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Decentralization and Natural Disasters

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Decentralization and Natural Disasters

Abstract

This paper surveys recent research on decentralization and natural disasters. The first part discusses results from theoretical models that have been used to study the issues that arise when natural disasters occur in a country with more than one level of government. The next section discusses the empirical results that have been found in the literature. A third section briefly touches upon practical problems that arise when decentralized governments are confronted with a natural disaster. The paper concludes by reflecting on what we know about whether policies to confront natural disasters should be centralized or decentralized.

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Keywords: natural disasters, decentralization, risk-sharing, redistributive transfers, federalism, intergovernmental relations, grants.

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I. Introduction

Natural disasters, such as floods, droughts, hurricanes, tornados, earthquakes, wildfires, tidal waves, and so forth have devastating effects on communities. The effects can be localized or spread across wide geographic areas. Private insurance is often available for homeowners, but governments also provide insurance in the form of disaster relief and invest in infrastructure to mitigate damages and loss of life from disasters. A national government is in a natural position to provide insurance across sub-national regions – it can pool risks. However, decentralized governments are often in a better position to know what infrastructure investments are needed in a locality. There is thus a natural interplay between national and sub-national governments in the ex-ante planning and investment in infrastructure, and ex-post clean-up and financial assistance after a disaster occurs.

Issues of planning, ex-ante investment, and ex-post clean-up of natural disasters are becoming more important. Figure 1 indicates the worldwide rise in estimated damages of natural disasters from 1975 to 2000. Many of these expensive natural disasters have taken place where governments are decentralized. Figure 2 shows the world distribution of the highest risk places in terms of economic loss for various types of natural disasters. One interesting fact to be noted from this figure is the degree to which economic losses occur in federal countries. Another is the variation in type and severity of disasters across the regions of federal countries. While all countries are affected by natural disasters, the frequency, variation, and severity of the effects in federal countries is notable. The map indicates that among the countries with the highest risk in terms of economic losses are federal countries such as the United States, Brazil, India, Japan, and China.

Figure 3 focuses on countries within Asia and shows the number of occurrences of a natural disaster within sub-regions of countries between 1974 and 2005. It is clear that most sub-regions within these countries have suffered from natural disasters. Indeed it is difficult to find sub-regions in Asia that did not suffer from natural disasters in Figure 3. Nevertheless, the frequency of disasters varies substantially between the regions pictured.

Of course, the incidence in Figures 2 and 3 relate to the size and location of these countries rather than their federal nature per se, but also suggests that any issues that are particular to decentralized governments and natural disasters are important to understand. In a federal or decentralized country, national insurance for disasters has complex incentive effects. First, in a decentralized system of government, regions typically have an interest in and actively plan and fund protective infrastructure projects designed to mitigate disasters. At the same time the national government has a natural role to play since national insurance pools risks across regions. With such national insurance, regions that get hit by natural disasters receive funds from regions that do not get hit. National disaster insurance and its' implied inter-regional transfers combined with regional responsibility for disaster prevention measures set in motion certain incentives that lie at the heart of the issues discussed in this chapter.

The chapter is composed of four sections after this one. The next section discusses results from theoretical models that have been used to study the issues that arise when natural disasters occur in a country with more than one level of government. The third section discusses the empirical results that have been found in the literature. A fourth section briefly touches upon practical problems that arise when decentralized governments are confronted with a natural disaster. The fifth part concludes by reflecting on what we know about whether policies to confront natural disasters should be centralized or decentralized.

II. Insights from Theoretical Models

Natural disasters are uncertain events with uncertain impacts on ex-post incomes. As such, the modeling of natural disasters in a decentralized setting is clearly related to the modeling of inter-regional insurance, and there are a number of models in that area that examine such insurance (such as Lockwood (1998) and the references therein). However, the explicit modeling of natural disasters in a decentralized setting is relatively unexplored, with only a few papers that explicitly model natural disaster policy when there are different levels of government. The main theoretical papers to date on the subject are Goodspeed and Haughwout (2012), Wildasin (2011), Lohse and Robledo (2013) and Buzzacchi and Turati (2009). These papers use slightly different models and concentrate on somewhat different aspects of the problem. Our initial discussion relies on the Goodspeed and Haughwout (2012) framework as a workhorse model. We then expand our discussion to consider mobility (the subject of Wildasin's model), private disaster insurance (the subject of Buzzacchi and Turati), and the welfare gain from joining a federation (examined in Lohse and Robledo).

A. National Disaster Insurance and Decentralized Protective Infrastructure Investment

Our initial frame of reference for thinking about natural disasters and decentralization will rely on the model of Goodspeed and Haughwout (2012) as a workhorse. This model uses a simple framework that nevertheless yields a number of important insights. It is a version of the model of Persson and Tabellini (1996), who study the institutions of federalism in an economy characterized by uncertainty about future income in distinct regions of a federation. This is an insightful framework to study the disaster issue in a federation because decentralized governments are often left in charge of preparing for disasters by implementing and often

overseeing and funding protective infrastructure investments, an important characteristic of this model. These regional and local investments will affect the damages from the natural disaster, or the probability of an income loss. In the Goodspeed and Haughwout version, a region is viewed as having certain income in the present but uncertain income in the future due to the possibility of a natural disaster. A region that is hit by a natural disaster in the future will suffer an income loss. Regions cannot affect whether they are hit by a natural disaster, but they can invest in protective infrastructure in the present which lessens the probability of a loss of income in the future.

It is often the case that many regions within a country are subject to risks from some sort of natural disaster, but the damages associated with a particular natural disaster event are more localized. The national government can facilitate the transfer of resources from regions that are spared a particular natural disaster to regions that happen to be hit by the natural disaster. This is the logic of the role of national government risk-sharing.

