5. Ability to Pay for the Risk: Optimum Decision on Risk-Sharing

5.1 Preliminary Remarks

Several discussion papers on adequate investments solutions for possible catastrophe risk financing exist. Because of the tremendous costs caused by natural hazards, nearly every disaster-prone country in the developed world has a combination of mitigation, coverage or local market pools to address financial impacts on the economy.[196] In contrast, Third World countries' capability to absorb unforeseen shocks appears limited due to their restricted external and internal financial resources.[197] Beside existing external aid programs that are designed by bilateral- and multilateral institutions in disaster management, many countries governments wish private arrangements to be adequately financially prepared to provide disaster provision.[198] Different sources of financing and hedging disaster risk gave reason for examining this subject more exhaustively.

There has been only limited work exploring how to adapt decision-making models in Third World countries. With the help of an optimum decision-making process, they have the opportunity to find a most favorable financing solution in spite of disregard their weak economy with only limited resources. This section should be seen as theoretical complement to the subject under investigation in this paper: the examination of methods that Third World countries can use to respond with difference instruments financing reoccurring natural disasters which might reduce economic damage and result at the end country-wide crises. The highlighting of the decision-model selected is based on a research findings

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[196] Cp. NUTTER, F. W.: The Role of Government in Financing Catastrophes, in: Geneva Papers on Risk and Insurance, Special Issue on Risk Management, Natural Catastrophes and Risk Management, Vol. 27, No. 2, 2002, pp. 288 ff.

[197] Cp. IMF: Honduras: …loc. cit., p. 16.

[198] Cp. section 4.3 in this paper.

by PAUL FREEMAN.[199,200] Other noteworthy contributions exist by FREEMAN; MARTIN; PFLUG[201] as well as FREEMAN; PFLUG[202] and MECHLER; PFLUG.[203]

With using the model, FREEMAN undertakes an attempt to create a framework helping governments to consider costs of insuring catastrophe losses and the risk of expected return resulted from a post-disaster financing strategy. The model can help identifying the optimum decision based on their risk assumptions; furthermore, it can assist calculating opportunity costs of catastrophe risk financing and economic costs of relying on different resources.[204]

5.2 Basic Assumptions for an One-Faktor Model

Two important initial questions have to be assumed: The first is the prospective risk attitude of governments. According to the common theory - as outlined in section 4.4.2.1 , governments have no need to hedge catastrophe risk and behave risk-neutral.[205] The status of all countries as risk-neutral is not theoretically sound, while the theory of government risk-neutrality may be applicable solely to most advanced economies. Government are willing to purchase an financing instrument depends on the compared costs compared to other options available, advantages and disadvantages.[206]

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199 FREEMAN, P. K.: Catastrophe Risk: …loc. cit., chapter 6.

200 As far nothing else is elucidated, the following explanations are to be basis of this model. Complementary or supplementary details are particularly cited.

201 FREEMAN, P.; MARTIN, L. A.; PFLUG, G. C.: Developing countries' problem of investments endangered by natural catastrophes: Optimal investment in insurance policies, IIASA, Laxenburg 2000.

202 FREEMAN, P.; PFLUG, G.: Infrastructure in Developing Countries: Risk and Protection, in: Risk Analysis, Vol. 23, Issue 3, 2003, pp. 601-609.

203 MECHLER, R.; PFLUG, G.: The IIASA Model for Evaluating Ex-ante Risk Management: Case Study Honduras, Report to the Inter-American Development Bank (IDB), Washington D.C. 2002.

204 In common economic literature, opportunity costs and economic costs are treated equally: as measure of using scarce resources (factor input) to produce one particular good in terms of alternatives of hereby foregone. [Cp. Pass, C.; Lowes, B.; Davies, L.: "opportunity costs" in: Dictionary of Economics, 2nd ed., Glasgow 1993.].

205 Cp. ARROW, K. J.; LIND R. C.: loc. cit., pp. 370ff.

206 Cp. appendix VII: Features and characteristics of financing opportunities in both private and public sector.

In contrast with governments in developed countries, FREEMAN explores characteristic features make them risk averse. Developing countries depend on either external financing sources, or use alternative risk transfer methods.[207]

If developing countries must turn to external resources, the question naturally arises as to which are the most efficient external resources for them to access? Risk-shifting techniques used by private parties may represent possibilities for risk-shifting by developing countries.

The second query considers on external financing, and the ability of Third World countries to rely on outside low-cost assistance post catastrophe to reconstruct damaged infrastructure. The model comes back on parts of this paper discussed earlier: As described in section 4.4.2, developing countries have very limited internal resources accessible to absorb direct losses from disasters and receive external financial aid. Their capital, which is allocated of their budgets to infrastructure investment, the government expects an economic rate of return.[208] This should be estimated annually. Starting from different risk-sharing mechanisms represented in section 4.4.3, the model focuses also its risk measure on efficiency[209] and confidence by a country on external financing of international aid to absorb risk.

For purpose of this analysis, additionally the following presumptions in the economy have to be made:

- Existing inventory of infrastructure returns as known rate of return.

