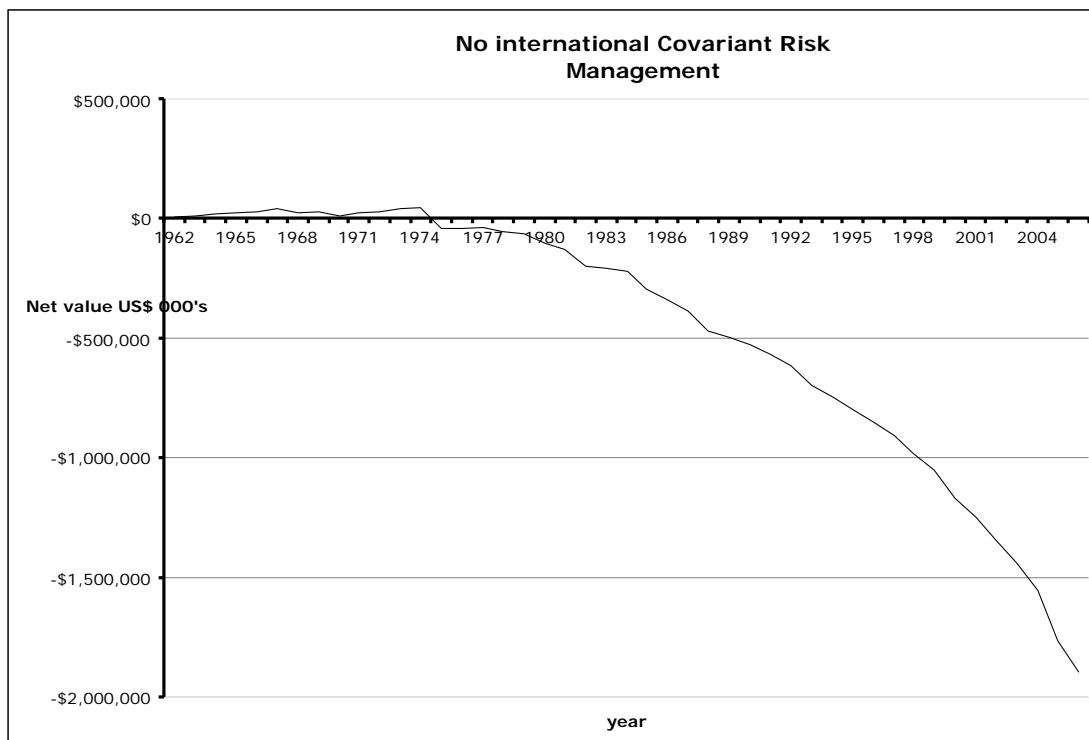
6.1 The benchmark case

The benchmark case is where there is no disaster foreign assistance and no international covariant-risk-transfer financial instruments available. At the end of

2006, the insurance provided by the COIFI has a net value of (U.S.)\$ -1.9 billion. This instance is illustrated in the following figure.

In this situation, the insurance system provided by the COIFI is not sustainable. Certainly the operations of this financial system need to be subsidised and integrated into the international risk market in order to be able to exist. This case illustrates the relevant argument presented in Section 2.

Figure 6.1: The benchmark model (no international covariant risk management)



6.2 Introduction of subsidies

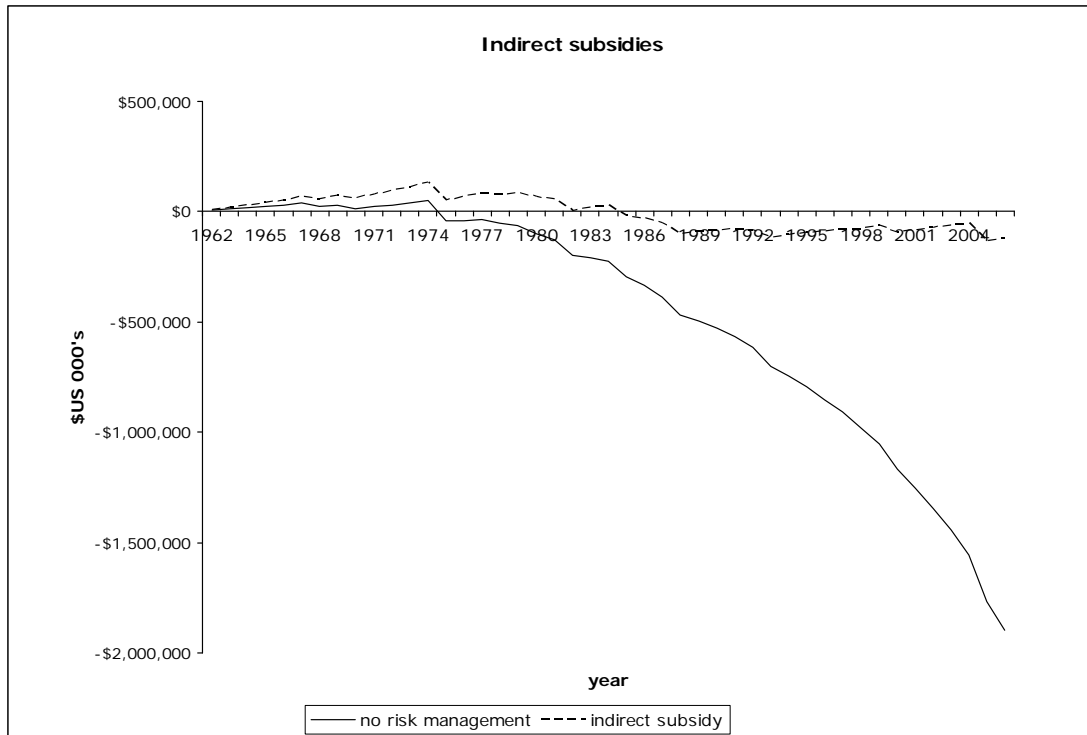
6.2.1 Variation 1: Subsidies to finance insurance provided by the COIFI

