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ARTICLE

Transactions and Friction as Concepts to Guide Disaster Recovery Policy

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Abstract Large-scale disaster events in Japan (2011), New Zealand (2011), Chile (2010), and China (2008) generate a need for understanding the dynamics of multilocation disaster recovery. This article uses analogs from contemporary economic theory to model recovery interactions over time and over large geographic areas. The model consists of the external and internal sectors and how they engage in transactions during the recovery period. The concept of transaction is developed and its use as a policy tool explored. The concepts of friction and uncertainty are introduced as barriers to efficient and effective completion of the transactions needed for recovery. Friction adds time and resource costs, while uncertainty slows the completion of transactions entered into by recovery stakeholders.

Keywords complex recovery systems, disaster policy, friction, multilocation recovery, recovery theory, transactions

1 Introduction

In 1755, Europe's largest earthquake and tsunami occurred in Lisbon, Portugal (Paice 2008). This event was the genesis for the scientific field now known as seismology. In 2008, 2010, and 2011 seismic and tsunami events impacting scores of cities and towns occurred in China, Chile, New Zealand, and Japan. These multilocation events increased the complexity of designing a recovery strategy by the central governments that could meet the needs of a diverse set of circumstances. These extreme impact events have begun to shape new ways of conceiving recovery and require larger frameworks to understand recent event dynamics and to shape appropriate recovery policy options. This article contributes to the dialogue on understanding recovery complexity and develops new elements of recovery theory. It applies selected economic market behavior theory as an analog for understanding multilocation recovery complexity. The concepts examined include: transactions, friction, and uncertainty.

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2 The Economic Analog

Labor markets and why and how they operate was the subject of the 2010 Nobel Prize in Economics. The prize recognized three scholars and their analysis of markets with search frictions (the costs—financial, labor, and production—associated with markets not clearing as they would under classical economic theory).[i] The Nobel award economists developed a framework that seeks to explain why there can be many people unemployed at the same time there are a large number of jobs offered. Their model helps explain the ways in which unemployment, job vacancies, and wages are affected by behavior, regulation, and economic policy. The model can also be applied to other areas of economic thinking. This author thinks their findings have relevance for disaster recovery theory. Why is this so?

These economists found that because of "friction," markets for jobs and labor do not easily clear, or reach a state of equilibrium. This results in not getting the right people offered jobs they qualify for, in places where the jobs are located. They discovered that matching employer needs to job seeker desires is not an easy process. Instead of one equilibrium unemployment rate for the nation, there may be many rates. The process of sorting out the people to the jobs, at varying wage rates, in different locations, does take time. When a job seeker and an employer agree to a course of action (generally called the terms of employment), they create a transaction. The search process is costly and complicated by rules of employment, as well as the effects of government unemployment and social support practices. The friction involved demonstrates that matching demand with supply is not a simple process. The friction itself can vary in intensity and scaled into units such as simple, compound, and complex according to subject at hand. For example, the time needed to verify job skills is a simple friction, just as qualifying people's losses for aid in a disaster can be classified as a simple friction. While policy makers (at local and national levels) may choose a desired unemployment target, given a particular level of friction, it is not easy to achieve the target at a given point in time.

This supports recent findings on hazard mitigation that few things are as simple as they first appear and that rationally based systems do not work well when faced with

complex conditions and poorly conceived policy implementation schemes (Alesch, Arendt, and Petak 2012). Context does matter in any analysis. The question of whose best interests are served always appears and adds a degree of uncertainty to the recovery process. By recognizing that friction does occur, policy to address its costs can be designed. If costs are very high a lower than optimum equilibrium level can be accepted. The friction concept can be applied to recovery from major disasters because no recovery is optimum, and each recovery is unique in terms of context and the types of friction generated.

3 The Contradictions in Recovery Viewpoints

We are beginning to understand that there are two important contradictory views of recovery. The first view is that recovery is not guaranteed. After nearly 100 years, Lisbon had not fully recovered (Paice 2008); after 17 years, Kobe, Japan still possesses neighborhoods in need of attention and an economy still less robust than before the event (Edgington 2010). What actually happens is that over time partial recovery works in an iterative manner to influence the overall set of outcomes to the social, economic, and built environments. The second view is that recovery almost always occurs as a natural process of impacted areas and people getting on with their lives (Vale and Campanella 2005). Lisbon close to 260 years later is a thriving city that is safer overall due to mitigation-based land planning and improved building systems put in place by its Royal Crown during the first 10 years of recovery. These different outcomes can be thought of as a continuum from abandonment of the impact area with people moving away, to everyone returning to their previous place of residence, resuming the same level of livelihood and social relations as before the event, or achieving some overall betterment.