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[207] Cp. section 4.2, in particular section 4.2.3.

[208] According to the World Bank's Development Report 1994: Infrastructure for Development, The World Bank, Washington D.C. 1994, developing countries earn a 16% economic rate of return in infrastructure investment.

[209] Generally, the term *efficiency* describes the relation between scarce factor inputs and outputs of goods. This relationship can be measured in physical (technological efficiency) or cost terms (economic efficiency). In this context, *economic efficiency* should be used more broadly and should be equated with the *effectiveness* of resource allocation in an economy as a whole. The concept is used as a criterion in judging how well markets have allocated resources. [Cp. PASS, C.; LOWES, B.; DAVIES, L.: "efficiency" and "economic efficiency", in: Dictionary of Economics, 2nd ed., Glasgow 1992:].

- The government has an annual budged to invest in new infrastructure, what is to results an expected rate of return.
- New infrastructure investment result an expected rate of return.
- Future rate of return will be lost if damaged or lost infrastructure is not reconstructed.
- Some internal resources to finance post disaster infrastructure reconstruction exists.
- Benefits of existing opportunities for catastrophes hedges exist also which provide funds for reconstruction post disaster. The expenditure hedge for some or all infrastructure reduces the amount available for new investment.

Furthermore, a one-period model is used, as catastrophe hedges and government budget are approved for one year period.

5.2.1 Optimum Decision on Using Limited Government Owned Resources – a general approach

The model focuses on how to spend budgeted funds. Denote X_0 units as government's prior accumulated investments of existing capital stock of the country. In year t_0 the government has an amount B to spend. B should be allocated between x_1 units of investment in new infrastructure, insurance to protect z_1 units of the new infrastructure, or insurance to protect z_0 units of already existing infrastructure. Only a component of existing or new infrastructure is destroyed from natural hazards; the random fraction of lost investment is denoted with ξ where $0 \le \xi \le 1$. F should be the distribution function of ξ where $F(u) = P\{\xi \le u\}$. Defining E as expectancy of ξ leads to:

$$E = E(\xi) = \int_0^1 v dF(v) = \int_0^1 [1 - F(v)] dv \qquad [1]$$

After a hazard occurred, $x\ \xi$ of the investment is destroyed, insured is the proportional part z of x and reconstructed the value z as fraction of lost investment ξ. The residual investment is

$$\left(X_0 + x_1\right)\left(1-\xi\right) + \left(z_0 + z_1\right)\xi \qquad [2]$$

what generates a random return of

$$\eta = R_0\left[X_0\left(1-\xi\right) + z_0\,\xi\right] + R_1\left[x_1\left(1-\xi\right) + z_1\,\xi\right]; \qquad [3]$$

R_0 and R_1 are return factors respectively. The expected return in future is a linear function in x_1 , z_0 and z_1 and described as

$$E(\eta) = R_0\left[X_0\left(1-E\right) + z_0\,E\right] + R_1\left[x_1\left(1-E\right) + z_1\,E\right]. \qquad [4]$$

After defining the risk premium of insurance as V times the expected loss, the price for insuring a value of the existing infrastructure is $z\,E(1+V)$. The price for both insurance and investment should be within the budget limit of the country and can be illustrated as:

$$z_0\,E(1+V) + z_1\,E(1+V) + x_1 \le B. \qquad [5]$$

Denote $R(\eta)$ as risk measure under consideration of constraint (M) as minimal expected return, the risk-minimizing problem can be denoted as

$$R\left(\eta\right) = R\left(R_0\left[X_0\left(1-\xi\right) + z_0\,\xi\right] + R_1\left[x_1\left(1-\xi\right) + z_1\,\xi\right]\right) \overset{!}{=} \min \qquad [6]$$

subject to	$0 \le z_0 \le X_0$	Only insure up to 100%	[6.1]
	$0 \le z_1 \le x_1$	same as above	[6.2]
$z_0\,E(1+V) + z_1\,E(1+V) + x_1 \le B$		costs not exceed the budget limit	[6.3]
$R_0\left[X_0\left(1-E\right) + z_0\,E\right] + R_1\left[x_1\left(1-E\right) + z_1\,E\right] \ge M$		the expected return does not fall below the minimum expected return.	[6.4]

As the expected return may vary, the range should be specified by minimizing the return factor. Denote M_{min} the minimal value and M_{max} the maximal value.

$$R_0\left[X_0(1-E)+z_0\,E\right]+R_1\left[x_1(1-E)+z_1\,E\right] \quad [8]$$

subject to $\quad 0 \le z_0 \le X_0$ [8.1]

$0 \le z_1 \le x_1$ [8.2]

$z_0\,E(1+V) + z_1\,E(1+V) + x_1 \;=\; B.$ [8.3]

5.2.2 *The Framework for Risk Measurement*

The paper proceeds now by specifying the risk function $R(\eta)$ to gain more explanation about optimum decision on risk-sharing within the range of expected values obtained from the previous section. The specification now considered is made under very simplified assumptions.