Subsidies in the model are assumed to be attained by the COIFI from the international community and/or the Indian government. Subsidies are available in two forms. The first is an indirect subsidy in the sense that it is not tied to any international covariant-risk-transfer financial instrument. It is paid at the beginning of the year and is calculated as a proportion of premium revenue charged for the insurance provided by the COIFI. The second type of subsidy is a direct subsidy that is directly tied to the payment of cat bond coupons or reinsurance premiums and thus is calculated as a percentage of this amount. As will be demonstrated later, this distinction between these two types of subsidies becomes particularly important in the case of cat bonds. The size of the subsidy is kept constant at an average of (U.S. 2006)\$ 31.7 million each year. This amount does not seem to be too large given the size of the amount of foreign emergency aid that is likely to have been given to India to cover flood damage experienced by poor households. This last point is explained in a footnote.³⁷

³⁷ There is no data available concerning the amount of emergency aid given to India over the period 1962 - 2004. Consequently we make a number of reasonable guesses to gain an idea of how much, approximately, disaster assistance is likely to have been given to India in this period. First we take the actual amount of emergency aid given by the Development Co-operative Directorate countries in 2004. This amount is then multiplied by 0.88 per cent to determine the value of the amount of disaster assistance given to India in 2004. (The percentage 0.88 is based on the fact that of all foreign aid provided in 2004, it was this percentage that was allocated to India.) The calculated amount is then adjusted into 2006 U.S. dollars to give the amount of (U.S. 2006)\$ 73.02 million per year. Finally, the resulting amount needs to be adjusted down, say by fifty percent, since we are only concerned with the assistance given solely for the purpose of covering the flood damage experienced by poor households in India. Based on these assumptions the level of the subsidy given to India for flood relief that is assumed in the main text does not seem to be too large. The data regarding all foreign aid provide by the Development Co-operative Directorate countries are to be found at www.oecd.org/dac. (The members of the Development Co-operative Directorate are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States.)

Finally, those receiving these subsidies possibly now have the incentive to make less of an effort to reduce the level of damage caused by a potential natural disaster. For simplicity it is assumed here, however, that this moral hazard behaviour is of the same level with respect to both direct and indirect subsidies, and with respect to cat bonds and re/insurance. In reality, and bearing in mind the earlier discussion in sub-Section 2.1, this behaviour is likely to be less of a problem with respect to direct subsidies that are used to finance the purchase of index-based re/insurance and cat bonds. In the instance of indirect subsidies, however, their provision to finance disaster assistance would tend to induce moral hazard behaviour if the insurance provided by the COIFI is not index based. Be that as it may, in the instance of both types of subsidies it would be prudent to allocate part of the relevant subsidy to financing the reduction of risks that can be avoided at reasonable cost. If this avoidance action is not taken then possibly this subsidy should be withheld. Alternatively, as indicated in sub-Section 2.1, the trigger for the index employed could be set in such a way so as to create the incentive for those insured to take appropriate risk-reducing action. This matter is not considered further here.

Figure 6.2: The effect of indirect subsidies



In this variation, where the COIFI does not have access to international covariant-risk-transfer financial instruments but does have access to indirect subsidies, the results are represented in Figure 6.2. These results possibly overstate the benefits derived from these subsidies due to, as noted in the previous paragraph, the possible presence of moral hazard behaviour.

At the end of 2006 the value of the subsidised (non-covariant-risk) insurance provided by the COIFI reached a net value amount of almost (U.S.)\$ -125 million. This situation is unsustainable. Hence it needs to draw on the international risk market and acquire a suitable covariant-risk-transfer financial instrument.

