Natural Hazard Risk and Privatization

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Increases in natural hazard losses intensify the need for financing dedicated to reconstruction. Multilateral institutions are addressing this issue and establishing new programs. For example, the World Bank recently implemented a Private Sector Development Strategy (PSDS) with the objective of increasing private participation in infrastructure. As noted by the Bank:

Most poor people in developing countries have little or no access to efficient infrastructure services. Typically, government policies aim at expanding access to infrastructure services and at rendering it affordable. Yet, progress has been slow in a number of the poorest countries. (PSDS 2002:10)

The tool to expand and accelerate access to infrastructure services is the harnessing of the private market to improve infrastructure services, particularly in telecommunications, electricity distribution and water pipeline systems. The PSDS focuses on activities that increase the use of the private market to provide essential services, including infrastructure.

The process of privatization is complicated. For each project, establishing the macro conditions necessary and conducting detailed cost/benefit analysis are required at a national level. Privatization can be described as a process that transfers responsibility for the provision of goods and services from the government to the private sector. The process also allocates risk for the provision of these goods and services from the government to a private party. In exchange, the private party is provided revenue sources.

A difficult task in the privatization process is allocating risk to the participating parties. A key principle of risk allocation is the assignation of risk to the party best able to cope, though the risks associated with privatization are often complex. The identification and allocation of risk is a central theme of manuals designed to assist in the privatization process.¹

This paper explores the role that privatization can play in shifting the risk of financing post-natural-disaster reconstruction from the government to the private sector. This is a topic not explored in detail in existing literature. Current practice allocates risk of infrastructure loss from natural hazard events to governments. Existing practice is predicated on the long-standing principle that governments are best able to cope with large, uncertain risks -- the type of risk that characterizes natural hazard catastrophe risk. Through the power of taxation, governments can efficiently transfer these types of risk to taxpayers.

For a number of developing countries, the risk of loss from natural hazards may be more efficiently handled by the private market. The relative cost of transferring risk to taxpayers may be more expensive than transferring risk to the private sector. For these countries, considering

¹ In 1998, the United States Department of Energy issued two sets of guidelines for privatization projects that remain benchmarks for work in privatization. The first is a Program-Project Manager’s Privatization Guide and the second is Privatization Cost Estimating Guide. These documents can be found on the website for the Department of Energy (http://www.em.doe.gov/private/projmangu.html). The Organization of Economic Cooperation and Development (OECD) has a Working Group on Privatization and Governance of State-owned Enterprises with a comprehensive list of documents related to privatization (http://www.oecd.org/EN/document/0,,EN-document-80-3-no-20-19549-80,00.html). As relates to work in developing and emerging economies, the Asian Development Bank has a Public-Private Infrastructure Advisory Facility (http://www.adb.org/Documents/ADBBO/RETA/35078012.ASP) that has examined best practices for privatization in a number of industries.
natural hazard risk as part of the bundle of risks transferred and a component of the privatization process may be warranted.

This paper will address natural hazard risk and privatization through discussion of the increasing costs of disasters to infrastructure; detailing the existing justification for allocating natural hazard risk to governments in the privatization process; exploring circumstances in which existing practice may be inappropriate; and discussing areas where additional research is needed.

Natural Hazard Losses to Infrastructure.

The losses to infrastructure from natural hazards are significant and continue to escalate at an increasing rate. Research indicates two main factors that contribute to these losses: increasing concentrations of people and assets in hazard-prone regions of the world and increases in the intensity and frequency of severe weather-related events. This section will briefly review these trends.

**Rising total direct damages from extreme events**

The ever increasing losses from natural hazard events are an important issue for economic development and poverty reduction. Over the last 10 years, economic losses from natural disasters have averaged nearly $580 billion a year. This is a 7.7-fold increase in losses from the decade of the 1960s (Munich Re 2002). Due to differences in size of economies in industrialized and developing countries, however, the per economic losses per capita were 20 times greater in developing countries (Bendimerad 2000). From 1991 through 2000, 2.1 billion people were affected by natural disasters; an average of 211 million people annually. Of that number, 98 percent lived in medium and low development countries as classified by the United Nations (IFRC 2001). Between 1990 and 1998, 94 percent of the world’s major natural disasters and 97 percent of all natural-disaster-related deaths were in developing countries (World Bank 2001).