Denote $\xi_{critical}$ such that one receive the lowest return *L* from which the economy recovers after a natural disaster occurred. *L* should be the return associated within a 1-in-10 year loss on uncovered infrastructure. This is expressed by

$$L = R_0\,X_0\,(1-\xi_{critical}) + R_1\,B\,(1-\xi_{critical}) \quad [9]$$

under consideration that a country expects to happen a disaster once every 10 years. Hence the risk measures an expected shortfall of the return beneath the limit L. With the definition of $R(\eta) = E([\eta - L])$ where $[u] = -min[u,0]$, the following situations can be expressed:

Set $\eta = a - b\,\xi$ [10]

with $a = R_0\,X_0 + R_1\,x_1,$ the return if no damage occurs [10.1]

$b = R_0\,(X_0 - z_0) + R_1\,(x_1 - z_1)$, the return on uninsured infrastructure. [10.2]

Thus, the risk measure can be rewritten:

$$R(\eta) = E\,[a-b\,\xi-L]. \quad [11]$$

After partial integration one receive now the optimization problem

Minimize $R(\eta) = (L - a) + bE + b\Im\left(\frac{a - L}{b}\right)$ [12]

subject to $0 \leq z_0 \leq X_0$ [12.1]

$0 \leq z_1 \leq x_1$ [12.2]

$z_0\, E(1+V) + z_1\, E(1+V) + x_1 \leq B$ [12.3]

$R_0\, [X_0\, (1\text{-}E) + z_0\, E] + R_1\, [x_1\, (1\text{-}E) + z_1\, E] \geq M.$ [12.4]

After taken into consideration the expected return constraints choosing $M_{min} \leq M \leq M_{max}$, and setting $E_1 = E(1+V)$ resp. $V_1{=}E[(1+V)(1\text{-}E)\text{-}1]$ one receive the full optimizing problem what can be written as

$(L - M) + b\,\Im\left(E + \frac{M - L}{b}\right)$ [15]

subject to $0 \leq z_0 \leq X_0$ [15.1]

$b(1\text{-}E)+R_0 z_0 \leq z_1 \leq x_1 \leq M$ [15.2]

$b+R_0 z_0 \geq R_0 X_0$ [15.3]

$z_0\, E_1(R_1 - R_0) - bV_1 = BR_1\text{-}M\,(1+E_1) + R_0 X_0.$ [15.4]

With these definitions we now can calculate the following cases allocate the capital *B* (which is the amount to invest) optimum:

- existing inventory of infrastructure z_0*
- budget for new investment in infrastructure and insurance z_1*
- the financial return on existing and new investment,
- a risk measure that accounts for existing resources of governments to respond to losses from natural disasters x_1*
- and costs of purchasing a catastrophe hedge which guarantees additional post disaster funding to repair expected losses to infrastructure.

The basic equation for the three different cases are as follows:

$$z_0^* = \frac{BR_1 - M(1+E_1) + R_0 + b^* V_1}{E_1(R_1 - R_0)} \qquad [16]$$

$$x_1^* = \frac{M + b^* E + R_0 X_0}{R_1} \qquad [17]$$

$$z_1^* = \frac{M - b^*(1-E\ ) - R_0 z^*{}_0}{E_1(R_1 - R_0)} \qquad [18]$$

5.3 Application and Critical Assessment of the Model

Freeman applied the model to two case studies: Honduras and Argentina. To illustrate the model, results for the case study of Honduras are presented in the following. Table 4 lists the modeling parameters used:

Parameter	Notation	Honduras	Argentina
Budget for infrastructure investment and insurance [million US$/year]	B	300	3 000
Expected annual loss to infrastructure [as % of K]	E	0.6	0.02
Return on existing infrastructure	R_0	0.3	0.2
return on new infrastructure	R_1	0.4	0.25
risk premium	V	0.2	0.2
Existing infrastructure (million US$)	X_0	3 900	65 000
largest event covered by internal resources	$\xi_{critical}$	0.8	0.015

Table 4: **Modeling Parameter Assumptions for Argentina and Honduras**

Source: FREEMAN, P.: Catastrophe Risk: …, loc. cit., p. 74

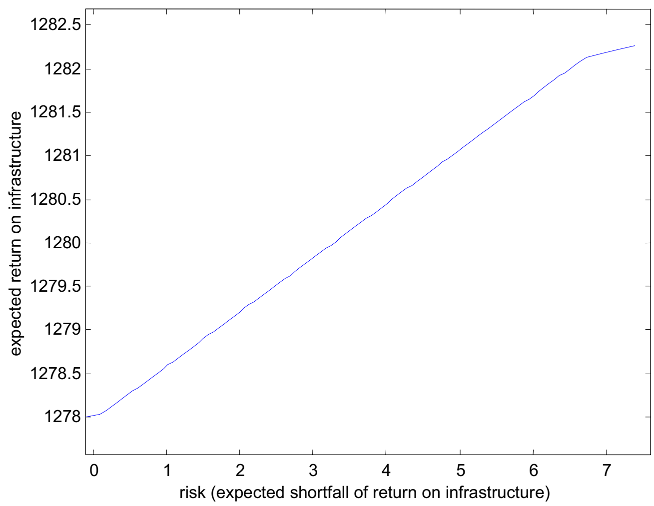

Figure 11: **Honduras: Expected Return Versus Risk [in millions US$]**

Source: FREEMAN, P. K..: Catastrophe Risk:…, loc. cit., p. 75

> FREEMAN states: "Figure 11 displays expected annual return on infrastructure (…) as a function of its associated risk. The associated risk is the expected annual shortfall in return from infrastructure damaged by natural disasters. Every point on the curve in Figure 11 can be read as either the highest possible expected return associated with a given amount of risk or as the smallest possible amount of risk associated with a given expected return."