6.2.1 Variation 2: Subsidies to finance *ex post* lump-sum disaster assistance

Alternatively the indirect subsidy could be used to finance *ex post* disaster assistance that takes the form of a lump-sum transfer after a flood. The relevant calculations reported in Table 6.1 clearly demonstrate, however, that this *ex post* assistance is inefficient compared to the situation where an equivalent amount of indirect subsidy is used to finance a reduction in the size of the premium charged by the COIFI for the insurance it provides.³⁸

Table 6.1: Comparison of financing instruments with equal expenditure

Type of financing	Total amount expended by financier (US\$ 000's)	Net value of insurance at 2006 (US\$ 000's)
Lump sum aid	\$104,752	\$ -1,097,929
Subsidized premiums	\$104,752	\$ -1,010,401

The calculations reported in the table above do not take account of a number of additional considerations that would tend to increase the relative level of inefficiency of lump-sum transfers. For instance, these transfers expose the community to the (implicit credit) risk that the payment of the *ex post* disaster assistance may be delayed. In contrast the social benefit derived from subsidising insurance premiums is much more certain even if the payment of this subsidy is delayed. (This is assuming that a natural disaster does not occur before any delayed payment of this subsidy.) In addition, this subsidy is tightly targeted at the socially desirable end of subsidising insurance premiums in order to encourage the purchase of the insurance provided by the COIFI. In contrast, there is no certainty

³⁸ The calculations in Table 6.1 are based upon the assumptions that the payments of lump-sum disaster aid are given when the aggregate annual disaster losses reach more than US\$ 30 million. When this trigger is reached the international aid community finances 28.5% of the aggregate annual loss. This equates to a total of US\$ 104,752 million.

that the *ex post* lump-sum payments will actually reach those who most require assistance in coping with a natural disaster.

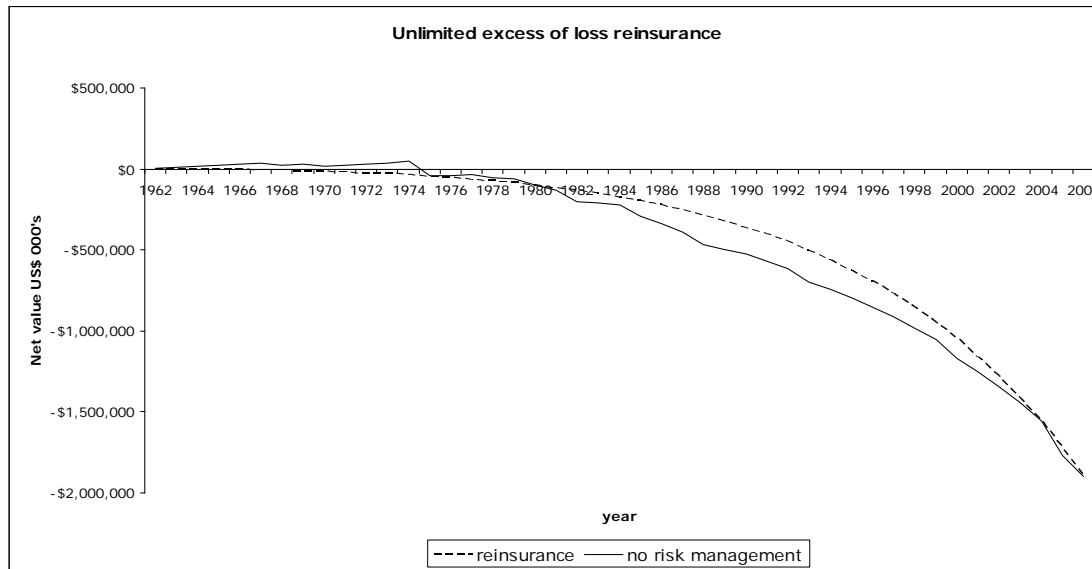
6.3 Variation 3: Incorporating reinsurance

The focus here is the incorporation of unlimited excess of loss reinsurance. Initial attempts to price reinsurance utilising a formula devised by Dubinsky and Laster (2004) proved futile because of the prohibitive cost of reinsurance. Instead the present value pricing of premiums is employed to determine a premium affordable to the COIFI and profitable for the reinsurer.

Reinsurance premiums increase by 5 per cent each year to reflect the increasing cost of disaster losses. Further, to mirror the cyclical pattern of reinsurance premiums, premiums increase by a further 5 per cent per annum following a year in which a natural disaster occurred. The reinsurance premium is determined by equating the net value of the insurance provided by the COIFI without international risk management to the net value of this insurance with reinsurance at the end of 2006. This ensures that the COIFI is no worse off than if they had not bought index-based reinsurance.

Using the present value premium pricing, the reinsurer receives a profit of (U.S.)\$ 45.3 million. This is a slim profit for the reinsurance provided as it is calculated without taking into account transaction and capital costs. Furthermore, this profit is the result of the entire reinsurance contract spanning 45 years. It is debateable whether the reinsurer would be willing to offer such favourable conditions. Nevertheless, the results of this variation in the model are displayed in Figure 6.3.