A first question that arises when thinking about national transfers that share natural disaster risk is how those transfers should be structured to maximize national welfare. In our workhorse model, the optimal design of transfers will maximize the sum of expected utility over regions. For two regions $k = \{A, B\}$ and two states of nature H (for high income) and L (for low income), the problem is to design national transfers to maximize expected joint utility:

$$(1) \quad \text{Max}_{T_{rs}} \sum_{k=A,B} \left[v(\bar{Y}^k - I^k) + \sum_{r,s \in \{L,H\}} P_{rs} (Y^A = Y_r^A(I^A), Y^B = Y_s^B(I^B)) u(Y_r^k + T_{rs}^k) \right]$$

where Y is income, I is investment in protective infrastructure, P_{rs} is the joint probability of incomes Y^A in A and Y^B in B given the state of nature r in A and s in B where r and s can be

either high (when there is no disaster) or low (in the event of a disaster), $v(\cdot)$ is the certain utility of a region in the present period, and $u(\cdot)$ is the utility of a region in the future period in which there is uncertainty. The second summation term is the sum of the expected utility of the regions in the uncertain future period. Note that investment by region A in the present period affects the probability that region A ends up with high or low income in the future (since it decreases the damages from a natural disaster) and similarly for region B. This affects the joint probability of outcomes for both region A and B, an externality one might term a probabilistic externality. Note also that the joint probability function written above assumes that income in region k depends only on the level of investment in that region.¹ Thus, even abstracting from one source of externality (the direct spillover effect of investment in one region on another), a different source of externality is present.

The optimal transfer design that solves this problem will generally result in transfers that equalize the expected marginal utility across regions. In the event of a natural disaster, optimal disaster transfers would shift resources from unharmed to harmed regions until risk-adjusted incomes are equalized. The literature has generally assumed that the probability of a disaster in one region is independent of the probability in the other, that the regions are identical and symmetric and that transfers are self-financing ex-post. Under these conditions, the optimal transfer design reduces to the very simple rule of equalizing regional incomes ex-post. This can be illustrated graphically by reference to Figure 4.

The difficulty with this simple rule is that it ends up distorting regional incentives to invest in protective infrastructure. This happens in two distinct ways. The first is that the

¹ As written, the function does not assume independence, a common assumption in the literature and one assumed in Goodspeed and Haughwout, 2012. The probabilistic externality remains in this case as well.

transfers lead to an externality (of the sort alluded to above) and strategic interaction between regions becomes relevant. The second is a time inconsistency problem as in Kydland and Prescott (1977). In this sub-section we discuss the first distortion. We leave the discussion of time inconsistency to sub-section C below.

An important aspect of the above problem is that the probability of a region ending up with high or low income depends on its investment in protective infrastructure. Regional governments can invest in protective infrastructure to lessen the destruction caused by the disasters, such as levees for floods and so forth. However, when regional governments can invest in protective infrastructure that alters the extent of damages that a disaster provokes (that is, the probability of ex-post high or low income in the event of a disaster), the transfers of the central government create an externality in investment decisions (Goodspeed and Haughwout, 2012). The transfers introduce an externality even without spillover benefits.

To better understand the nature of the externality, first note that absent the transfers the investment decision of the regional government affects only itself. However, the presence of the transfers implies that a region's investment has consequences not only for itself but also for the other region. This is because a possible transfer depends on the probability of a bad outcome in the other region, which depends on the other region's level of investment in prevention measures. Hence, the optimal investment decision of region A with the transfer affects the utility and investment decision of region B. Once we allow the central government to engage in disaster insurance when regional government investments alter the extent of disaster damages, the investment decision of a regional government becomes strategic vis-à-vis the other region.

The solution to this strategic interaction depends on the nature of the game played between regions. However, a natural starting point is to analyze the Nash equilibrium. In the Nash Equilibrium, each region ignores the benefit to other regions from its investment decision. As shown in Goodspeed and Haughwout (2012), the symmetric Nash Equilibrium level of regional investment in protective infrastructure will be less than the first-best level of investment. Figure 5 illustrates this graphically by plotting the regional reaction functions for the 2-region case.

An intuitive description of this result follows from the externality nature of the investment decision. The social marginal benefit from region A's investment decision is the change in expected utility of region A plus the change in the expected utility of region B. Region B's expected utility changes when region A changes its level of protective investment because this changes the joint probability of one region ending up with high and the other with low income, in which case a transfer is made. That is, if region A increases its investment in protective infrastructure, and this increases the probability of region A ending up with high income, region B will benefit. Region B would benefit both from the fact that it is less likely to transfer money to region A (in the case of a disaster happening in A) and because it is more likely to receive a transfer from region A (in the case of a disaster happening in B). The transfer is going to affect the utility of both the giving and receiving region, but each region only takes into account its own well-being as it considers its investment in protective infrastructure. Moreover, this is a typical prisoner's dilemma situation: each region predicts that the other region will under-invest, so the best response is to under-invest as well.

It is also important to note that the investment in protective infrastructure made by the regional government depends on the transfer level of the central government. Higher transfer

levels imply lower levels of investment. Thus, the central government has something of a dilemma. With full national insurance against losses in income due to natural disasters, regional investment in protective infrastructure is too low. To increase regional investment levels, the central government can reduce its transfers, but this implies less than full national insurance against natural disaster losses. There is thus a trade-off between the degree of insurance against natural disasters provided at the central level and optimal regional investment in protective infrastructure.

B. Second-Best National Disaster Relief

The optimal amount of insurance to be provided by the central government is thus more complicated than the full insurance scheme (insurance that equalizes regional incomes after a disaster) suggested by the simple first-best set-up. If the central government commits and offers complete insurance against natural disasters while regions choose their investments in protective infrastructure and act non-cooperatively, regions will tend to underinvest in protective infrastructure from a national perspective. Thus, the first-best level of regional protective investment and first-best national disaster insurance cannot both be achieved under these circumstances. Can the central government use its knowledge that regional government investment is higher when insurance is lower to design a national disaster insurance system that achieves higher overall welfare – in other words to design a second-best insurance system for disaster relief?

Goodspeed and Haughwout (2012) derive the necessary conditions for a second-best system of national disaster insurance, and compare this to the first-best system. It turns out that

the relation between the two depends on the ex-ante expected utility of the high-income state of nature versus the ex-ante expected utility of the low-income state of nature.

For disasters that are infrequent and cause large damages, the second-best insurance system implies less national insurance than the first-best system. There are costs to the central government of giving less relief (redistributing less), but there are also gains because the less relief that is given ex-post, the greater is the level of investment in protective infrastructure that regional governments will undertake ex-ante. It turns out that for disasters that are infrequent and cause large damages the gain to the central government from inducing an increase in regional investment is greater than the loss resulting from a smaller amount of insurance. The central government trades a lower level of ex-post national disaster insurance for more regional investment in protective insurance ex-ante.