And the overall result of the modeling can graphically be illustrated as follows:

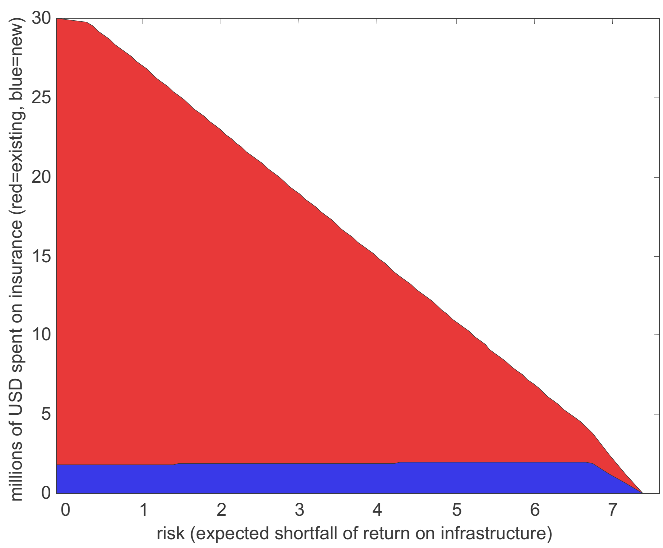

Figure 12: **Honduras: Optimal Insurance Decisions [in million US$]**

Source: FREEMAN, P. K..: Catastrophe Risk:…, loc. cit., p. 76

One shortcoming of the Freeman model is that the risk metric used is the expected value. Natural disasters, however, are low probability, high severity events, so averages will not fully represent the nature of these events and the benefits of engaging in risk financing activities.

In another modeling effort, PFLUG and MECHLER at IIASA modified and expanded this modeling for a research project for the Inter-American Development Bank[210] In contrast to the model described above, they built a simulation rather than optimization model for analyzing cost-efficient choices for financing disaster risk in developing countries. A major reason for the focus on simulation was that with a high number of scenarios and other risk indicators such as variance, computing time quickly becomes very long in the optimizing algorithm.

For a case study of El Salvador (a country with similar natural hazard exposure and economic characteristics as Honduras), growth paths of the economy with and without insurance protection for public assets were analyzed for a time horizon of 11 years. Figure 13 shows different trajectories for these two cases. It has to be noted that the ca. 60 trajectories shown here are a selection out of a total of 3000 scenarios generated and have different probabilities. The ones with the largest adverse impacts on the economy have a very low probability, while those with more moderate effects are more likely. The purpose of such a figure, though, is to represent the whole spectrum of possible impacts:

[210] E. g. MECHLER, R.; PFLUG, G.: The IIASA Model for Evaluating Ex-ante Risk Management: Case Study Honduras, Report to the Inter-American Development Bank (IDB), Washington D.C. 2002 and Freeman, P. K. et al.: Disaster Risk Management: National Systems for the Comprehensive Management of Disaster Risk and Financial Strategies for Natural Disaster Reconstruction, Inter-American Development Bank (IDB), Washington D.C. 2003.