**Figure 1: Economic losses from natural catastrophes in the 20th century**

![Graph showing economic losses from natural catastrophes from 1960 to 2000.](image)

Source: Munich Re 2002
**Relationship between Increased Damage and Climate Change**

Researchers have isolated several factors contributing to the rising trend in direct damage from catastrophes. One significant factor is the acceleration in weather-related natural hazard events such as hurricanes, cyclones and flooding. They account for nearly two-thirds of all losses from natural hazards while earthquakes account for most of the remaining third. Figure 2 divides losses into specific types of events and shows that while earthquake occurrences have remained relatively stable over time, the incidence of weather-related events has accelerated. The economic costs of rainstorms, floods, droughts, and other extreme weather events have increased 14 times from the decade of the 1950’s to the decade of the 1990’s (Munich Re 2002).

![Figure 2: Natural catastrophe trends in the Twentieth Century](image)

**Socioeconomic Factors and Increased Vulnerability to Natural Hazards**

While the increasing frequency and severity of extreme weather events impacts the cost of natural hazard risk, the most important variable increasing damage is the concentration of human populations and their assets in hazard-prone regions.

It is estimated that natural disaster losses will increase dramatically over the next 50 years. The global cost of natural disasters is anticipated to top $300 billion annually by 2050 (ISDR 2001). There are two broad demographic trends directly impacting the increasing losses from natural hazards in the developing world: population growth and the concentration of populations in megacities. In 1999, the world’s population surpassed 6 billion. This represents a tripling of population since the beginning of the twentieth century. According to U.S. Census Bureau projections, the world population will increase to nearly 8 billion by the end of 2025 and

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reach 9.3 billion by 2050 -- a 50 percent increase above current levels (Census Bureau 1999). Ninety-nine percent of the global increase will occur in developing countries. In 1960, 70 percent of the global population lived in less developed regions. By 1999, that percentage had increased to 80 percent (UNFPA 1999), though increases in population do not necessarily translate into increased vulnerability to natural hazards.

Populations are concentrating in urban areas. The movement of people toward cities has accelerated in the last 40 years, with 47 percent of the world’s population living in cities compared to one-third in 1960. The growth of cities results from births and migration to the cities from rural areas. In developing countries, the proportion of people living in cities has doubled since 1960, with more than 40 percent now living in urban areas. This trend is expected to continue and by 2030 nearly 57 percent of the population in less developed regions will live in urban areas. In Latin America and the Caribbean, it is projected that more than 75 percent of the population will reside in urban areas by 2030 (UNFPA 1999). Urban concentrations in Latin America are the highest in the world (Charveriat 2000).

Increasing population concentrations in urban regions are primarily concentrated in “megacities” with populations of more than 10 million people. In 1960, only New York and Tokyo had populations greater than 10 million. By 1999, there were 17 cities of that size, 13 of which were in less developed countries. It is projected that by 2015 there will be 26 mega cities, 22 of which will be in less-developed regions of the world. Nearly 10 percent of the world’s population will live in these cities, up from just 1.7 percent in 1950 (UNFPA 1999). Urbanization increases risk by concentrating people and investments in limited geographic zones. As a result, natural hazards can inflict substantial damage in a short period of time. Hurricane Andrew inflicted $20 billion in damage in a few hours when it struck Miami in 1992 (Blaikie 1994).

Megacities are highly vulnerable to natural disasters. Nearly half of the world’s largest cities are situated along major earthquake zones or tropical cyclone tracks (Bendimerad 1999). Floods, earthquakes, and tropical cyclones often strike the same geographic zones more than once and some of the highest risk areas are also the most populous. India, China, and Southeast Asia are at high risk from seismic activity and floods, hurricanes, and cyclones. Increasing population concentrations in urban areas far outstrip the capacity of cities to absorb this growth. In the 1990s, 60 to 70 percent of urban growth was unplanned (ISDR 2001). Since governments in many developing countries already struggle to provide basic services to burgeoning populations, however, it is already difficult to find resources to decrease the vulnerability of poor residents of megacities to natural disaster risk. The spiraling costs of natural hazard events in developing countries are linked to the increasing number and intensity of events as well as concentrations of urban poor in hazard-prone regions. Losses from catastrophes will be reflected in increasing infrastructure loss.