For disasters that happen with frequency and cause relatively little damage, or little variance in damage across regions, it may be better to have even more insurance than in the first-best. To understand this case, recall that the optimal rule for ex-post national disaster insurance is being made from an ex-ante perspective. While it is obvious that both regions attaining the high-income state is preferred to both regions realizing the low-income state ex-post, in this case the ex-ante probabilities are such that the expected utility from both regions realizing the low-income state is actually higher than the expected utility of both attaining the high-income state; this can only happen if the probability of a low income outcome is relatively high and there is not too much difference between the low and high incomes. More insurance implies less investment in protective infrastructure as before (and hence a lower probability of the high income state), but in this case it is desirable because it increases the odds of the ex-ante preferred low-income outcome. Somewhat paradoxically, the low-income, high-probability outcome has a higher

expected utility than the high-income, low-probability outcome. The redistribution motive is irrelevant for these cases since both regions either escape or are hit by the disaster. Hence, for this case, the investment motive leads to national insurance that is higher in the second-best than the first-best.

A graphical depiction of both cases can be provided by reference to Figure 4. Second-best transfers add an additional term to the marginal utility of income for the region that suffers a disaster. The interpretation of this additional term is the net marginal benefit of the change in investment resulting from an increase in transfers to the region struck by the disaster. If the net marginal benefit is negative, the value of the transfer is less than the loss from lower investment. Hence, less weight is given to the marginal utility of the region suffering the low-income shock than under the first-best, the marginal utility of this region (region B in the figure) shifts down, transfers are lower and investment is higher. If the net marginal benefit is positive, the opposite is the case.

C. The Problem of Time-Inconsistency in National Disaster Relief

The above discussion of second-best national disaster insurance suggests that, for natural disasters with low probabilities, the central government would need to commit ex-ante to a second-best national disaster insurance scheme that effectively punishes regions that end up with high costs ex-post. This would increase the incentive of regions to invest in protective infrastructure ex-ante and thereby lessen the costs of the disaster. But there is a real question concerning the credibility of the central government commitment. In the United States, as shown in Figure 6, the vast majority of central government disaster aid is ex-post supplemental

appropriations, and this is rising over time in concert with the rising damages of disasters noted in Figure 1.

If the central government cannot credibly commit to a second-best national disaster insurance scheme that punishes regions that end up with high costs, regions may react strategically with respect to the central government. A different and distinct reason for regional underinvestment in protective infrastructure will arise: the anticipation by a region that ex-post payments from the central government can be influenced by its investment choices. Given this, the region can exploit the anticipated reaction of the central government (effectively exploiting a soft budget constraint) which induces a further under-investment in regional protective infrastructure.

The difficulty in committing ex-post comes from the fact that the central government will want to rescue disaster-prone regions once the disaster has occurred. Returning to problem (1) but treating it as an ex-post problem where all uncertainty has been resolved and ex-ante investment levels have already been chosen, the central government will again try to equate the marginal utility across regions. In the simplest case of symmetric and identical regions, the central government will want to equalize incomes ex-post.

Furthermore, this time inconsistency of the central government's disaster insurance decision implies an even lower level of ex-ante regional investment. As a region considers its investment in prevention measures ex-ante, it will consider what it expects to happen to ex-post national insurance payments should a disaster arise. The regions realize that their ex-ante behavior will change the predicted ex-post transfer since greater investment is going to increase the probability of a high income outcome and decrease the probability of a low income outcome,

and each region would want to take this into account in its ex-ante investment decision. This will create a soft budget constraint and an additional reason for underinvestment by the region.

An attempt by the central government to implement a second-best national disaster insurance scheme may thus result in regional investment that is below even the original non-cooperative Nash equilibrium, as shown in Goodspeed and Haughwout (2012). The intuition is that there are now two reasons for underinvestment by a region. The first is due to the externality introduced by the transfers. The second is due to the soft budget constraint problem introduced by the time inconsistency of the central government transfer decision.

Effectively the reaction functions pictured in Figure 5 are both shifted down. The resulting Nash equilibrium levels of investment (the investment corresponding to the intersection of the shifted-down reaction functions) will evidently be lower than the initial Nash equilibrium.

D. Locational Mobility

We have thus far ignored the mobility of individuals between jurisdictions. If one jurisdiction is more likely to be hit by a natural disaster, complete national disaster insurance may lead individuals to undervalue the true costs of a disaster, and lead to too great a population in the disaster-prone areas. Since models of locational choice are well-developed, a natural way to analyze this issue is to incorporate uncertainty into a developed model of locational choice. This is the approach of Wildasin (2011) who augments a model of locational choice that derives from the works of Flatters, Henderson, and Mieszkowski (1974) among others. In his model there are two jurisdictions, a coastal jurisdiction and an inland jurisdiction. Each region has immobile owners of land and mobile workers, the total number of which are fixed in the economy. The owners of land are assumed to be risk-neutral. The coastal area has a positive

probability of a disaster, and can tax its residents (land owners and laborers) to provide public infrastructure that lowers the probability of a disaster and/or losses from a disaster. (The inland area does not experience disasters in the model so there is no role for inland public expenditures.) If a disaster strikes, it is assumed that the central government will provide relief funded by taxes on (potentially) both factors of both regions. Locational choices are assumed to occur before any disaster is realized and a locational equilibrium implies that the utility of the mobile factor, labor, is the same in the inland and coastal regions. Wildasin (2011) allows the national government to have ex-ante grant instruments to which it commits as well as separate ex-post disaster relief transfers.

The essence of the solution in this model is that the ex-ante and ex-post grants are used by the central government to achieve different aims. The central government uses the ex-post disaster relief transfers to fully insure residents of the coastal region against a disaster. However, this leads too many people to locate in the coastal region since they know that they will be fully insured if a disaster strikes. To counter this tendency, the central government uses its ex-ante grants to disadvantage the coastal relative to the inland region. Thus, the ex-ante grants are used to provide the proper migration incentives while the ex-post grants equalize utilities.

With respect to regional governments, the model finds that any taxes will be placed on the immobile factors. Unfortunately, the model also finds that regional governments will not provide any public infrastructure (regardless of the matching rate) since the national government will always step in to fill the void; any infrastructure spending must be mandated.

E. Public versus Private Insurance

Buzzacchi and Turati (2009) explore a model that is similar to Goodspeed and Haughwout (2012). The key innovation is that they allow private insurers as well as a public mutual fund. The difference is essentially that the private insurer contracts for a premium ex-ante and commits to repay a share of the loss ex-post. The public transfer depends on the distribution of actual losses ex-post.