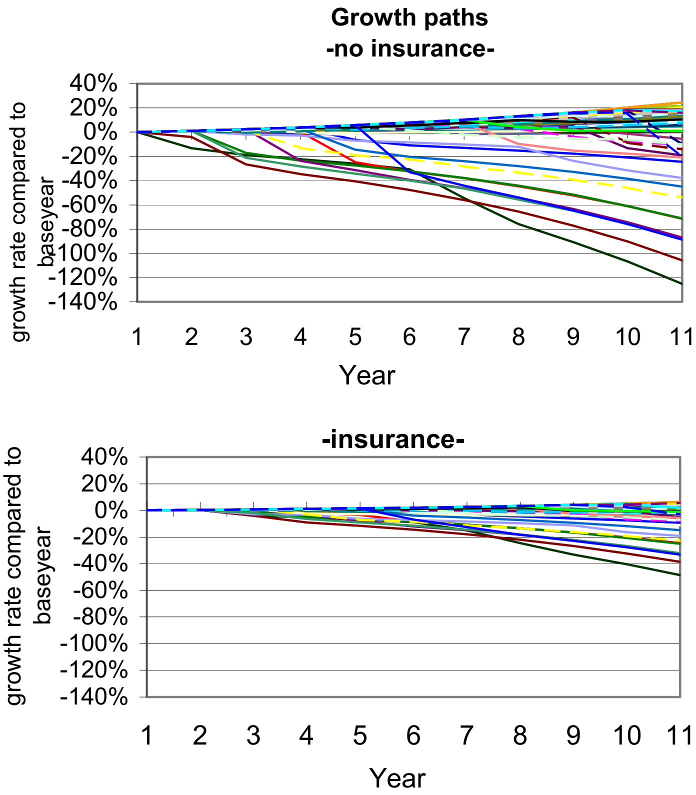

Figure 13: **Trade-off between Growth and Stability in El Salvador**

Source: FREEMAN et al.: Disaster Risk Management: National Systems for the Comprehensive Management of Disaster Risk and Financial Strategies for Natural Disaster Reconstruction, Inter-American Development Bank, Washington D.C. 2003, p. 63.

According to these results, buying insurance helps hedging against unfavorable outcomes (the spread of outcomes is reduced), but has costs in terms of less maximum potential growth. When analyzing averages only, the hedging effect will be underrepresented, as the very unfavorable outcomes (with probabilities of e.g. from 1 in 3000, a 3000 year event, to 30 in 3000, a 100 year event) will only slightly change averages over all 3000 scenarios.

This means, a decision model does not provide an unambiguous or meaningful information. Consequently, the government receives neither a clear nor a wrong recommendation about on how coping best with disastrous consequences of natural catastrophes, merely it provides an indication of possible benefits and disadvantages. Instead of, the model used is an instrument designed to give governments an assessment about the cost-efficiency of different possible catastrophe hedging solutions.

The decision process is influenced by factors reviewed from section 4.4.2, such as (1) potential risk of size, (2), internal sources available to cope with losses, (3) the consequences of not recon structuring the affected area, (4) the cost of insurance, (5) the available budget of the country to spend on insurance and other investments, and (6) the opportunity to receive financial help from external resources.

Basically, natural hazards do not destroy an economy as a whole. Instead only components of essential infrastructure cause a decrease of the economic production. By this means, the model provides governments an excellent opportunity to weight between accepting higher risk by managing it on his own in order to support country's growth potential, or using possibilities for risk-sharing such as on private or on country level.

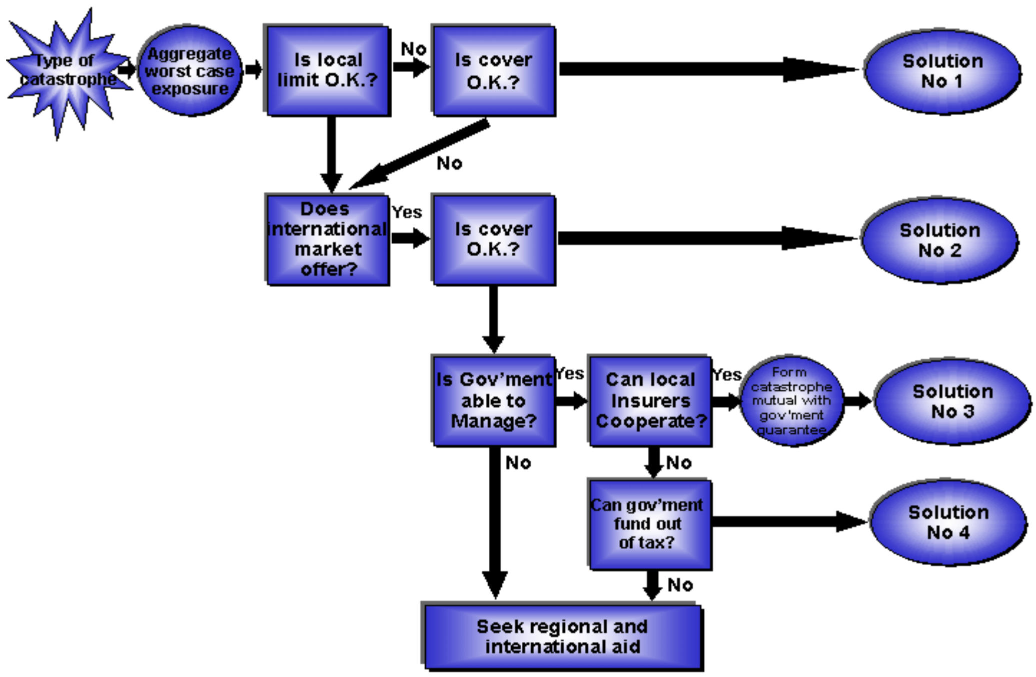

Figure 14: **Decision-Making Procedure for Appropriate Catastrophe Protection**

Source: Own compilation

Governments are then better able to decide independently – under consideration of the influence of external sources that is still given – to use this model as criterion in judging how well internal markets can allocate resources. Hence, is it easier to understand trade-offs between higher ex-ante budget allocation and ex-post reconstruction. In this context, an example could be costs of restoring full production of the damaged infrastructure versus costs for essential new infrastructure.[211] To sum up, different optimizing procedures are shown in figure 14. It illustrates the decision-making procedure for choosing appropriate catastrophe financing opportunities. The government role in offering catastrophe protection is linked to its unenviable responsibility to step in wherever a major catastrophe occurs.[212] The different outcomes of the decision process are influenced by the advantages and disadvantages of the options considered in the preceding chapter.