Current Infrastructure Losses as a Component of Worldwide Direct Losses

Since total direct damage increased dramatically worldwide over the past decades, it can be assumed that infrastructure damage as a portion of overall losses increased as well. Data from World Development Indicators (World Bank 1999) show that 24 percent of invested capital stock is public infrastructure. As of 2001, total direct losses for infrastructure have reached $9.6 billion, though this annual loss figure can vary significantly depending upon the frequency and severity

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3 Earthquake risk lies along well-defined seismic zones that incorporate a large number of developing countries. High-risk areas include Turkey, Pakistan, Afghanistan, India, China, Indonesia and the west coasts of North, Central and South America. The pattern of hurricanes in the Caribbean and typhoons in South Asia, Southeast Asia, and the South Pacific is well established. Floods occur on 1 percent of the worldwide landmass. (Swiss Re, 1997).
of weather-related events in a given year. Based on historical data, infrastructure losses in 1995 alone were $32.6 billion (Munich Re 2002).

Research suggests that specific types of infrastructure are vulnerable to different types of natural hazard events. Housing and roads are particularly vulnerable to earthquake damage (Albala-Bertrand 1993). Droughts may have minor impacts on infrastructure and productive capacity, but can result in heavy crop and livestock losses. Floods can cause extensive damage to infrastructure and other production capacities such as wiping out agricultural yields (Benson and Clay 2000).

In a manual for estimating the socioeconomic effects of natural disasters, the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) provides broad outlines of the most probable types of infrastructure damage by type of disaster. For example, the manual explains how floods can impact clean water supplies; damage buried and semi-buried tanks and dam structures; and harm pump equipment. Floods were considered to cause damage in all infrastructure categories, deteriorating or destroying integral structural components, deforming the land on which infrastructure rests, or rendering it useless when wind and water have deposited extraneous material such as mud, ash, and debris. Droughts tend to impact infrastructure more mildly, though highways can buckle and railroad tracks can misalign when soldered rails become distorted. Windstorms put additional stress on buildings, affecting both structural and non-structural elements, though only minimally affecting foundations and underground elements (ECLAC 1999).

Since different types of infrastructure are differently affected by disasters, the impacts of climate change will likely affect critical infrastructure. Increases in flooding and windstorms will have implications for buildings, bridges, roads, and water systems whereas droughts will affect agriculture and some transportation systems.

Allocation of Natural Hazard Risk in the Privatization Process

The loss of infrastructure due to natural hazard events is well known, though at issue – and the topic of this paper - is finding the most appropriate entity to bear the cost of post disaster reconstruction. As a general proposition, the risk of loss to government-owned assets is best borne by the government. The justification lies in the ability of governments to use their power of taxation to spread the cost of loss to their taxpayers. Generally, the relative size of the loss to the capacity of the government to spread the loss across taxpayers has made governments the most efficient instrument to manage risk. “It is profitable for all concerned that risks should be shifted to the agency best able to bear them through its wealth and its ability to pool risks. The government, above all other economic agencies, fits this description” (Arrow 1992). The characteristic that a government is the most efficient entity to bear risk underpins decision-making about government investments.

Most governments maintain a risk-neutral position: they ignore the risk in making public investment decisions. Justification for this approach is found in the work of Kenneth Arrow (Arrow and Lind 1970). The critical question for Arrow is: “What is the per capita cost of public risk bearing?” The answer lies in computing individual costs and weighting them against the benefits of public risk bearing. As the cost of risk approaches zero in the hands of each individual, the risk also approaches zero for the government. As the cost of risk per citizen or per person that can be taxed approaches zero, the risk for a country’s total wealth decreases. As Arrow states, “when the government undertakes an investment it, in effect, spreads the risk among all the taxpayers.”