In this model the central government is assumed to maximize a social welfare function that includes both efficiency (the sum of expected utility) and equality (the dispersion of regional incomes around the average). Whether private or public insurance is better depends on the time-commitment problem of the central government mentioned above. Private insurance gets high marks on the efficiency dimension but not on the equality dimension. The result is that if the central government transfer commitment is credible, public insurance is better than private insurance because the central government optimally trades off efficiency and equity concerns. However, when the central government cannot commit, either the public mutual fund or private insurance may dominate depending on certain parameter values of the model. Public insurance may still dominate, but there are cases when private insurance is better.

F. Self-Protection versus Self-Insurance and the Incentive to Join a Federation

Ehrlich and Becker (1972) differentiate between actions that lower the size of a loss (termed self-insurance) and investments that alter the probability of a loss (termed self-protection). Whereas Goodspeed and Haughwout examine self-protection (which entails moral hazard), Lohse and Robledo (2013) use a similar model but examine the case of self-insurance (in which there is no moral hazard) and explore the impact of public disaster insurance on the

incentives of regions to join a federation. With respect to the former, Lohse and Robledo (2013) examine the case where investments in protective infrastructure affect only the losses should a disaster strike and do not affect incomes if a disaster does not strike. No moral hazard is present since such investments do not change probabilities, and investments are assumed to have no effect on incomes if there is no disaster. Nevertheless, most of the propositions from Goodspeed and Haughwout (2012) follow, save the ones related to second-best transfers where the presence of moral hazard results in a more complex relationship.

With respect to the incentives of regions to join a federation, Lohse and Robledo examine the welfare of a single region in autarky and compare this to its welfare if it is part of a federation with disaster insurance. Joining a federation when there is disaster insurance has certain advantages – the federation allows the pooling of risks as noted above. For this reason, the utility of a region rises when it joins a federation. However, as we have seen, regional investment in protective infrastructure falls when a region joins a federation and interacts strategically with other regions. Lower investment in protective infrastructure lowers regional utility and is a disadvantage of joining the federation. The results of Lohse and Robledo indicate that either effect may dominate so that joining a federation may increase or decrease the welfare of a region when public disaster insurance is available in the federation.

G. Underexplored Areas

A number of areas remain unexplored by theoretical models. In this section, we suggest some areas in which the further exploration of the relationship between decentralization and natural disasters can be fruitfully pursued.

A first topic is the question of whether the central government can take time-consistent ex-ante actions to correct some of the distortions we have discussed. Given the role of externalities, a natural solution to think about would be the traditional role of matching grants to correct externalities. Such ex-ante matching grants could be used to try to increase regional investment, thereby correcting the problem of underinvestment. This would require specifying an additional ex-ante instrument for the central government (as well as ex-post transfers).

A second area that would be useful to explore is relaxing the assumption of symmetric regions. The study of asymmetric regions (in population) in the tax competition literature has resulted in important insights, for instance the insight of Kanbur and Keen (1993) that small countries have an incentive to undercut the tax rates of large ones, something that is consistent with the fact that tax havens tend to be small countries.

Asymmetry in natural disasters is perhaps even more important. One important type of asymmetry is the risk from natural disasters. Are the risks from natural disasters in general or from particular types of natural disasters similar across regions? If they are, the role of the national government in risk-sharing is greater since such symmetries underlie the logic of national risk-sharing. If they are not, the role for decentralization of disaster insurance is greater. For instance, consider two regions where the probability of natural disasters in one is zero and in the other is one. There is no role for risk-sharing here since one of the regions has no risk to share and the regions will have very different demands for investment in protective infrastructure.

Another type of asymmetry is the importance of a region to the rest of the economy. To put it in stark terms, contrast the effects of a natural disaster on an uninhabited land area to such effects on a densely populated area important to the economies of other regions of a country.

A third area that is underexplored is a different sort of asymmetry – asymmetries in information. One argument in favor of decentralization is that lower levels of government have better knowledge of the needs of the community. Models of this type have been used to analyze decentralized decision-making, but none thus far have been studied for the case of disasters, and could prove fruitful in pointing to empirical tests relating to underinvestment.

Finally, as noted in the following section, the empirical work on decentralization and disasters has used disaster-related deaths as a measure of damage rather than income fluctuations. Following the environmental literature, there is a debate about whether and how to value the loss of human life. That is, it might be that the value of expected deaths or irreversible losses cannot be fully compensated by ex-post disaster mitigation programs. This aspect could be more fully investigated in the theoretical literature.

III. Insights from Empirical Work

A. Disaster-Related Deaths and Decentralized Government

The empirical work on decentralization and natural disasters to date is very limited. Two recent studies, Toya and Skidmore (2010) and Escaleris and Register (2012), ask how decentralization is related to one measure of the impact of natural disasters, disaster-related deaths. These papers were written at almost the same time, use the same data, have similar (though slightly different) specifications, and come to the same conclusion. Both of these papers ask whether countries that are more decentralized have higher or lower disaster-related deaths.

Each finds that disaster-related deaths are lower in countries that are more decentralized, controlling for other factors that might also be related to disaster-related deaths. Some of the factors controlled for are GDP per capita, population, elevation, the size of government, and openness. The evidence is mainly cross-sectional – Escalaris and Register report that many countries have only one disaster during the period – although Toya and Montoya report that much the same qualitative relationship holds for a reduced sample of eight countries with country fixed effects included.

One problem with the evidence to date is that it is difficult to know whether the observed relationship between disaster-related deaths and decentralization is causal or just a correlation. This is due in part to the fact that the theoretical literature does not model deaths per se, but rather damages in terms of a fall in incomes and underinvestment in protective infrastructure. Disaster-related-deaths is an outcome that could result from underinvestment in protective infrastructure, but is not a direct measure of protective infrastructure or its underinvestment. Other dependent variables, such as property damage or economic losses that are more directly related to damage are important to study in the future, as are direct measures of investment. It is not too difficult to imagine that a locality may try to prevent the most serious effect – the deaths of its citizens - while at the same time underinvesting in prevention measures related to property damage or other economic losses. And it is also difficult to know whether disaster-related deaths are low because the central government comes to the rescue in hard times, a prediction of the theory.

In addition, studies to date have used rather blunt measures of decentralization – the percent of decentralized expenditures for instance. Yet, decentralized countries have widely different government structures. Some have strong regional governments, while others have

weak regional governments. Some regional governments act as administrators of central government policy while others have a great amount of autonomy. Some regional governments depend heavily on financing from the central government while others do not. Some regional governments have severe restrictions on borrowing while others do not. All of these aspects are worthy of further exploration in the empirical study of natural disasters and decentralization.