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[211] Cp. FREEMAN, P.; MARTIN, L. A.; PFLUG, G. C.: Developing countries' problem of investments endangered by natural catastrophes: Optimal investment and insurance policies, IIASA, undated, p. 3. Online in internet: URL: http://www.iiasa.ac.at/Research/CAT/FMP.ps [Cited 2003-08-26].

[212] Ibid., pp. 15ff.

6. Conclusion

Natural disasters were defined as phenomena that are potentially harmful to productive activities in Third World countries. The impacts – economically or monetarily – overwhelm local financial capacity and provoke economic crises.

Chapter 2 of this thesis began with a description of Third World countries, which indicated an increasing occurrence of natural disasters in that area. Furthermore, non-existing risk markets and the vulnerability of financial markets led to economic and financial losses during the past years in the event a catastrophe occurred. Macroeconomic crises caused by natural catastrophes were a prime example of aggregate shocks to an economy.

The impacts of a disaster are more devastating in developing economies than in developed countries. Long-term economic effects due to direct, indirect and secondary effects can be dramatic. This was shown in chapter 3. In many examples, consequences followed such as slower economic growth, increasing indebtedness and higher regional income inequality. The environmental and social costs are substantial, although they are more difficult to assess in monetary terms.[213]

Several ex-ante opportunities to cope with disasters were described in chapter 4. Different transfer instruments for natural disaster risk were additionally highlighted. The section continued with an examination of the principal ways that Third World countries have to manage catastrophic risk, namely risk-sharing through (1) private finance, (2) government finance, and (3) public-private partnerships.

Based on the elucidations in the previous sections, the effects were underlined in chapter 5 with a model to evaluate the decision process for Third World countries.

Although the effectiveness of managing economic crises caused by natural

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[213] Cp. CHARVÉRIAT, C.: loc. cit., p. 9.

disasters was illuminated from different sides, one has to take into consideration the fundamental difficulties in dealing with extreme events in Third World countries:

- Firstly, after a disaster occurs, time of recuperation and restructuring of damages in the economy depends on a country's ability to engage proactive risk mitigation.

- Secondly, one has to keep in mind their dependence on external resources. Due to Third World economic instability Bilateral and Multilateral institutions have a large influence on a country's risk attitude and their decision on what is the appropriate catastrophe protection.

- Thirdly, the optimum decision for coping with financial impacts of natural disasters cannot be generalized.

As shown in this work, the financing of disasters is more appropriate for private-public partnerships rather than for each sector alone. Governments and the private sector in disaster prone countries can and should exploit such alternative catastrophe risk management instruments to the fullest extent in order to assure that national development is least affected by economic and financial shocks from such disasters.[214]

Local governments may be more effective in the evaluation and enforcement of loss-reduction and loss-spreading measures, but this is possible only through location-specific analysis of potential losses and the sensitivities of the losses to new risk management strategies.[215]

It is still an open question to what extent economies in the Third World will be flexible enough to accept the experience made in developed countries.

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[214] Cp. POLLNER, J.: loc. cit., p. 86.
[215] Cp. MACKELLAR ET AL.: loc. cit., pp. 3ff.

Due to the limited resources of poor countries all losses cannot be absorbed so governments must also be prepared to fulfill their obligations after natural disasters. The private sector is willing to provide assistance in building catastrophe risk management schemes.

The minimum level of experience shows that optimum allocated and specifically structured, finance solutions can provide enhancement for both the economic stability and the best possible preparation to cope with disastrous hazard events.

Following from the previous discussions, suggestions for further discussion are addressed to developed countries: they are required to provide assistance to vulnerable Third World areas in adapting to the impacts of catastrophe events.

In addition, bilateral and multilateral organizations should pay more attention to specified needs of countries in disaster-prone areas. Regarding the risk-sharing opportunities, hedging instruments can be designed individually to the Third World country's financial situation and needs. Many opportunities exist to intensify the cooperation with the local financial industry. There might be possibilities to reinforce the involvement of the insurance industry and provoke a participation of regional financial institutions on voluntary basis.
One inventive idea to combine both the insurance industry and regional financial institutions could be a catastrophe financing structure linked with an index of welfare of the country or other macroeconomic components like GDP scale or inflation rate. Further actions could be done in structuring such solutions with the help of both reinsurance industry and external organizations. As assumed, the role of government has to be examined before policy makers create appropriate and effective catastrophe management strategies. The same applies to the nature of the decision making process.