A second basis for government risk-neutrality is based on portfolio theory. Since risk may be reduced by portfolio diversification as well as spreading risk over large populations, the government as owner of a wide variety of investments has the potential for the widest portfolio diversification. This theory underpins work by Paul Samuelson on capital investment decisions.
made by governments, which arrives at similar conclusions to Arrow’s analysis (Samuelson and Vickrey 1964; Arrow and Lind 1970).

Because of the risk-neutral status of governments, they are the natural entities to which risk is often shifted by societies. In industrialized countries, the government supplies insurance for retirement. In many countries, medical care is financed by the government, particularly for the aged and indigent (Priest 1996). As relates to natural hazard losses, the government is often the agent to assume the risk of loss for its citizens (Lewis and Murdock 1999).

The risk-neutral status of governments has influenced the behavior of industrialized countries in dealing with natural catastrophe risk in the privatization process. In examining opportunities to privatize energy activities in the United States, the government explicitly retains the risk of natural hazard losses in the privatization process. Guidelines from the U.S. Department of Energy (referenced in footnote 1) state that the risk of loss from natural hazards is less expensive in the hands of the government than any other party. As a result, the government is presumed to be better off by retaining the risk of loss from natural hazards than attempting to transfer the risk as a component of the privatization process. The same justification has been applied to privatization of government-owned facilities in developing countries (Lewis and Mody 1998).

While the theory of government risk-neutrality may be applicable to most industrialized countries, the use of this theory to justify assumption of natural hazard risk by governments in all cases is limited. As relates to the privatization of infrastructure projects, the theoretical limits of the policy have a particular application.

Arrow recognized limitations on the general theory of the risk neutral status of governments (Arrow 1970). He was particularly interested in projects where the loss would be felt by one specific group. For example, a bridge that services a limited geographic region. In this case, it is appropriate that the risk profile of the geographic region to dictate how risk for that project be managed. Another example cited by Arrow concerns government projects directed at a particular population group that receives the benefits of a project and bears its risk of loss. An irrigation project in a defined watershed region is such an example. In this case, if the risk of loss is borne by those dependent upon the project, Arrow maintains that the risk profile of the directly-impacted group, not the entire population, is most relevant. Both of these examples highlight the same principle: if the risk of an investment is borne by a limited group, the risk adversity of that group should dominate the investment decision (Arrow 1970).

As to the comparative advantage of the government in diversifying risk through its portfolio strategy, a compelling argument can be made that this is a small advantage when dealing with correlated risk. The risk of loss from catastrophes in smaller countries is correlated since the catastrophe is likely to impact the entire country at the same time. The core of the portfolio strategy lies in aggregating independent risks, whose error terms cancel out increasing predictive ability. This does not occur when aggregating highly variant risks (Priest 1996).

Several arguments emerge as to why developing countries should be risk-averse. For many, the large size of the potential loss in absolute terms in comparison to their internal risk spreading ability means that risk does not approach zero in the hands of the population. Honduras presents such an example. In 1998, Hurricane Mitch caused total losses approaching $5 billion in a country with a total population of 4 million. Seventy percent of the population earn less than $2 per day (World Bank 1999). The average per capita cost of $1,250 per person, therefore, is not insignificant and the cost of risk does not begin to approach zero for Honduras or countries in similar circumstances.

The mere calculation of per capita cost does not reflect the difficulty countries have in increasing internal tax revenues. Many have only a limited ability to spread the cost of risk
internally through taxation (Rodrik 1998). Many countries rely on a system of indirect taxes, the
increase of which has political implications for specific segments of society. For these countries,
the budgetary adjustment process is difficult and politically costly (Lewis and Murdock 1999). As
a result, the process of spreading even small dollar amounts of risk has high political costs (Meier
1995). In addition, shallow financial markets and weak financial systems limit the capacity to
access internal and commercial external savings in times of catastrophes (Ferranti, Perry et al
2000). Therefore, even if the cost of risk approached zero in the hands of each taxpayer, the
barriers to transferring the risk to each taxpayer can be high in many countries.