Figure 6.3: The effect of reinsurance



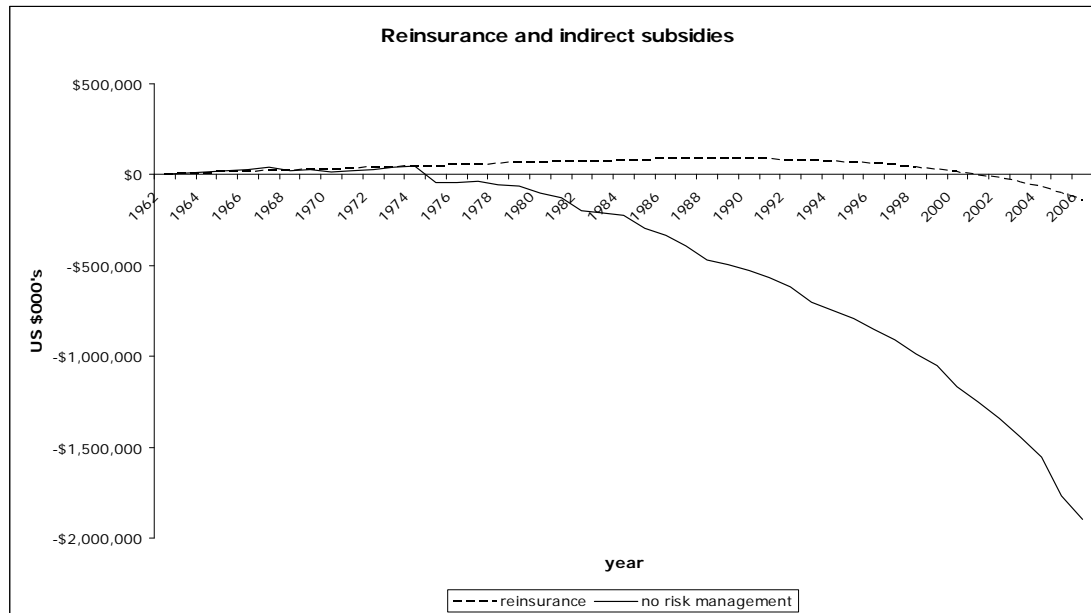
The methodology utilised to determine the reinsurance premium cost results in the insurance provided by the COIFI having the same net value at the end of the period regardless of whether or not the reinsurance is purchased. The real improvement, however, reflected in the net value curve is in the inter-temporal smoothing achieved by the purchase of reinsurance. Nonetheless as the case depicted in Figure 6.3 makes clear, the COIFI needs to be provided with a suitable level of subsidy in order to be solvent.

6.4 Variation 4: Reinsurance with the incorporation of indirect subsidies

The incorporation of reinsurance and indirect subsidies greatly improves the net value curve of the COIFI. As represented in Figure 6. 4, for the most part the value curve remains positive slipping into negative territory from 2001 on up to 2006. Furthermore, the present value curve is smooth, indicating that reinsurance has

allowed inter-temporal smoothing. Finally, in order to mitigate any moral hazard behaviour it is assumed that a suitable parametric index is applied to this insurance.

Figure 6.4: The effect of reinsurance and indirect subsidies



6.5 Variation 5: Reinsurance with the incorporation of direct subsidies

In contrast, the empirical calculations indicate that direct subsidies along with reinsurance bring slightly fewer benefits to the COIFI than indirect subsidies. Specifically the relevant calculations indicate that in the instance of direct subsidies the net value of the COIFI is (U.S.)\$ -140 million at the end of 2006, whereas the use of indirect subsidies results in this value being (U.S.)\$ -139 million. (Naturally the size of the subsidy is the same for both.) The reason why the indirect subsidy is

to be preferred is that in this instance the funds provided to the COIFI arrive at the beginning of each period and, therefore earlier than is the case with direct subsidies. This allows the COIFI to gain from the interest earned on the earlier payment of the indirect subsidy.

6.6 Variation 6: Cat bond with the incorporation of indirect subsidies

In order to assess the utility of a cat bond, a hypothetical cat bond is considered. It is assumed that this cat bond has a principle of (U.S.)\$150 million (or face value) and an indemnity trigger of (U.S.)\$ 35 million and has a term of 45 years (viz. the entire period of the model).³⁹ This means that in a year when the natural disaster losses exceed (U.S.)\$ 35 million the cat bond will be triggered and the COIFI will not have to pay a coupon to the investor. (This assumption is made in order to ease the calculations. In reality, and for the reasons indicated in sub-Section 2.1, this trigger will need to be linked directly to an agreed relevant parametric index - such as the level of a flood. Implicitly it is being assumed here that the index trigger applies as if the disaster losses exceed (U.S.)\$ 35 million.)