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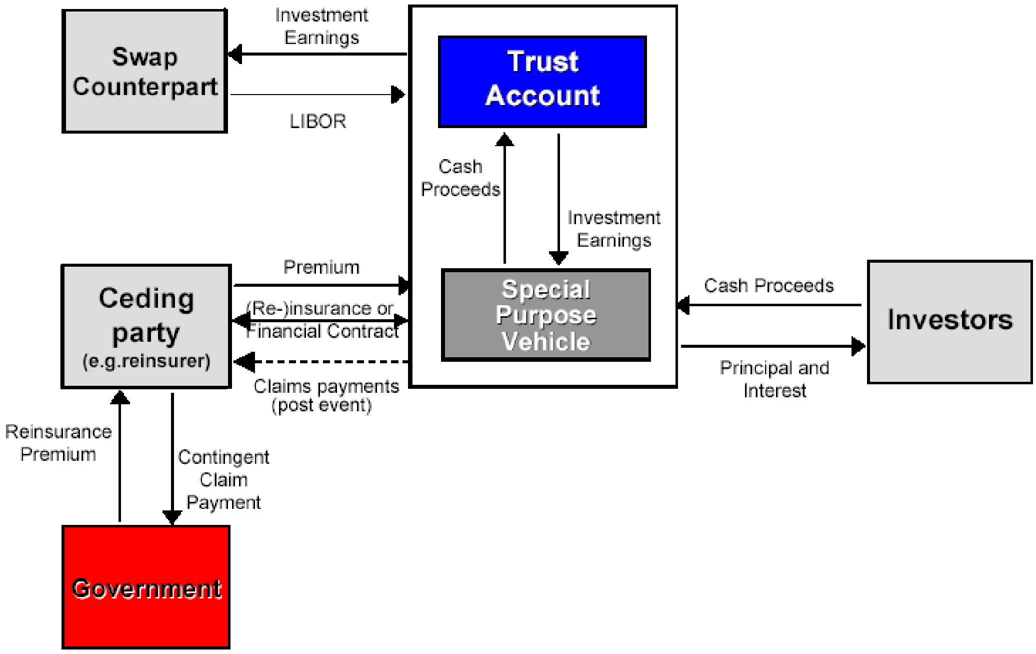
LIST OF APPENDICES

Appendix I: Direct and Indirect Damages from Selected Natural Catastrophes

Year	Country	Type of Hazard	Damages (millions of US$, 1998)		
			Direct	Indirect	Total
1972	Nicaragua	Earthquake	2 383	584	2 968
1974	Honduras	Hurricane Fifi	512	818	1 331
1976	Guatemala	Earthquake	586	1 561	2 147
1979	Dominican Republic	Hurricanes David and Frederick	1 301	568	1 869
1985	Mexico	Earthquake	5 436	780	6 216
1987	Ecuador	Earthquake	1 170	267	1 352
1988	Nicaragua	Hurricane Joan	1,030	131	1160
1995	Saint Maarten, Netherland Antilles	Hurricanes Luis and Marilyn	611	502	1 112
1997-98	Andean Countries	El Niño	2 784	4 910	7 694
1998	Dominican Republic	Hurricane Georges	1 337	856	2 193
1998	Central America	Hurricane Mitch	3 078	2 930	6 008
1999	Colombia	Earthquake	1 391	188	1 580
1999	Venezuela	Floods/debris flows	1 961	1 264	3 237

Source: CHARVÉRIAT, C.: Natural Disasters in Latin America and the Caribbean: An Overview of Risk, Inter-American Development Bank (IDB), Washington D.C. 2000, p. 14.

Appendix II: "Full Risk Transfer" Catastrophe Bond Arrangement



Source: ANDERSEN, T. J.: Innovative Financial Instruments for Natural Disaster Risk Management, Inter-American Development Bank (IDB), Washington D.C. 2002, p. 33 and SWISS REINSURANCE COMPANY.

Appendix III: World Bank's Involvement and IMF's Financial Assistance Related to Natural Catastrophes

Country	World Bank - Risk Management Status	IMF - Emergency Assistance
Cambodia	Risk management study	Since 1990: US$2 billion
Caribbean countries	Risk Management study	1998: US$2.3 million 1998: US$55.9 million 2003: US$4.0 million
Columbia	Insurance lending program under preparation	1997: US$ 12.2 million
India	Risk management study is complete	1998: US$138.2 million
Iran	Ongoing risk financing and technical assistance for risk management	n/a
Mexico	Technical assistance and lending under preparation	n/a
Philippines	Risk management study under preparation	n/a
Romania	Insurance component under preparation	n/a
Turkey	Ongoing risk financing and technical assistance	1999: US$501.0 million

Source: Revised plotting to GURENKO, E. N.: Managing Catastrophe Risks at the Country Level: The World Bank Group Perspective, paper presented at the conference "Risk Transfer: Financial Instruments to Manage Climate Risk", The World Bank, Washington D.C. 14 March 2003, p. 14 and INTERNATIONAL MONETARY FUND (IMF): IMF Emergency Assistance: Supporting Recovery from Natural Disasters and Armed Conflicts: Factsheet, Washington D.C. 2003.

