Natural Hazards
and Earth System
Sciences

Discussions

Interactive comment on "Forecast-based financing: an approach for catalyzing humanitarian action based on extreme weather and climate forecasts" *by* E. Coughlan de Perez et al.

E. Coughlan de Perez et al.

coughlan.erin@gmail.com

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We would like to thank the reviewer for the thoughtful comments and suggestions on this manuscript. Our replies to specific suggestions are below.

COMMENT: The paper address the design of early warning systems and potential actions to take before the disaster based on such mechanisms. It is very well written and the link to the related literature is very clearly exposed.

AUTHOR RESPONSE: Thank you for the comments.

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COMMENT: The overall objective is to help the design of 'forecast based financing system to automatically trigger action based on climate forecasts or observations'. It seem however not so easy to calibrate the model explained, this should probably be expand or at least discussed. For instance, the cost of an action taken on the basis of a wrong forecast can decrease the confidence of (deciders as well as final users) actors/agents, which may be very delicate to estimate.

AUTHOR RESPONSE: Excellent point. Based on this suggestion, the following text was added to the discussion section on sensitivity analysis of costs.

CHANGES TO MANUSCRIPT: Calibrating cost and benefit estimates will be difficult. For example, the cost of acting or the cost of acting in vain might need to be estimated iteratively, based on whether the actor had recently acted in vain, and would therefore be reluctant to take a risk again. The equations here could be extended with a "risk perception" factor that changes in response to false alarms or successful interventions. This would be calibrated with information from the practitioners.

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COMMENT: The formalization of the article introduce a (probably new) framework, however it is not clear (and should give more precision if possible) what it brings to the current knowledge and to practitioners. In addition to the rather difficult calibration (particularly due to the high diversity of the contexts it may be applied: e.g. forecasts vs. observations) the probabilities are their selves very uncertain. Extreme events are characterized by specific distributions (e.g. fat tailed) that are thus difficult to parametrize, moreover the reliability of a forecasts also depends on the way it is expressed as well as the accepted confidence interval (that may be different across agents and institutions). This comment should be taken with caution since such po-

tential difficulties in the implementation should not prevent the theoretical framework to be questioned and built, but rather taken into account for its design. AUTHOR RESPONSE: These are excellent points, and we agree that this will need to be taken into account when operationalizing this framework. In the discussion section, the following text addresses these points:

CHANGES TO MANUSCRIPT: This framework quantifies the intuitive notion that many practitioners already have about when acting early may be worth it. This quantification also helps them make the case to donor agencies for such early action, which is currently often not implemented because the financing for it is not available.

Of course such quantification is not trivial – it does require context-specific analysis. In that analysis, the lack of historical disaster data will pose certain constraints. The impact of uncertainty in probability estimates, both of disaster impacts and of forecast probabilities, needs to be assessed, and thresholds of certainty established for identifying meaningful results. Local knowledge about the recurrence period and impact of extremes can be incorporated when calculating the fund, even if it carries inherent uncertainty.

In this vein, additional research will be required to achieve a large-scale application of forecast-based financing schemes. In particular, calculating the risk of hazards based on forecasted rainfall should be assessed and verified with hydrological estimates using statistical and dynamical techniques.

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COMMENT: Regarding the following sentence of the conclusion: 'During non-disaster episodes, the knowledge that such a system exists with a known likelihood of providing funding before a disaster will allow all involved parties to invest in long-term disaster-resilient development.' It is not made very clear how the quantification of monetary benefits of such mechanisms will give incentives to third parties (or any other national shareholders) to invest in resilience-enhancing investments for a given level of founds

allocated to such issues (nationally or internationally).

AUTHOR RESPONSE: This has been clarified with the following changes to the text. The sentence in question has been replaced with the below sentences.

CHANGES TO MANUSCRIPT: Ultimately, the value of forecast-based financing systems will be greater than simply the losses avoided when the fund is released. If such a system is in place, actors in that region will be aware that many disaster effects are likely to be prevented due to forecast-based action. Because of this, actors can focus on development investments with less concern that a disaster event will suddenly demolish their investment.

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COMMENT: The discount rate is not taken into account (this is maybe mentioned a bit late in the article, i.e. in eq. 6 and with not explanation or justification of such choice) while it is probably the major reason for inaction. Discounting the future is indeed a major reason for explaining inaction regarding future events at the individual and the institutional levels, however since the timing of the disasters does not count (or only counts when we consider people will avoid using a mechanism that happened after a missed crisis) and will probably leave results largely unchanged since both costs and benefits will be discounted (but it may, and probably should, be discussed, for instance simply by adding an exponential term within the integrals of benefits, costs and losses). However since some costs may occur more often that the benefits (that will only occur when an actual disaster take place, contrarily to the cost of implementation and reputational risk) the discount factor will decrease the relative weight of benefits. The basic intuition behind this idea is the way people weight current costs (we have to implement the system now, and probably dedicate efforts and resources for its implementation) and potential benefits in the long run (the benefits of such implementation may be only seen in the long run). AUTHOR RESPONSE: See below additional text that will be added to section 3.1 (much earlier in the article).