The COIFI will receive the amount by which the annual loss exceeds (U.S.)\$ 35 million as long as there is still some of the principal remaining. Once the principal is exhausted the investor will no longer be liable for any disaster losses although, as mentioned earlier, the investor will not receive a coupon in the twelve months following the natural disaster. Nonetheless, the exhaustion of the principal does not

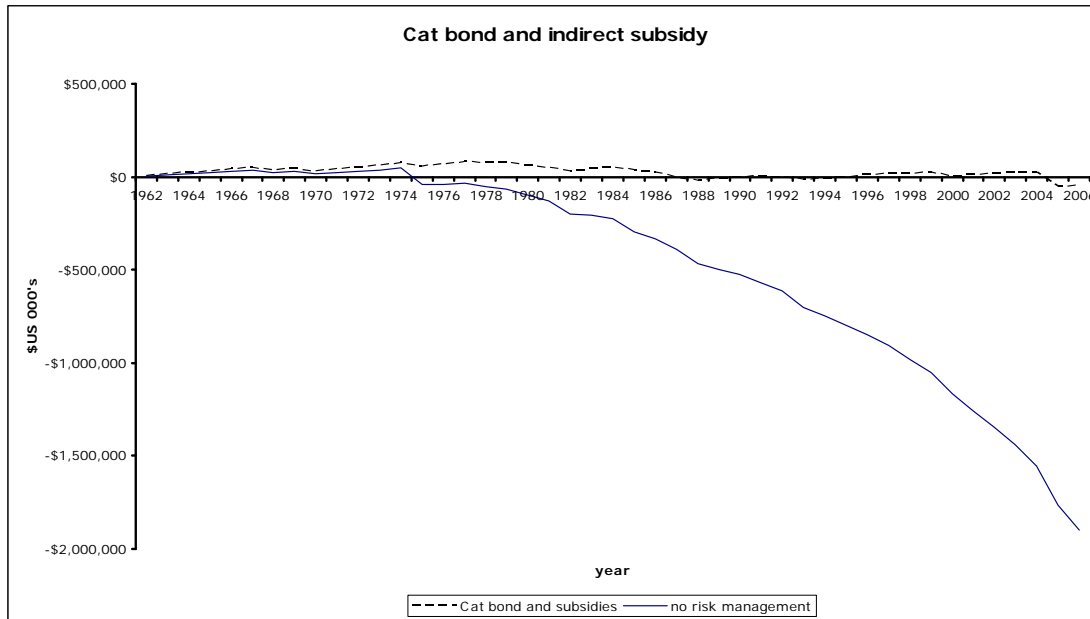
³⁹ A term of 45 years is unrealistic as most cat bonds last a maximum of 10 years. However, a cat bond of this length creates a more conservative model. This is so due to the possibility that the principal will be exhausted before the end of the period. Had the COIFI issued a new cat bond after 20 years, for example, it would have been able to increase its coverage over the period by increasing the pool of funds available to cover the loss of the principal.

negate the COIFI's obligation to pay coupons in the years in which a natural disaster does not occur. Rather the COIFI will still be required to pay coupons in these years for the full term of the bond.

In order to price the cat bond fairly, the investor's profit, or return in excess of the risk free rate of return is required to match the profit received by the reinsurer (in the reinsurance case). The return for the investor is 8.43 per cent p.a. and thus the coupon amount each year will be 8.43 per cent of the principal ((U.S.)\$150 million) – which is (U.S.)\$12.65 million. The amount of the coupon to be paid does not change as the amount of the remaining principal changes.

As with reinsurance, the indirect subsidy is available to the COIFI at the beginning of the year and is calculated as a percentage of the premium revenue. The impact of issuing cat bonds and the indirect subsidy can be seen in Figure 6.5 below. This representation indicates that the COIFI is still not financially viable as its net value curve slips below zero intermittently and does not recover by the end of 2006. The fact that the net value curve is not as smooth as that for the reinsurance case implies that the cat bond is limited to covering only larger losses. Hence the COIFI still carries the risk of smaller natural disaster losses.

