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Consequences of public programs and private transfers on household's investment in protection from natural disasters

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The incidence of natural calamities induced by global climate change is increasing. Governments lack the capacity to properly protect households living in areas that are prone to natural disasters like floods, earthquakes, cyclones, and associated storm surges. As a result, a household might be forced to engage in private defensive actions and investments to protect its members and property from recurring natural disaster events. However, the household's incentives to allocate funds to support its private defensive strategies against damages from a future natural disaster event might also be influenced by its access to private inward remittances and charities. This factor might be more pertinent among households who are representative of a developing country economy and located in vulnerable areas prone to more frequent natural disasters. Considering these issues of households' accessibility to public programs and private inward remittances, there is a need to better understand the linkages through which households' decision to pursue private defensive strategies (or private protection activities) might be influenced. This has significant policy implications especially for low-and-middle income countries vulnerable to natural disasters. We introduce a theoretical model of household private investment in protection against damages from a natural disaster event given the presence of public programs and the possibility of receiving inward remittances from members of the household.

To keep our exposition simple, we assume the household is representative of a developing country economy and vulnerable to a frequent natural disaster event, such as cyclones or hurricanes as a result of being located in coastal areas. We assume that the household's risk associated with storm-inflicted damages is endogenous. This latter presumption is based on the premise that a household through its private actions can avoid or mitigate the negative impacts of a major storm event.

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Under incomplete market insurance, we classify household's private storm protection actions into two categories: (1) *self-protection*, a form of ex-ante prevention, which are private investments that can reduce expected storm-inflicted damages from occurring; and, (2*) self-insurance*, a form of ex-post adaptation, which are private investments in human, physical, and social capital that can reduce losses in the event of storm-inflicted damages. From a low-and middle-income country perspective, examples of self-protection include converting a mud-built house to brick, raising the height of the homestead, moving the house inside an embankment, taking refuge in a neighbor's house, and locating further away from the shoreline to a safer place. Examples of self-insurance include income source diversification, crop and plot diversification, reciprocal gift exchanges, and inter-and intra-household income transfers based on insurance motives (or informal risk sharing). All these possibilities are directly or indirectly resulting from household private investments in human, physical, and social capital to reduce the severity or magnitude of damages to property as a result of a major storm event.

Under the endogenous risk framework, the household model of private investment in protection against storm-inflicted damages reveals four household types: (1) households pursuing *both self-protection and self-insurance*; (2) households practicing *only self-protection* but no self-insurance; (3) households pursuing *only self-insurance* but no self-protection; and, (4) households practicing *no self-protection and no self-insurance*.

Comparative static results of our theoretical model reveal that for a risk-averse household, *ex-ante* public programs, such as government spending on infrastructures in terms of embankments, dams, roads and highways, education on major storms and early storm warning systems, lead to more private investments in self-protection (crowding-in), but less private investments in self-insurance (crowding-out). On the other hand, private investment allocations for self-protection declines (crowding-out) but self-insurance increases (crowding-in) if households have more access to *ex-post* public-assisted disaster relief and rehabilitation programs once the major storm event has occurred. However, we can trace out the possible influences of *ex-post* public programs on private storm protection actions by assuming a household is risk-neutral rather than risk-averse. Regarding the influence of private inward remittances, we find that self-protection declines if households have more access to private remittances and charities. This implies that self-protection and private remittances are substitutes. Conversely, self-insurance increases with more access to

private remittances. Hence, self-insurance expenditures and private remittances are complements.

There is significant evidence of some of the important conditions applied in our theoretical model. However, the direction of the sign of relationships between public programs and private storm protection behavior is an empirical question to provide credence to our theoretical underpinnings. Same also applies in determining the sign of the relationships between private inward remittances received from a migrant family member and its possible influence on private storm protection behavior. It will be interesting to see whether access to either public programs or private inward remittances is enough to deter or encourage private investments to reduce risks from storm-inflicted damages to property by averting the likelihood as well as reducing the severity or magnitude of such risk event.

Our theory of household private investment in storm protection could be generalized to all coastal communities that are affected by climate change. Hypotheses based on the research questions and the propositions derived from the theoretical model could be tested empirically. Findings from such studies could recommend the steps that the governments might take to develop an institutional setup under joint public-private partnerships by encouraging more collective and individual participation in storm-protection activities among the vulnerable communities. By identifying and nurturing such form of institutions, governments representing the low-and middle-income countries would be able to mitigate the impacts of market failures due to moral hazard and adverse selection that arise from public-sponsored programs. In addition, we consider that identifying the channels through which private inward remittances directly and indirectly influence private storm protection behavior or attitudes towards reducing the likelihood as well as severity from storm-inflicted damages to property has some serious policy implications in the future. Outcomes from our research will be particularly relevant for developing countries' (especially from south-east Asia and small island states of the Pacific) intention to promote and support sustainable development projects by improving their resilience and response capacity to cope against natural disaster events as a result of global climate change.