These two different end states can be conceived as a 0–1 continuum with 0 being the abandonment of the disaster site and 1 being near complete rebuilding of economic, social, and physical environments as previously existed. Outcomes closer to 0 occur when the probability of disaster reoccurrence or level of estimated damage and risk levels are so high that remaining in place becomes an unacceptable societal (collective) or individual choice. Some modeling of the various components is needed to estimate parameters, which then can be used to make basic decisions that shape the recovery strategy. Then some target between 0–1 might be chosen and the model tested. Depending on the extent of damage to people, the economy, and the built environment the model would test the target estimate (somewhere between 0 and 1). While not often the case, abandonment does occur. Abandonment was the recovery choice made for an entire Chinese city impacted by the 2008 Wenchuan Earthquake (Chen and Booth 2011).

The City of Beichuan, China suffered at least 20,000 deaths, including 400 of its local officials. The city is located in a deep valley with large unstable mountains on all sides. The magnitude 7.9 earthquake on 12 May 2008 sheared off parts of the mountains causing extreme landslides. In this case the recovery "in place" had a long-term probability of near to 0, if it remained there, but closer to 1 in a different location.

A site 15 km south of the old city was obtained, and by 2012 housing for 30,000 people was being built. According to He Wang, the city's architect and urban planner, the qualities that the Chinese Premier wished to be included in the new Beichuan were: safety, livability, the character of the ethnic Qiang people, prosperity, a modern civilization, and harmony (NPR 2012).

In the case of Haiti's magnitude 7.0 earthquake in 2010, the large temporary camps that have existed for more than two years could become permanent settlements, and thus the previous locations where victims resided might be abandoned because of lack of demand and infrastructure reinvestment. In such a case, the outcome would be 0, or close to it, at least in the mid-term period (up to five years). Due to lack of funds, and historic circumstances of corrupt leadership, Nicaragua's old capital city of Managua has remained abandoned since the 1972 earthquake that destroyed 13 km^2 of the central city.

4 Defining the Recovery Sectors

Continuing with the labor market analogy, in the recovery process we can conceive of two main sectors: internal and external. The internal sector consists of the local people with their socioeconomic, and built environment event loss-based needs. The external sectors consist of the governmental, private, and donor institutions that can provide recovery resources and assistance. The internal and external sectors need information concerning internal needs and external capacities in order to sort out transactions, time to determine the location and type of transactions, and the options available to conduct the transactions. This is not unlike labor markets that need to transmit adequate information in order for the employment search process to sort itself out.

The recovery process consists of the two main sectors attempting to conduct transactions and the friction that slows the implementation of transactions. In this case, friction is the cost (in terms of time, funds, political support, economic loss, and physical displacement) related to coming to agreement on how to "transact" (in the institutional sense) the agreements needed to satisfy the internal and external sector requirements. Friction occurs when the objectives of the subsectors conflict. In many cases this conflict is based on imperfect information flows. For example, in the Chilean recovery from the 27 February 2010 earthquake and tsunami, the central government provided 220,000 housing subsidies to replace damaged and destroyed houses, but required local government to provide the building approvals to replace houses in

safe locations. This has slowed down the housing replacement process, causing people to live up to three years in temporary housing. The level of friction in this example is determined by the time required for constructing replacement housing as well as a reliance on local government capacity, and the ability of the private construction sector to deliver a large number of houses throughout four different regions of the country, each with different capacities to respond to increased demand for housing. What began as a complicated level of friction in the first year after the disaster in 2010 has eased in the second year as the allocated subsidies have begun to be converted into permanent housing in different communities. All of this takes time, which is always in short supply in disaster recovery.

When the disaster event is quite large, the two main sectors first need to establish what are the "new conditions" under which recovery will take place (Alesch and Siembieda 2011). This may take some time, as what constitutes the new conditions may not be fully understood by the actors. Due to differentiation of conditions, larger events generate a more complex set of transactions needed between the sectors. The larger set of transactions is a function of the scale of an event and its impact on the areas' economic, physical, and social functions. This can be seen in Japan responding to the Great East Japan Earthquake and Tsunami of March 2011 that involved more than 30 cities, three prefectures, and a severely damaged nuclear power-plant complex in the Fukushima Prefecture. An example of establishing new conditions is the city of Ofunato in Iwate Prefecture in Japan. Ofunato accepts that the challenge before the city is to provide the conditions to keep the marine industries (fishing, processing, and repair) in the city and to protect it against future tsunamis. Physical protection of the marine industries subsector is the basis for designing the transaction for the new sea wall height to be proposed to the central government along with relocation of people from high danger areas. Most other types of transactions for recovery will stem from Ofunato accepting the new conditions and providing enough information to internal subgroups to understand them.

The concepts of transactions and friction are shown in Table 1 as a matrix of elements. The transaction levels are: simple, compound, and complex. This set of levels is a starting point for classifying the transactions in the process at a point in time. More refined levels can be set as required by a particular event. The friction occurs in five categories: information, communication, engineering, procedure, and political action. The five categories represent a set of areas that recovery stakeholders need to address at some point in time. Any activity in the recovery process can be placed in the matrix according to its characteristics at any point in time. Complex activities will become complicated, and then move to simple activities. Complex activities will need to be decomposed to become new sets of complicated activities subject to different frictions. Any activity should move within the matrix over time and at some point be dropped out upon completion.