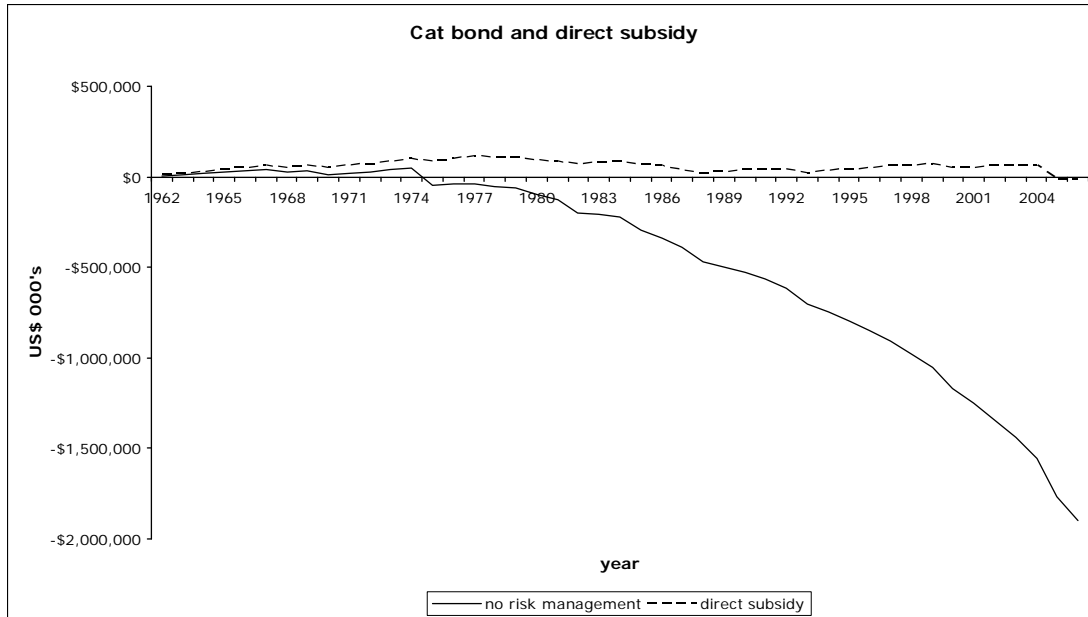
Figure 6.5: The effect of a cat bond and an indirect subsidy



6.7 Variation 7: Cat bond with the incorporation of direct subsidies

This variation offers the most promising possibility for the financial viability of the COIFI. At the end of 2006 the COIFI has a net value of (U.S.)\$ -16.5 million. In addition the net value curve indicates that the net value of the COIFI is greater than zero for every year except in the last year. Nevertheless, as pointed out in the previous case cat bonds do not smooth out inter-temporal fluctuations as well as reinsurance.

Figure 6.6: The effect of a cat bond and a direct subsidy



This added variability of the net value curve, however, should not be a matter of concern for the COIFI. In fact the opposite is more likely the case. The reason is that the added variability of the net value curve that results from the use of cat bonds (instead of reinsurance) reflects the fact that, as part of the indemnity, during the twelve months immediately after a natural disaster occurs the COIFI does not have to pay coupons and may also receive part of the principal (if the principal has not been exhausted). Thus the increased upward variability of the net value curve actually reflects a double benefit that results from the use of a cat bond by the COIFI instead of reinsurance. If the COIFI is only concerned with downward variability (or downside risk) this upward variability is of no concern.

The representation in Figure 6.6 therefore indicates the clear advantage, over other methods of mitigating a given amount of covariant risk that results from using a direct subsidy to assist with the payment of coupon payments for the cat bonds

issued by the COIFI.⁴⁰ The reason why this outcome is to be preferred to the indirect subsidy case (along with cat bonds) is that when the cat bond is triggered the donor of the direct subsidy does not have to subsidise the COIFI since the coupon payments do not need to be paid. (In the indirect subsidy case the subsidy still has to be paid to the COIFI in order to subsidize the insurance it provides.) If required, payments also are made by the bond holders out of the principle to compensate the issuers of the bonds for the damage inflicted by the contingent event. The coupon payments resume, however, exactly one year after the date of the contingent event. This sequence of various payments means that this allows the donor to provide a greater level of subsidies when coupon payments do need to be paid. This fact assists the COIFI in reducing the level of its own expenses.

Finally, it is useful to compare the cases represented in Figure 6.6, Figure 6.2 and Table 6.1 respectively. The comparison of these two figures indicates that a direct subsidy used to finance the payment of coupons for the cat bonds issued by the COIFI provides a greater level of indemnity than that provided by an indirect subsidy used to assist the COIFI reduce the level of the premium it charges for insurance. This latter case in turn provides a greater level of indemnity, as the results reported in Table 6.2 indicate, than that provided by using the indirect subsidy to finance *ex post* disaster assistance in the form of lump-sum transfers. It follows from these comparisons that the provision of a given amount of funds to subsidise the payment of coupons for the cat bonds issued by the COIFI will provide

⁴⁰ Remember that in the comparisons made in the main text the respective sizes of the level of profits and the level of subsidies have been kept the same for each risk-transfer financial instrument. Also, as noted in sub-Section 5.3 in the main text the cost to the COIFI of acquiring cat bonds is slightly less than that for acquiring reinsurance.

a greater level of indemnity than if these funds were used instead to finance *ex post* lump-sum disaster assistance.