This raises a critical issue when examining risk spreading. The issue for some
governments is not only the absolute size of the risk; it is also the relative ability of a country to
dedicate resources to dealing with the risk. In examining external shocks to economies, a growing
body of research is emerging to describe why some countries recover from shocks better than
others. These studies relate primarily to credit and commodity price shocks (Cornelius 2000). A
core factor is that financial markets in many countries remain shallow and financial systems are
weak (Ferranti, Perry et al 2000). The imperfections of the financial markets severely limit their
ability to diversify risk and reallocate financial resources during times of distress. Another factor
of economic recovery is the political will of the country to reallocate costs of adjustment
programs within the domestic economy (Rodrik 1998). In a study examining differences in
recovery from the recent debt crises in East Asia and Latin America, Rodrik found that countries
with the ability to distribute the cost of risk with few political repercussions were able to recover
relatively quickly. These countries tended to be located in East Asia. However, countries that
lacked the ability to allocate the cost of risk without considerable political turmoil took long
periods of time to recover from external shocks to their economies. These countries tended to be
in Latin America. In the meantime, economic growth within these slowly recovering countries
was significantly curtailed (Ferranti, Perry et al. 2000). The importance of this observation is that
risk aversion at a government level should be influenced as much by the capacity of the country
to allocate risk within society as the relative size of the risk. Since many countries have difficulty
reallocating internal resources, reliance on external debt is often the preferred tool to address the
need for additional resources (Cornelius 2000). Additional external debt may have the least
internal political cost.

As described earlier, it is not clear that governments in smaller countries can efficiently
spread highly-correlated risk. Since natural disasters tend to recur within geographically defined
regions and can impact significant portions of smaller countries, no benefit arises from
aggregation of risk at the country level (Priest 1996). This analysis begins to define investment
decisions where the traditional assumption of government risk neutrality should be challenged.
The first group of decisions are those for which the risk of loss relative to the capacity of the
population to absorb the risk is high. Honduras is a good example of this problem: the risk of loss
on a per capita basis is very high.

Risk analysis is different for another group of countries that includes those where the cost
of catastrophe losses per capita is small, but the ability to shift the cost of risk to the population is
limited. These are countries with fragile taxation systems and those with weak democratic
institutions that lack the power to impose costs on entrenched power elites within the country. As
described earlier, Rodrik has identified a group of countries that lacked the ability to institute
required political change to adjust to non-catastrophe external stocks, despite the considerable
costs borne by these countries due to a lack of economic growth. The countries he identified,
primarily in Latin America and Africa, would likely lack the political will to allocate the risk of
loss internally through taxation. The World Bank has also developed an index that describes
countries with imperfect financial markets that tend to magnify rather than absorb the cost of external shocks (Ferranti et al. 2000). A third situation arises when investments target the poor. If a specific group benefits from government investment, the risk profile of that group should dictate how risk is handled.

An analysis of when government should assume risk associated with past investment decisions has a direct bearing on what risks should be assumed or transferred by governments in the privatization process. As noted earlier, the risk neutral status of governments in industrialized countries leads them to retain natural hazard risk in the privatization process. The issue of concern for developing countries is whether the same theory holds true, particularly for those with high catastrophe exposure.

**Capacity of Countries to Absorb Natural Hazard Risk**

A key principal in the privatization process is the identification and allocation of risks to the party best able to cover them. With respect to infrastructure projects, there are a wide variety of risks that must be addressed such as risks during construction, projected use of new infrastructure, the willingness of people to pay to use the infrastructure, and the maintenance and ongoing operations required. As discussed earlier, another risk is the partial or complete destruction of a project by a natural hazard event. Since this risk may be large, and such losses are often difficult to predict, it is a risk generally retained by governments.