CHANGES TO MANUSCRIPT: [Section 3.1] The discount rate is not acknowledged here, as most of the actions take place on a timescale of less than a year. Time discounting would therefore have a fairly insignificant impact compared to the existing uncertainties. If the actions lasted for many years, it would be appropriate to include the discount rate, which could decrease the relative weight of the benefits, assuming that they occur less frequently than the costs. A more complicated version would also take into account the probability density function of different magnitudes of disaster, but the general principles outlined here will remain in effect.

[Conclusion] The net benefit of such a system will only be clear in the long term, as the hits and false alarms begin to accumulate and converge on their true frequency.

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COMMENT: Moreover, the issue of risk aversion that is not a time related issue but may play a role in apprehension of such risk since the cost benefit approach retained in this article does not consider non-linearities in the utility function, may help to apprehend poverty trap effect, probably important in the context of the developing world. This will most probably significantly affect the result by increasing the weight of benefits: avoiding heavy losses associated to low probability of occurrence in the objective function (i.e. eq. 6). AUTHOR RESPONSE: We agree with the comment on the poverty trap effect, and this is acknowledged in the clarification of the concluding statements (re-printed below).

CHANGES TO MANUSCRIPT: Ultimately, the value of forecast-based financing systems will be greater than simply the losses avoided when the fund is released. If such a system is in place, actors in that region will be aware that many disaster effects are likely to be prevented due to forecast-based action. Because of this, actors can focus on development investments with less concern that a disaster event will suddenly demolish their investment.

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COMMENT: Last but not least, uncertainty issues may be raised as gains are depending on the occurrence of extreme events for which probability apprehension are biased by individuals since they are associated to low probabilities and high damages. In this regards, type I (false alarm) and type II errors (missed crisis) may have very different outcomes (depending on delta and $a(p)$ / $b(p)$, cf. basis risk in the literature on weather index-based insurance: e.g. Leblois and Quirion 2013). It would be interesting to develop shortly the potential effects of those both (only missed crisis are discussed and illustrated) issues that may arise with such methods (e.g. loss of public money in the first case, decrease in people confidence in the system in the second one).

AUTHOR RESPONSE: In the article, we address the potential effects of type I errors (false alarms) with the discussion of delta C, or the additional cost that would be incurred in such a case. We do not add an additional term for type II errors (missed crises), because this is business-as-usual in the humanitarian sector, which regularly responds to crises. However, you make a good point that this could cause a loss of confidence in the system, which we have added to the text, and we have added a review of the index insurance literature at the beginning. The Leblois and Quirion article is an excellent suggestion, and we have included further discussion of weather index-based insurance.

CHANGES TO MANUSCRIPT: [Section 5 Discussion]: Similarly, a "miss" by the system could cause a lack of confidence in the system itself.

[Section 2.2 Warnings] Such SOPs would be based on thresholds of climate variables, similar to those calculated for post-disaster payments in index insurance programs (Leblois and Quirion, 2013, Hellmuth et al., 2011, Barnett and Mahul, 2007). In fact, forecast-based financing is informed by precedents that integrate seasonal forecasts into index insurance products. For example, Osgood et al (2008) propose a mechanism to influence the amount of high- yield agricultural inputs given to farmers according to whether favorable or unfavorable rainfall conditions are expected for the season. An El Niño contingent insurance product was developed for the region of Piura (northern

Peru): A business interruption insurance policy was designed to compensate for lost profits or extra costs likely to occur as a result of the catastrophic floods as predicted by a specific indicator of El Niño (known as "ENSO 1.2"). Indemnities were based on sea surface temperatures measured in November and December, which were taken as a forecast of flood losses that would occur a few months into the future (February to April). The insured entity chooses the amount to insure (which must not be larger than a maximum amount determined by an estimation of the largest plausible flood losses). Designers of this instrument specifically targeted risk aggregators: firms that provide services to numerous households or businesses exposed to El Niño and related floods, such as loan providers and the fertilizer sector. This is likely the first "forecast index insurance" product to receive regulatory approval. (GlobalAgRisk Inc. 2010). For a comprehensive analysis of insurance-related instruments for disaster risk reduction, see Suarez and Linnerooth-Bayer (2011).