7. Conclusions

It was indicated in Section 2, within the context of a representative developing country where the financial infrastructure is of limited size and quality, that the use of any covariant-risk-transfer financial instrument should only be seen as part of a system that attempts to transfer assistance to those most in need during (viz. drought) and/or immediately after (viz. flood) a natural disaster. Within this general context we have made a number of suggestions, which we have attempted to justify, as to what appears to be the most effective institutional framework (discussed in Section 2) and the preferred covariant-risk-transfer financial instrument (discussed in Section 3 through to Section 6) to employ in the attempt to mitigate the pressing problem of underinsured covariant risk in developing countries. The suggestions are that, beside national governments, conglomerates of intermediary financial institutions should be formed that, in turn, insure against covariant risk by issuing cat bonds (instead of acquiring re/insurance) on the international financial market. Arguments are also presented (in Section 4) that suggest why there should be a significant level of demand by investors – that are seeking effective ways to diversify their portfolio of risky assets - for this risk-transferring financial instrument.

As for the reasons why cat bonds are the preferred risk-transfer financial instrument, one is that the institutional arrangements regarding the management of cat bonds discussed in Section 3 ensure that this financial instrument does not suffer from credit risk or any risk of there being delays in the payment of indemnity.

Re/insurance is exposed to both of these risks. This difference is important within the context of a developing country that has just experienced a natural disaster and, consequently the immediate payment of the indemnity is particularly pressing for poor households that probably are highly risk-averse. The actuarial inter-temporal deterministic valuation model applied in Section 6 also indicates that cat bonds have more desirable properties than reinsurance for managing the risks (other than just credit risk) associated with natural disasters. Given certain basic assumptions, while reinsurance provides the greatest inter-temporal smoothing of income streams, cat bonds provide a greater level of certainty as to the likely solvency and hence the viability of this type of risk management. Again this matter is an important consideration as far as the highly risk-averse less well off in developing countries are concerned.

These observations point to the fundamental overall reason why cat bonds are to be preferred to re/insurance. Specifically cat bonds allow the more satisfactory *timing* of relevant payments to cat bond holders and indemnity payments to the issuers of these bonds.

Despite this desirable general property of cat bonds, currently the *private* insuring of developing countries against covariant risk in international risk markets is not a profitable venture. Covariant risk-transfer programs still require the substantial commitment of public financial assistance. Our calculations indicate, however, that the level of foreign aid required to sustain these programs is not unreasonable when compared with the amounts of emergency aid that actually has been provided by developed countries in the recent past. (See the relevant discussion in sub-Section

6.2.) What is more this subsidising of the acquisition of cat bonds is to be preferred to providing undirected emergency assistance that may, but possibly will not arrive in time to minimize the costs imposed by a natural disaster on poor communities. In addition, even if this assistance arrives on time, for a given reasonable amount of *ex post* financial disaster assistance that is provided, a significantly higher level of *ex ante* assistance (viz. a significantly higher level of indemnity) would have been attained if this *ex post* financial disaster assistance has been utilised instead to finance the issuing of cat bonds. (See the discussion at the end of previous section.)

Finally, the use of public funds to subsidise the private international risk-transfer market should result in the generation of new information and skills relating to the provision of risk-transfer financial instruments to developing countries. These learning externalities in turn should result in improving the level of efficiency in this market leading to a decline in the prices charged for cat bonds and re/insurance respectively – other things remaining the same.

Appendix A

This discussion expands on the explanation of equation (1) provided in Section 5. That equation is used to calculate the net present value of the insurance system created by the COIFI is a deterministic actuarial model. The inflows to, and outflows from the COIFI are tracked in that equation while also adjusting these flows to a baseline level at 2006 (U.S.)\$.

Unlike other actuarial models, this model based is not stochastic. In these alternative actuarial models, the model is based on a probability function or a

probability distribution function (pdf). Here, however, the complexity of natural disaster claims modelling is bypassed by the use of historical data since the use of this data implies that the exact values of relevant past events - such as indemnity levels in a given year - are known. This allows the comparison of alternative risk management techniques, which is all that is required here of the model. We do not need to know the value of future claims. A stochastic model would be required for that purpose.

In developing the following formula to calculate the net present value of the COIFI at the end of the year, three considerations need to be established.

1. The inputs to the model, including which cash-flow items are to be included in the net present value.
2. The timing of these inputs (at the beginning of the period, in the middle of the period or at the end of the period)
3. Whether the prior year's net present value is positive or negative.

The explanation of the formula can be broken down in to four sections. The first component represents the accumulation of the previous year's net present value:

$$NV_{t-1} \times I \times (1 + l) + NV_{t-1} \times (1 - I) \times (1 + r).$$

In this component of the formula NV_{t-1} represents the net present value of the insurance system in the previous year. The value of the net present value from the previous year has an impact on the risk discount rate used to accumulate to the end

of the current year. This distinguishing feature is added to maintain a realistic difference between the borrowing and lending rates. It is not used to discount other sections of the model, as the difference is not as material as the impact on the accumulation of the net present value. Because of this feature an indicator variable, I , is used to determine whether the net present value is positive or negative. The indicator variable is set to one when the previous year's net present value is negative and zero when it is positive.

In order to accumulate the net present value of the previous year to the end of the current year, the previous year's net present value is to be multiplied by $(1 + r)$ when positive and $(1 + l)$ when negative.