B. Politics and Ex-Post Disaster Relief

An early and important paper concerning ex-post disaster relief in a federation is Garrett and Sobel (2003). They provide evidence of political manipulation of ex-post FEMA disaster relief funds in the United States. They find that states that are politically important to the president receive more declarations of disasters and that states that have congressional seats on FEMA oversight committees receive more funds. Healy and Malhotra (2009) find that the percentage of votes for the presidential incumbent rises with ex-post disaster relief spending; thus a politician that diverts resources can expect a pay-off at the ballot box. This is consistent with a political interpretation of the inability of the central government to commit to ex-ante transfer design. The (small) empirical work to date suggests that politics and the issue of central government commitment are important, and deserve further study.

C. Inequality and Natural Disaster Deaths

Anbarcia, Escaleras, and Register (2005) study the relationship between inequality and natural disaster fatalities, but not decentralization per se. Nevertheless, the evidence they present, that inequality in incomes in a country is positively related to fatalities and other sorts of damage that result from natural disasters, is relevant. They attribute the observed relationship to the inability to reach collective agreement concerning protective infrastructure investments when

there are large income differences in a country. This general point of collective action failing under circumstances of wide divergences is related to the failings of national collective action that can lead to a federal system of government. Moreover, as discussed above, decentralization can also lead to under-investment in protective infrastructure. It is unclear whether collective agreements on infrastructure would be more or less likely with decentralization, but it would be interesting to examine this hypothesis in federal versus non-federal countries.

D. Variation in Risks across Regions

The extent to which the risks from natural disasters vary across regions of a country is not well-documented. One paper that does document the variation in flood risks across the US States is Wildasin (2008). Averaged over the years 1955-2003, the variation across US States is substantial. Taken as a percent of state income, the figures range from a low of 0.00% in Delaware to 0.89% in North Dakota. In the same paper, Wildasin suggests the possibility of a regional reserve fund where premiums are higher for states with higher risks. It is interesting to note that national flood insurance for individuals does this to some extent in the US, with premiums being higher for those located closer to the shore.

Variation in risk across the world and Asia is also highlighted in Figures 2 and 3. For certain areas comprised of many small countries, this raises the question of whether certain regions might gain from cooperation in regional disaster insurance.

IV. Practical Difficulties in Dealing with Natural Disasters

Decentralized countries face a number of practical difficulties in dealing with natural disasters. We highlight in this section some of these.

A main practical reason that national governments are compelled to help subnational governments when disasters occur is that lower levels of governments often face a budgetary constraint and find it difficult to borrow in the face of a disaster. Consequently, the ability of sub-national governments to undertake large ex-ante investments or ex-post clean-ups is often difficult. The budget and borrowing constraints differ across countries, and even across regions within a country. Some subnational governments have access to their own tax resources while others rely heavily on grants from the central government. Borrowing constraints are common at the subnational level and, facing these constraints, it may be impossible for them to fund a large infrastructure project without central government help to say nothing of the usually very high cost of clean-up.

Moreover, there is likely to be a shortfall in current revenues. Regional governments are likely to need supplemental revenue after a disaster strikes to finance current on-going public services. For instance, if local property taxes are used to fund schools, the reduction in property values after a disaster is likely to reduce revenues, and this in turn implies a reduction in spending on education in that locality. Clearly rainy-day funds are important in this regard. Unfortunately, rainy-day funds typically are not sufficient to sustain spending levels, much less recovery efforts.

Planning is also an issue especially if subnational governments are lacking in expertise. In addition, subnational governments may suffer from institutional rigidities and may not have complete power over land use, infrastructure, and environmental policies. In the US, the Army Corps of Engineers plays a role in subnational investments in preventive infrastructure. According to a report by the CRS (2011), the Corps helps to assess and build infrastructure to prevent disasters such as flooding. The costs are shared between the national and subnational

governments. However, the subnational governments are responsible for the costs of the operation and maintenance of the infrastructure.

Besides financial and institutional constraints, subnational governments are likely to have logistical problems. They often do not have quick access to the manpower necessary to provide basic safety and security in the wake of a natural disaster. The national government sometimes helps in this regard with the mobilization of the military for safety and security as well as humanitarian tasks; in terms of the earlier theory, this might be viewed as an in-kind transfer from the central government.

V. Conclusion: To Centralize or Decentralize Policies on Natural Disasters?

To summarize, natural disasters have been on the increase, strike almost all countries, and issues of planning, ex-ante investment, and ex-post clean-up of natural disasters are becoming more important. When the countries involved are federal, the decentralization of some of these responsibilities leads to particularly complex incentives. I conclude this chapter by assessing whether a general case can be made for centralizing or decentralizing responsibilities for natural disasters on theoretical, empirical, and/or practical grounds. As the following paragraphs will attempt to clarify, the answer is that it depends.

On the theoretical side, the case for centralized disaster insurance has relied on the basic argument that the central government is in the best position to pool risks. The case is not clear-cut, however, because such national disaster insurance can distort regional incentives for investment in protective infrastructure. This can happen for two distinct reasons. First, when inter-jurisdictional national disaster insurance exists and regional governments are involved in ex-ante investment decisions, the actions of one regional government (deciding how much it will

invest in protective infrastructure ex-ante) will influence the expected ex-post income of all of the sub-national regions. The centralized transfers will thus distort the decentralized choice between current (or certain) and future (or uncertain) income, and the strategic interaction between regions implies lower ex-ante investment in protective infrastructure. Second, any ex-post adjustment of the transfers by the central government will further distort regional incentives if regions understand and take into account the future central government actions, and will lead to a further incentive to underinvest ex-ante. The problem of time inconsistency by the central government can become dangerously real when dealing with natural disasters.

When theoretical models consider the impact of mobility, the problem of too many people locating in disaster-prone regions is added to the problem of underinvestment in protective infrastructure. Theoretically, the literature has suggested that the locational problem can be addressed by charging disaster-prone regions more ex-ante. Unfortunately, this may exacerbate the problem of underinvestment and raises again the question of time-consistency of such a policy.

Could private insurance provide a better alternative? Theoretically, compulsory private insurance could be useful when the central government suffers from time-inconsistency and some other conditions are met. However, public insurance is also sometimes better, so the theoretical results on this point are ambiguous.

Finally, it has been pointed out that region-wide disaster insurance affects the calculus of the regions joining in a federation. There is an advantage in joining to pool risks, but by joining together the regions also are induced to lower their own investment in protective infrastructure. Whether the benefits outweigh the costs is ambiguous.