Appendix IV: Impacts on Economic Variables Due to Natural Hazards

Macroeconomic Indicator	Expected Change after Disaster
Growth Rate of GDP	Decrease or negative rate in year of disaster and subsequent increase during 1 to 2 years
Growth Rate of GDP (Agricultural Sector)	Significant fall in production (if hurricane, flood, or drought)
Growth Rate of GDP (Manufacture Sector)	Decrease in activity due to disruption of transportation, reduced production capacities
Growth Rate of GDP (Export Sector)	Poor performance due to effects described above
Gross Formation of Fixed Capital	Sharp increase in year following the disaster
Inflation Rate	Increase caused by the disruption of production and distribution and increasing transportation costs
Public Finances	Worsening of deficit due to a shortfall in tax revenues and increase in public expenditures
Trade Balance	Deficit due to decrease in exports and increase in imports, associated with the decline in production capacities and strong public and private investment for reconstruction
Current Account	Increase in deficit due to trade imbalance, partially offset by capital inflows generated by official and private donations

Source: CHARVÉRIAT, C.: Natural Disasters in Latin America and the Caribbean: An Overview of Risk, Inter-American Development Bank (IDB), Washington D.C. 2000, p.16.

Appendix V: Government Sponsored Catastrophe Insurance Pools and Funds in Third World countries

	General Information		
	Current Arrangements / Planned Actions	**Perils Covered**	**Motivation**
India	National Catastrophe Insurance Management	Perils of floods and cyclones in eastern India and the area of Bangladesh	• Lack of fully competitive insurance markets • Development of an institutional arrangement for risk transfer and financing
Iran	National Catastrophe Insurance Pool	Perils of floods and tsunamis	• Absence of adequate catastrophe insurance coverage • Technical assistance to the government
Mexico	• Mexican Catastrophe Reserve Fund (FONDEM) • Designed in 1996	Perils of earthquakes, volcanic eruptions and hailstorms	• Since 1980, direct damage from natural disasters exceeded US$6.5 billion • financing of reconstruction of public infrastructure on government level
Romania	Disaster Response Project	Perils of earthquakes, tsunamis and floods	• Insufficient infrastructure for insurance services • Technical Assistance from WB to the Government • Design of an earthquake insurance program
Taiwan	• Taiwan Residential Earthquake Insurance Pool (TREIP) • Formed in 2002 • Consequence of the Chi-Chi Earthquake	Perils of earthquakes and tropical storms in Central Taiwan	• Lack of residential earthquake insurance cover • Includes a quasi-mandatory purchase of EQ cover • Minimize government budget exposure
Turkey	• Turkish Catastrophe Insurance Fund (TCIP) • Launched in 2000 • Consequence of the Namara and Duzce earthquake • Combined with compulsory seismic coverage	Perils of earthquakes	• Expected annual economic losses due to earthquakes around US$1 billion • Low insurance penetration • Insufficient earthquake cover for homeowners

Source: Own compilation, based on various emails obtained from regional insurance and banking authorities and factsheets from the World Bank and the IMF

Appendix VI: Hazard Vulnerability in Honduras

(a) Loss Potential of Honduras - Wind

Wind Speed:

10 – 20 m/s

20 – 30 m/s

30 – 35 m/s

35 – 40 m/s

Source: SWISS REINSURANCE

(b) Loss Potential of Honduras - Earthquake

Seismic Hazard:

low

moderate

significant

high

very high

Source: SWISS REINSURANCE

(c) Macroeconomic Indicators in Honduras, 1997 – 2000

Macroeconomic indicators	1997	1998 (before Hurricane Mitch struck)	1999	2000
GDP	n/a	n/a	n/a	US$5.9 billion
GNP/capita	US$700	US$725	n/a	US$850
Real GDP growth [%]	4.5	3.0	-2.9	3.2
Inflation [%]	20.2	13.7	11.6	10.5
Central government finances [balance, La mio]	-	2,080.7	1,089.5	n/a
Current deficit account [% of GDP]	5.7	6.4	6.5	n/a
Total external debt, US$ mio.	4,698	5,017	5,652	Present Value debt/exports: 118.2%

Source: SIMCO DATABASE, The World Bank, Washington D. C. 2003. Online in internet: URL: http://www.worldbank.org/statistics/ [Cited 2003-08-28].

Appendix VII: Features and Characteristics of Financing Opportunities in both Private and Public Sector

	Ex-ante risk financing by insurance	Ex-post loss financing
Costs before event	• Premium payment causes opportunity costs	-
Benefits after event	• All needed funds available immediately for risks insured • Increased capital inflows from abroad to depressed economy • Financial and economic stability	-
Costs after event	None	• Instability for foreign financing: potential for financing gap • Negotiating external loans may cause time lag and delay in financing reconstruction • Opportunity costs of diverting • In case of financing gap long term developmental impacts
Incentive for mitigation?	Yes	No
Additional	• Active strategy • Theoretical risk of (re-) insurer going bankrupt • Diversification opportunity for reinsurer	• Passive strategy • International donor community demands more ex-ante involvement

Source: MECHLER, R.: Natural Disaster Risk Management and Financing Disaster Losses in Developing Countries, doctoral dissertation, University Fridericana zu Karlsruhe, Karlsruhe 2003, p. 78.