The second component of the formula represents cash flows that occur at the beginning of the period:

$$(P_t + SS_t - RE_t - TC_t) \times (1 + r).$$

At the beginning of the period, premium income, P_t , from those covered by insurance are received for the following year. Also received as income is the amount SS_t - any subsidies or aid paid at the beginning of the period.

As for the outflows from the insurance system at the beginning of the period, these are the reinsurance expense, RE_t , and the transaction cost incurred by the insurance system, TC_t .

Similar to the previous year's net present value, these cash flows occur at the beginning of the period. Therefore, they must accumulate for a year at the risk free rate, $(1 + r)$.

The third component of equation (1) represents the cash flows that occur in the middle of the period:

$$(\text{COIFIC}_t - \text{IC}_t) \times (1 + r)^{1/2}.$$

The cat bond payments in the event of a natural disaster, COIFIC_t , are paid in the middle of the period. This timing of the payment from the cat bond differs from that for a reinsurance claim. The indemnity for a cat bond, which is based on the index employed, is automatic and immediate once the claim is triggered. In contrast there is a delay in the payment of index-based reinsurance since there is a need to file claims or provide relevant information to establish the magnitude of the claim – although this payment would be facilitated by the fact that the claim would be based on some agreed index. (Naturally, if the reinsurer became insolvent – viz. credit risk applied – then the limited indemnity payments would be much delayed by bankruptcy proceedings.)

Equally the indemnity for natural disaster relief, IC_t , to those covered by insurance is immediate. This reasonable assumption is represented by these claims being paid in the middle of the year.

As these cash flows occur in the middle of the year they are accumulated only by half a year reflected by the accumulation rate, $(1 + r)^{1/2}$.

The fourth component of the formula represents the cash flows that occur at the end of the period.

$$\text{COIFIR}_t - \text{CB}_t + \text{SE}_t.$$

The inflows to the COIFI at the end of the period include the indemnities from the reinsurer to the COIFI in the event of a natural disaster, $COIFIR_t$, and any subsidies paid at the end of the period, SE_t . (In the model these are the direct subsidies following a natural disaster.)

The outflows from the insurance system at the end of the period are the coupon payments to the cat bond investor, CB_t .

As these cash flows occur at the end of the period, there is no need to apply an accumulating factor to them.

The net present value formula is applied to each year of the model from 1962 through to 2006. This creates a time series of data that can be directly compared to other variations of the model.

Appendix B.

As noted at the end of the introduction, Cardenas *et al.* (2007) considered the same problem as addressed in Sections 4 through to 6 in the main text. They, however, made use of a stochastic model whereas we employ a deterministic inter-temporal model. The benefit derived from exploiting the latter model is that it is transparent and results can be replicated by following the process described in the main text without the use of statistical programs to create stochastic simulations. The transparency of the model lends itself to a greater understanding of the process of payments (into and out of the relevant risk-transfer financial instrument).

The disadvantage of applying this model, however, is that the reliance on past historic, instead of stochastically simulated data means that it is not possible to measure the expected (as distinct from the actual) loss in any given year. However, the expected losses (derived from an accurate stochastic model), when averaged out over all years, should tend towards the average of the actual losses (over all years). It is this latter average situation that we are interested in since the deterministic model is based on calculating the present value of losses incurred over all years. That said a stochastic model does provide more information since it also provides the standard deviation of expected losses.

Despite these differences some of the assumptions imposed by Cardenas *et al.* are similar to those imposed Section 4 in the main text. Both of these models allow for the pricing of reinsurance premiums having a cyclical component. Thus the size of the premiums charged will be increased in the year following a disaster. Also, both models allow for reinsurance having an element of credit risk.

Nonetheless, the focus of risk management in these alternative models differs in one important respect. The Cardenas *et al.* model seeks to manage a middle layer of risk while ignoring extreme layers of risk. In this regard Cardenas *et al.* (2007: 42) explicitly state: 'Extreme layers of risk will not be transferred to other agents because of the high and exponentially increasing costs of transfer.' This observation is integrated into the development of the stochastic model by it being explicitly assumed that the losses imposed by more severe earthquakes will not be covered by reinsurance or cat bonds (Cardenas *et al.* (2007: 46)). Instead the

Mexican government is assumed to turn to alternative sources of finance – such as disaster foreign aid - to cover the costs imposed by extreme events.

This class of insurance contract – or the CatXL (catastrophe excess of loss) contract – is becoming more widely used (Zimmerli (2003: 40) and may be the appropriate contract to consider when developing a risk management strategy for the Mexican government. We ignore this class of insurance contract, however. The reason is that we are particularly concerned to determine how best to cover all the losses incurred by poor households in Indian society due to floods. Hence we do not consider any layering of losses since all the losses incurred by this poor group should be of a relatively small magnitude and, therefore, should be easily handled by an international reinsurer or investors in cat bonds.

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