Increasingly, research has measured the risk of loss from natural hazards in developing countries and the capacity of countries to manage that risk. In a recent study for the Inter-American Development Bank, a technique was developed that measures the capacity of a government to finance probabilistic losses from natural hazard events. For the Dominican Republic, El Salvador, Bolivia and Colombia a “resource gap” was developed. A resource gap is a measurement of a country’s ability to finance its reconstruction obligations following a disaster. Calculation of the resource gap requires the following computations:

- **Country risk from natural hazard losses.** The risk is a function of the probability of hazards of different magnitudes impacting a country and the vulnerability to loss of the potentially exposed population and assets.
- **The financial responsibility of the government to finance country losses.** Primary losses from disasters may be the responsibility of various parties in addition to the government: industry, businesses, homeowners, and individuals. For this analysis, we are concerned about the portion of loss borne by the government;
- **The capacity of the government to meet its financial obligations.** To the extent that a government lacks the resources to fund its obligations there is a natural hazard resource gap. The required resources may come from international aid, government revenues (taxes), reserves, insurance proceeds, borrowing, and the diversion of resources from other programs.

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4 The discussion in the following section is based on work done for the Regional Policy Dialogue of the Inter-American Development Bank on Natural Hazard Risk. The resource gap described in this section is based on methodology prepared by Leslie Martin and described in greater detail in Freeman and Martin, “National Systems for Comprehensive Disaster Management: Financing Reconstruction,” May 1, 2002. The paper and methodology can be found at the Regional Policy Dialogue web site: (http://www.iadb.org/int/drp/).
A natural hazard resource gap articulates the ability of a government to meet the needs of financing post disaster reconstruction. For countries with a resource gap, it means that significant costs to meet the risk of loss to natural hazard risk will be incurred.

**Resource Gap**

A *natural hazard resource gap* is developed for each of the case study countries. The resource gap is a measurement of the inability of a country to finance its reconstruction obligations after a disaster. The measurement of the resource gap requires the calculation of a catastrophe exposure for each country. Catastrophe exposure is determined by combining hazard and vulnerability estimates for each country. The following catastrophe exposure estimates are developed:

<table>
<thead>
<tr>
<th>Country</th>
<th>20-year event</th>
<th>50-year event</th>
<th>100-year event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>200</td>
<td>600</td>
<td>1,000</td>
</tr>
<tr>
<td>Colombia</td>
<td>2,000</td>
<td>5,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>1,250</td>
<td>3,000</td>
<td>6,000</td>
</tr>
<tr>
<td>El Salvador</td>
<td>900</td>
<td>3,000</td>
<td>4,500</td>
</tr>
</tbody>
</table>

All values in millions of U.S. dollars

For example, Bolivia can expect direct losses to capital stock of at least $200 million approximately every 20 years; more specifically, there is a 1-in-20 chance every year that there will be a catastrophic event equaling or exceeding $200 million in losses. Likewise, there is a 1-in-50 chance, or 2 percent probability, every year of at least $600 million in direct losses. The magnitude of that figure could double, however, if indirect losses from lost production, tourism, and other services were to be included.

Since the capacity of governments to finance obligations after a disaster is often limited, it is essential to know the responsibility of the government for a country’s catastrophe exposure. Generally, two broad categories of governmental responsibility can be defined: risk to government-owned property and the risk a government assumes from others. In the former, the risk of loss is to government buildings, schools and hospitals, and infrastructure such as roads, bridges, and airports. The second category is the risk that government assumes from others. This generally includes the risk to homeowners, agriculture, local and provincial governments, and the poor.

It is estimated that the government will finance 50 percent of the losses in the four countries. Table 2 (which is 50 percent of Table 1) shows the share of losses borne by the government:

<table>
<thead>
<tr>
<th>Country</th>
<th>20-year event</th>
<th>50-year event</th>
<th>100-year event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>100</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>Colombia</td>
<td>1,000</td>
<td>2,500</td>
<td>4,000</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>625</td>
<td>1,500</td>
<td>3,000</td>
</tr>
<tr>
<td>El Salvador</td>
<td>450</td>
<td>1,500</td>
<td>2,250</td>
</tr>
</tbody>
</table>

All figures in millions of U.S. dollars
These estimates represent government responsibility for reconstruction of government-owned property as well as the assumption of risk to private housing, agriculture, and programs targeting the poor in post-disaster periods.