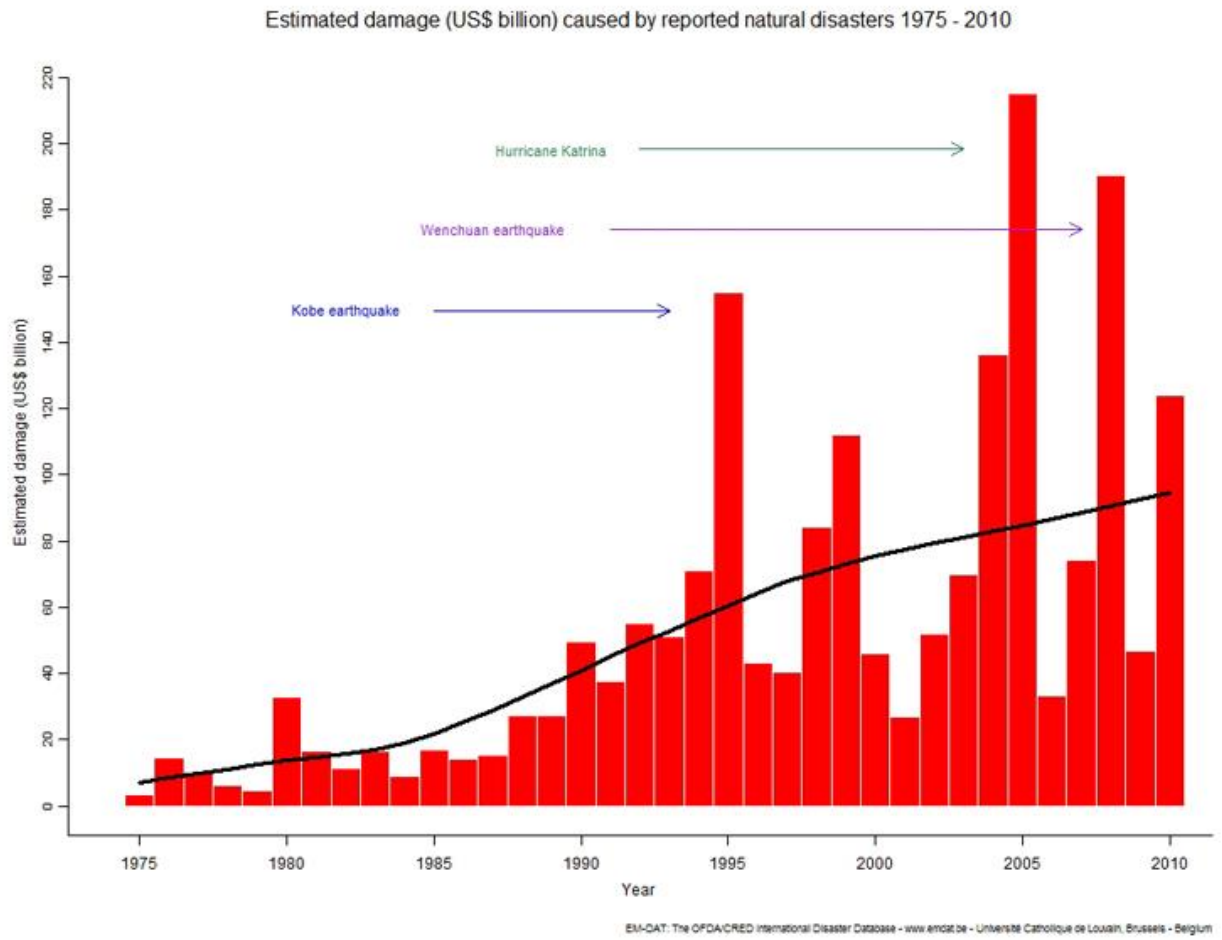
The empirical literature has presented evidence that countries with more decentralization also have lower disaster-related deaths. However, the exact reasons for this have not been investigated, and there is precious little evidence on whether national insurance leads to lower regional investment in protective infrastructure. There is some evidence of political manipulation of ex-post national disaster funds that relies on US data. There is also some evidence that countries with high levels of inequality also have high fatalities from natural disasters, possibly due to an inability of such countries to engage in effective collective action. Finally, the similarity or dissimilarity in frequency of disasters across regions of a country is an important piece of information on which there is little evidence, though there appears to be substantial variation in flood losses across US states. Much of the evidence noted above points to a role for decentralization in dealing with disasters; however, little is known about the size of benefits resulting from national pooling of risks, a main argument for centralization.

Practical difficulties in decentralizing natural disaster policies will often revolve around financing. Budgetary and borrowing rules and markets constrain the ability of sub-national governments to undertake large ex-ante investments or ex-post clean-ups. Moreover, current revenues are likely to be depressed after a natural disaster, making necessary some sort of intergovernmental aid. Planning (especially where local skills are deficient) and institutional and logistical constraints can also be a problem for decentralized governments coping with a natural disaster.

The state of the literature thus leaves us with a somewhat ambiguous answer to the question of whether it is better to centralize or decentralize policies on natural disasters. This naturally calls for more research to fill in the many remaining gaps in our understanding. We are unlikely to find a definitive answer on whether policies on natural disasters should be centralized

or decentralized, however. The best policy is likely to remain dependent on the particular circumstances of a given region or country.