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COMMENT: - Finally the delta is often used for additional entities, it should be made clear that the so-called reputation cost may be very significant (and is not negligible) if people does not pay attention to forecasts in a period following a 'false alarm'. AUTHOR RESPONSE: Great point; see additional text below.

CHANGES TO MANUSCRIPT: [Section 3.1] The additional cost, ΔC may be very significant; the reputational risk of a false alarm could outweigh (qualitatively) the benefits of a worthy action.

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COMMENT: Moreover a 'missed crisis' may also be damageable to such mechanisms if risk aversion is taken into account as long as the implementation cost is considered. For instance in the case of a poor country, for which the implementation of such mechanism is costly not even in forecasted disasters but also for long run investment (for instance in the forecast capacity of in rainfall station network development, investments

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quoted in the manuscript), then the trade-off between paying those costs (especially in a year of a missed crisis if the objective function is concave relatively to gains/losses and/or potentially triggering a poverty trap through dynamical effects). The implementation of such actions based on early warning may generally crowd-off other (public or private) resilience-enhancing investments, but also specifically let people to be less careful in case of an (always imperfect) forecast of an absence of disaster and thus increase losses.

AUTHOR RESPONSE: Good point, see additional text below.

CHANGES TO MANUSCRIPT: Individual cases of "missed events" could draw criticism to such investments in forecasting; it is key to weigh the investment in forecasting capacity or other aspects of an enabling environment for forecast-based financing with the possible benefit of such a system over time.

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COMMENT: This may take part in a broader question about the non-existence of such mechanisms (discussed in the context section, the example of Somalia speaking by itself), while the benefits exceed the costs. Question that probably deserve an explanation/mention in the context of the article (how to explain it with rational decisions and within nondiscounted cost benefit ratio as decision rule). The rather cynical example of smokers, quoted in the conclusion, also emphasize this point (that does not serve, in my opinion, the rationale behind the article's framework). The take-up of such risk reducing/coping/management mechanisms are known to be very low (in rich as well as in poor countries) and this is probably due to factors that can not be taken into account in the proposed framework: uncertainty/ambiguity aversion, confidence in supplying institutions among others. The last comments are not accurate for costless measures such as diffusion of existing and available information (radio alerts and preparing the people to what will happen) but still remains for evacuating people or implementation of flood response drills.

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AUTHOR RESPONSE: Here, the proposal is to create Standard Operating Procedures that will trigger action automatically, therefore removing individual reluctance to act in vain. Many studies have investigated the barriers to forecast-based action, and we provide an overview of this in section 2.2 but do not attempt to fully analyze all factors in this paper. We agree that the example of smokers seems outside the framework of the article and have deleted it.

CHANGES TO MANUSCRIPT: [Section 6 Conclusion: Deleted the example of smokers]

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COMMENT: - The example of Pakistan relates that rainfall was predicted 'several days in advance', which does not seem to be a sufficient time window for evacuating (a significant share of the) 20 million people given the available resources.

AUTHOR RESPONSE: We would argue that a good deal of disaster preparedness work could have been done during those days, some evacuations included. For example, 400,000 people were evacuated in the days between warning and landfall of Cyclone Phailin in India (see Harriman, L., 2013. Cyclone Phailin in India: Early warning and timely actions saved lives. Environmental Development.) In particular, this forecast-based financing system would provide resources based on forecasts, so people would not be limited by the available resources that you mention. Therefore, we would affirm that this is a good example of a situation where forecast-based financing could have made a significant difference.

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COMMENT: When discussing existing early warning systems in developing countries FEWSNET (in Africa) could be quoted since it exists since 1984.

AUTHOR RESPONSE: Good point; see below text.

CHANGES TO MANUSCRIPT: [Section 2.2 Warnings] The Famine Early Warning Sys-

tem (FEWS) provides detailed forecasts using both short and long-term information in Africa and the Caribbean (Ross et al. 2009).

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COMMENT: - ODI and GFDRR should be defined (at least explain what GFDRR is, which unclear to me)

AUTHOR RESPONSE: We have spelled these out now, and note that they are included as such given their significance to practitioners and policy makers in the disaster risk management world (GFDRR is a trustfund in the World Bank and among the premier innovative disaster financing modalities, ODI is a London-based policy thinktank with a very strong reputation on the humanitarian-development-climate nexus).

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COMMENT: - I am not sure the following sentence does make sense: 'Ultimately, such as system [...]' AUTHOR RESPONSE: Thank you for noticing this typo.

CHANGES TO MANUSCRIPT: "Such a system"
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