Once an estimate of future financing needs has been determined, the next question addressed is the ability of government to meet those needs. Is there a gap between the probabilistically-determined resources and the ability of the government to fund the required resources? The potential difference is a resource gap. A resource gap is calculated by comparing a government’s probabilistic or contingent need for reconstruction funds in the current year with its anticipated access to internal and external funds. Table 3 shows the estimated resource gap for the four countries:

Table 3: Resource gap in case study countries

<table>
<thead>
<tr>
<th></th>
<th>Bolivia</th>
<th>Colombia</th>
<th>Dom Rep</th>
<th>El Salv</th>
<th>Bolivia</th>
<th>Colombia</th>
<th>Dom Rep</th>
<th>El Salv</th>
<th>Bolivia</th>
<th>Colombia</th>
<th>Dom Rep</th>
<th>El Salv</th>
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</thead>
<tbody>
<tr>
<td><strong>20-year recurrence</strong></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Direct damages</td>
<td>200</td>
<td>2000</td>
<td>1250</td>
<td>900</td>
<td>800</td>
<td>5000</td>
<td>3000</td>
<td>3000</td>
<td>1000</td>
<td>6000</td>
<td>4000</td>
<td>2250</td>
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<tr>
<td>Gov responsibility</td>
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<td>1000</td>
<td>625</td>
<td>450</td>
<td>300</td>
<td>2500</td>
<td>1500</td>
<td>1500</td>
<td>500</td>
<td>4000</td>
<td>3000</td>
<td>2250</td>
</tr>
<tr>
<td>Aid</td>
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<td>17</td>
<td>11</td>
<td>8</td>
<td>5</td>
<td>43</td>
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<td>20</td>
<td>9</td>
<td>69</td>
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<tr>
<td>Insurance Payments</td>
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<td>50</td>
<td>31</td>
<td>23</td>
<td>15</td>
<td>125</td>
<td>75</td>
<td>75</td>
<td>25</td>
<td>200</td>
<td>150</td>
<td>113</td>
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<tr>
<td>Budget realloc</td>
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<td>1500</td>
<td>500</td>
<td>250</td>
<td>250</td>
<td>1500</td>
<td>500</td>
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<td>250</td>
<td>1500</td>
<td>500</td>
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<tr>
<td>New taxes</td>
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<td>500</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>1000</td>
<td>0</td>
<td>190</td>
<td>0</td>
<td>1500</td>
<td>0</td>
<td>270</td>
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<tr>
<td>Domestic credit</td>
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<td>0</td>
<td>150</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>150</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>External credit IDB/WB</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
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<td>200</td>
</tr>
<tr>
<td>External credit market</td>
<td>0</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>0</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>0</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Resource gap w/o IDB/WB</td>
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<td>579</td>
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<td>1150</td>
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<tr>
<td><strong>100-year recurrence</strong></td>
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<td>731</td>
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The resource gap for each country depends upon critical assumptions regarding the ability to access internal and external resources. For example, the resource gap in Colombia is primarily affected by the ability to raise funds through taxation. Historically, Colombia has raised internal taxes as a major tool in financing natural disaster losses. It is assumed that Colombia could raise taxes by an additional $1.5 billion if required. If it has the ability to raise taxes by $2 billion, the resource gap for the 100-year event would disappear. The resource gap is also dependent upon a series of assumptions regarding future financing sources. The report details all assumptions used and the source of the data. The chart raises this question: How are countries able to finance their probabilistic losses from natural hazards? The resource gap provides the basis for evaluating whether a country can efficiently absorb losses to infrastructure. In some cases, transferring the risk of loss from natural hazards to the private market as a component of the privatization process might be the best option for countries with a high resource gap.