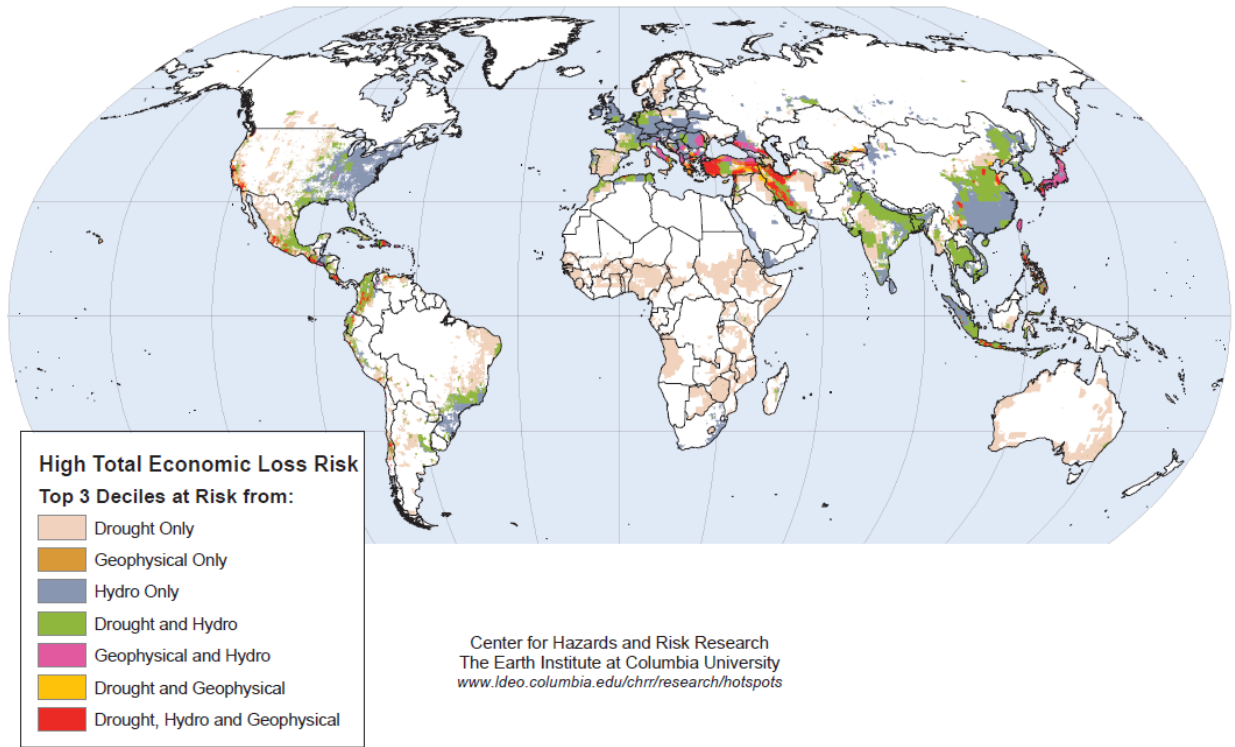
Figure 1: Estimated Damages from Natural Disasters, 1975-2010



Source: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be , Université Catholique de Louvain, Brussels (Belgium).

Figure 2: World Highest Total Economic Loss Risk by Disaster Type

Global Distribution of Highest Risk Disaster Hotspots by Hazard Type
Total Economic Loss Risks

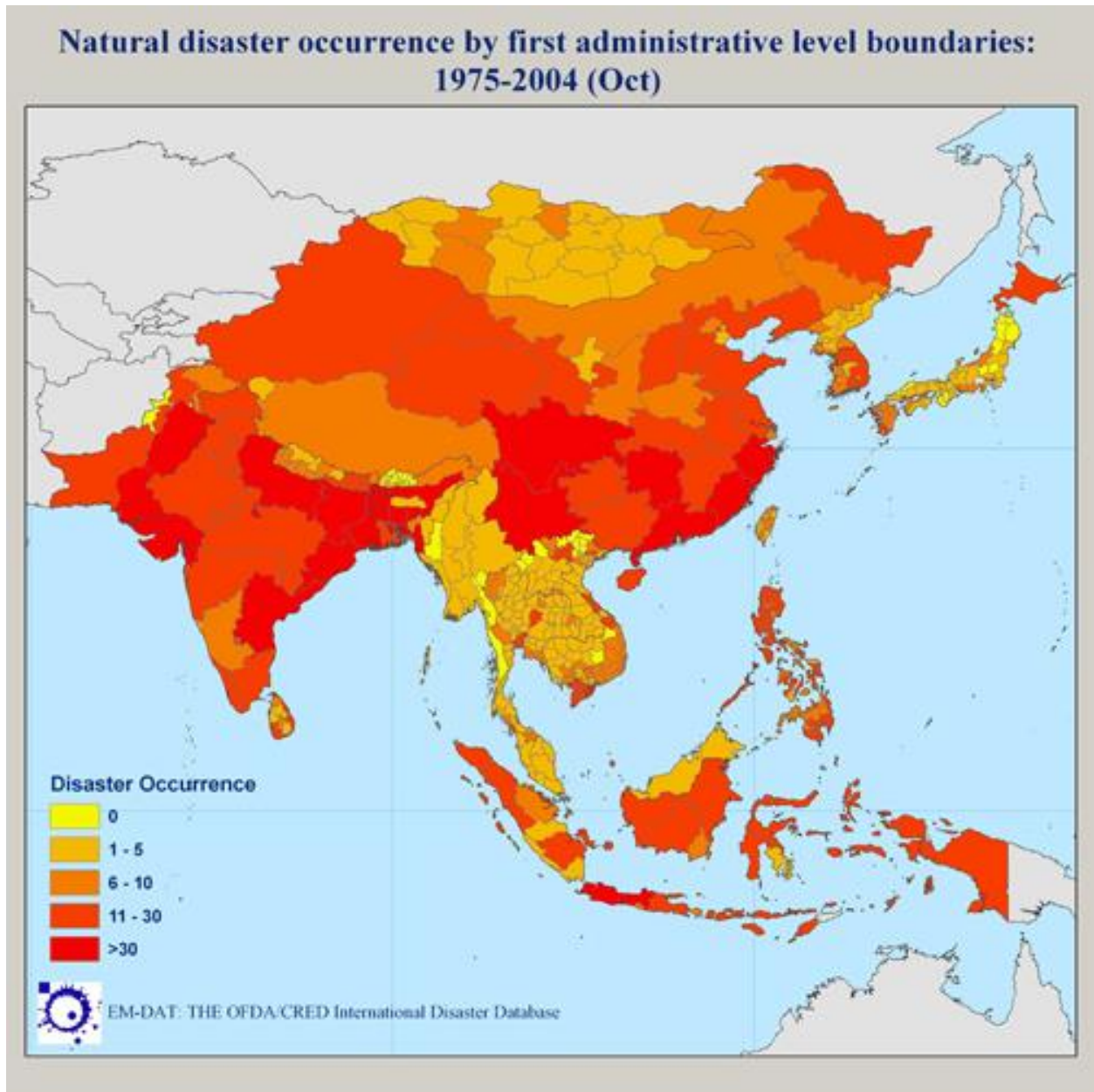


Note: Geophysical hazards include earthquakes and volcanoes;
hydrological hazards include floods, cyclones, and landslides.