Before addressing this option, however, the variations in the resource gap among countries should be understood. According to this analysis, Bolivia can anticipate no resource gap over the range of 20, 50, and 100-year events, though Bolivia is the poorest country in South America and would be expected to be the most vulnerable. Its level of hazard risk, however, is so low that it should have sufficient resources (assuming substantial increased borrowing) to respond. Colombia, by contrast, has a very high natural hazard risk, but per capita incomes are high and risks are geographically diverse. The government should be able to absorb the cost of disasters until it reaches a 100-year event. Even then, its resource gap can be covered if the government is able to raise taxes. Alternatively, El Salvador and the Dominican Republic can anticipate resource gaps given their catastrophic risk exposure. Both countries are small and have limited geographic diversity with respect to risk, a high exposure to large-scale natural disasters and limited financial resources. For these two countries, there is at least a 1 in 100 chance of being struck by an event that outstrips their ability to raise post-disaster reconstruction funds.

The calculation of a resource gap for countries is the beginning of a process. The resource gap identifies possible sources of financing for losses from natural hazards, but the analysis does...
not quantify the cost of accessing those resources. As discussed earlier, accessing available resources has a cost. There are political costs to raising taxes and diverting budgetary allocations. The use of increased debt absorbs borrowing capacity that may be better used for other purposes. The borrowing gap calculation frames the issue so that a determination of whether it is more efficient for a government to retain or transfer risk of natural hazard losses as a component of the privatization process can be made.

Conclusions and Future Research

The need to expand the provision of infrastructure in developing countries is clear. The use of privatization as a tool to assist in the extension of infrastructure to the poor is a priority of the international financial community. While myriad issues are associated with privatization, defining and allocating risk as a component of the privatization process to determine the most cost-effective allocation is especially difficult. If risks are large and difficult to control, government retention of the risk might prove the best option. These risks will be extremely expensive to shift to the private sector and in the worst case, could prove to be a "deal killer." Justification for government assumption of risk is that governments are best able to handle unknown risk through their power of taxation. The ability to spread risk to taxpayers is an enormous efficiency advantage of governments.

Circumstances exist where it may be more efficient for the risk of natural hazard losses be shifted to the market as a component of privatization. The main circumstances are:

- The project benefits a limited geographic area.
- The project assists a limited population group such as the poor.
- The size of the risk is larger than the capacity of the government to shift the risk efficiently to the population. For those countries with a resource gap, it may not be possible for them to finance the natural hazard risk.
- Countries without a resource gap may have institutional barriers that prevent them from shifting risk to their populations. For countries lacking the ability to develop institutional compromise, the political costs of financing post disaster reconstruction may make it more desirable to include risk as a component of the privatization process. This may be the case for a number of Latin American countries.

In these instances, the cost of transferring risk to the market should be considered a component of privatization. It may be that the cost of assigning the risk to the market is too high and the risk must be absorbed by the government, but natural hazard risk should not be placed automatically, as is currently done, in those categories of risk best left with the government. As the losses to infrastructure continue to escalate, the ability to shift the risk from natural hazards to the market will become increasingly important.

The analysis presented in this paper also has application to other types of risk that may arise from the privatization process. In Eastern Europe, for example, the privatization of state-owned manufacturing enterprises is ongoing. Many of these facilities involve chemical and hazardous waste risk from prior operations. Mechanisms such as environmental insurance exist for market assumption of private enterprises and the risk associated with contamination created from prior business operations, including chemical facilities (Freeman and Kunreuther 1997). It may be that risks from prior hazardous chemical operations may also be more efficiently handled by the transfer of the risk as a component of the privatization process.

Research on the proper allocation and financing of natural and manmade hazard risk for developing countries is in the early stages. For many countries, information about the level of risk to infrastructure has not been systematically developed, although techniques to make the
necessary calculations are well understood. The concept of “risk aversion” for governments is not well understood, either. As globalization continues, it may be that the market (including large international corporations) is much more efficient in coping with natural hazard risk. If so, it makes the most sense for that risk to be assumed by the market as a component of the privatization process.

Specifically, the following issues need to be addressed:

- The exposure of an infrastructure project to natural hazard risk.
- The capacity of a country to absorb the risk.
- An evaluation of infrastructure projects to determine their primary beneficiaries and an analysis of the risk tolerance of that particular group.
- The cost of the assumption of the natural hazard risk by the market on a project by project basis.

A number of these questions are novel in the context of developing countries. With increased losses to infrastructure from natural hazard events, the efficient assumption of risk will be increasingly important.
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