Source: Figure 1.2b. *Natural Disaster Hotspots - A Global Risk Analysis*
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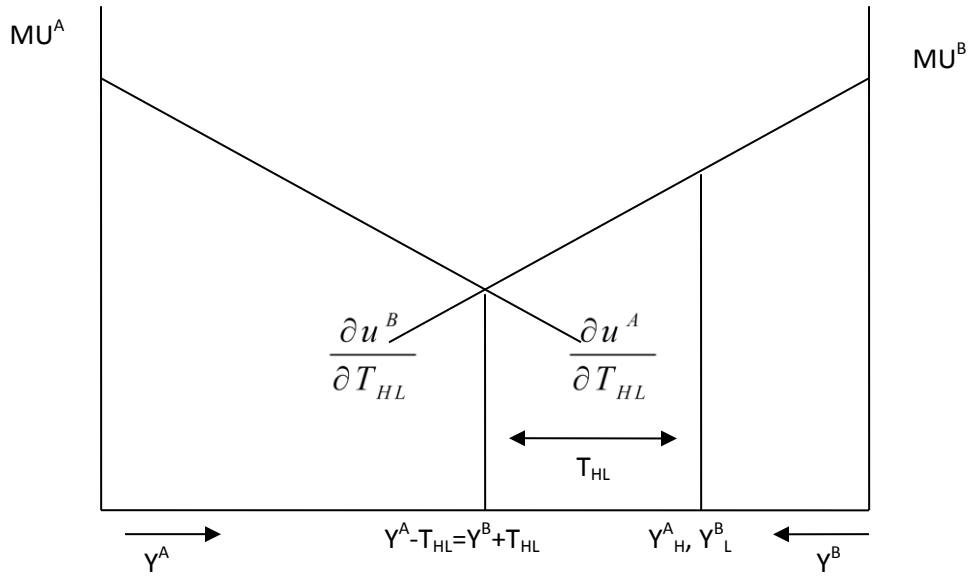
Source: Columbia University, Center for Hazards and Risk Research,
<http://www.ldeo.columbia.edu/chrr/research/hotspots/maps.html>

Figure 3: Number of natural disasters by sub-region in Asia



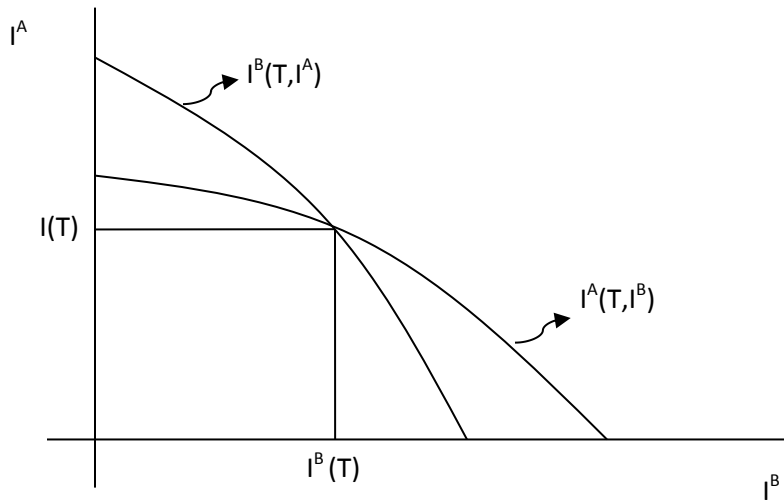
Source: EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be , Université Catholique de Louvain, Brussels (Belgium).

Figure 4
 Optimal First-Best Transfer for (Y^A_H, Y^B_L) case



Source: Goodspeed and Haughwout (2012).

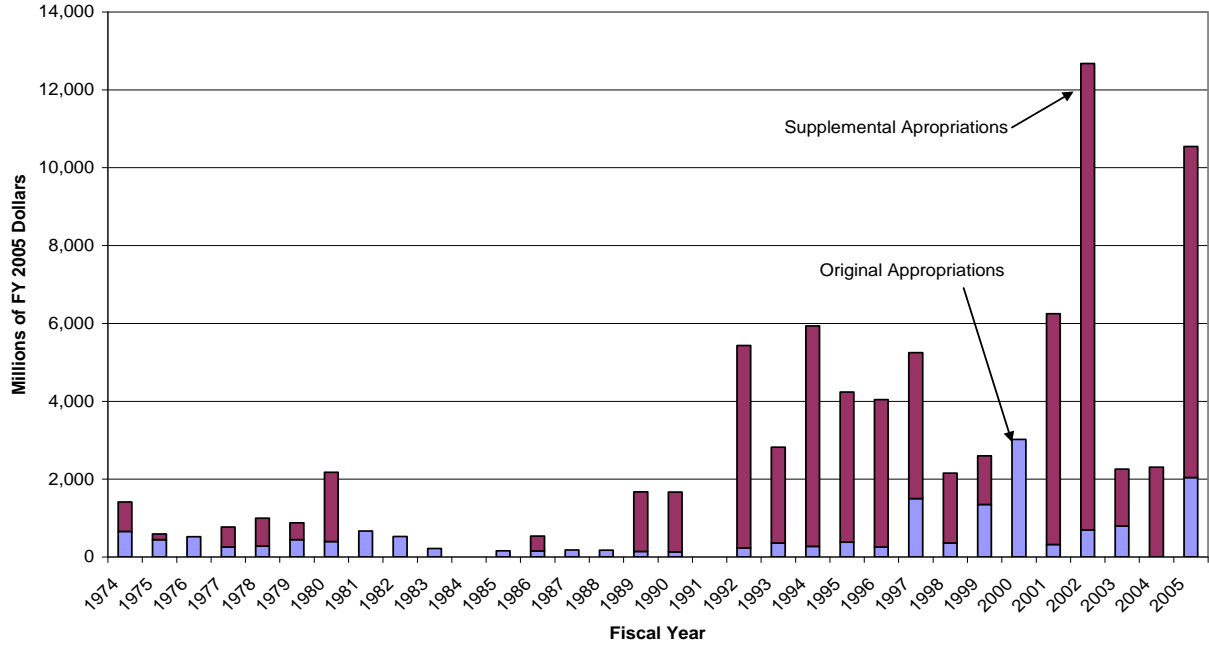
Figure 5
Nash Equilibrium Regional Investment



Source: Goodspeed and Haughwout (2012).

Figure 6

Disaster Relief Fund Appropriations Fiscal Years 1974-2005



Source: Goodspeed and Haughwout (2012). Note: Data exclude effects of Hurricane Katrina.

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