Policy makers, or influential actors, in both sectors may desire different rates and levels of recovery (for example, time or percentage of completion) thus causing friction because the expectations are not well understood and high levels of uncertainty exist.[ii] Rates of recovery are sectoral and can have different measurements. In the housing sector an international standard is to have permanent housing in place two years after the event if sufficient resources can be applied to the task (Comerio 1998). For the most part the Chinese Wenchuan housing recovery meets this standard, but the Chilean recovery did not because the delivery system is decentralized and relies on private sector builders to deliver permanent housing on sites approved by local government.

In cities such as Minamisoma in Japan's Fukushima Prefecture, located at the edge of the 20-km restricted zone, permanent housing will be delayed until land remediation is completed on sites needing radioactive decontamination. This will be at least a two-year process, and only then can an assessment on safety levels be made. The people who have been evacuated will not be able to return until allowed to by local government.

The recovery plans for the impacted prefectures in Japan estimate a 3–6 year permanent housing replacement goal. Residents of Sendai City in Miyagi Prefecture are opposing the city's request for them to leave a 1200 hectares area designated as hazardous and relocate under a collective relocation program. Residents are asking for the city to revise the recovery plan and construct a different set of tsunami counter measures. This request creates friction in the recovery process and a time delay to enact a permanent housing solution.

A number of different recovery levels are possible under this model as sector subcomponents (such as employment, education, health, shelter, infrastructure, and social support) may result in acceptable transaction levels separately (reaching some equilibrium). Because each subcomponent takes a different amount of time to complete, the overall level of recovery may be in flux for many years. The conflicting time factor inherent in the behavior of sector subcomponents is

Table 1. Transaction and friction matrix of recovery processes

Transaction Level	Friction Category				
	Information	Communication	Engineering	Procedure	Political Action
Simple					
Compound					
Complex					

part of the overall friction concept: the sum of costs of completing a transaction (resources, time, conflicting regulation, leadership changes, and so on). In the recovery from the New York City World Trade Center 9/11 (2001) disaster there were repeated delays in crafting and implementing a recovery plan. Ten years after the terrorist attack, and with USD 20 billion spent, not a single completed building was in operation on the original site (Mammen 2011). In the case of New York City the actual World Trade Center site is owned by a special purpose government agency of the State of New York and the State of New Jersey. The governors of both states appoint the board of directors. The mayor of New York has no direct authority over the site. The United States Federal government has no direct involvement in the 9/11 recovery site except to supply funding provided by the United States Congress. Deciding how to recover and what to build was not an easy task. What constituted the internal sector was subject to change at different points in time. The 9/11 experience reflects many changing sector transactional requirements.

In the general model the needs of the internal sector are not fixed; they can change as actors adapt and learn. In large disaster events, some people leave, others come in to take their place (for short or extended periods), and the pool of people who become secondary victims of the event emerges. Therefore, the information needed for the external sector to supply resources to the internal sector is more dynamic than static. This is illustrated in Figure 1 where the transactions adapt over time through a learning process and establish new requirements as information is processed and barriers to completing transactions are overcome. The figure illustrates that learning and adaptation occur as transactions are formed and completed. Transaction complication is an indicator that frictions have reached a point where action can occur.

For example, in the Japanese system most emergency rules, such as no rebuilding on the same site, are in effect for a two-month period. But in certain cities in the 2011 Great East Japan Earthquake the two-month rule has been extended to two years. In the early period after an extreme event there is much uncertainty that contributes to friction and therefore completing transactions. As uncertainty lessens, which usually happens over time, the level of friction also declines. Uncertainty gets resolved as various internal and external actors make decisions and act on these decisions. For example, in the 2011 Great East Japan Earthquake the placement and height of the Japan Rail (JR) railway stations can result in difference levels of safety from tsunami danger. In this case the railway can be considered part of the internal as well as the external sector. A decision on station location and height of tracks would require substantial agreement from the central government on land acquisition and payments for the project. Such complex choices keep the level of uncertainty high. In the city of Sendai the decision to use debris rubble to elevate a major roadway close to the ocean results in a higher level of tsunami protection and increased levels of certainty about where to zone resettlement land.

A more complex transaction in the Japan case would be a change from the "build anywhere" practice to a "build in a safe area" practice (Ito and Ojima 2011). Such a change would require rethinking of the way the country's economic model operates. Another example is that of thousands of houses in the city of Christchurch, New Zealand, sited on parcels subject to liquefaction and lateral spread. Due to the changing soil, building, and infrastructure conditions it took more than a year for a decision to be made on which of the houses need to be placed in the "red zone," and which houses in the "orange zone" need to be abandoned and demolished. The "red zone" consists of locations where the land damage and infrastructure damage are so great that one or both could not be remediated or repaired in the near term and the cost exceeds the site and building value. The "orange zone" consists of locations where the extent of land and infrastructure damage is serious, but final costs or remediation methods have not been determined. The serial earthquakes occurred over a nine month period and caused severe soil damage

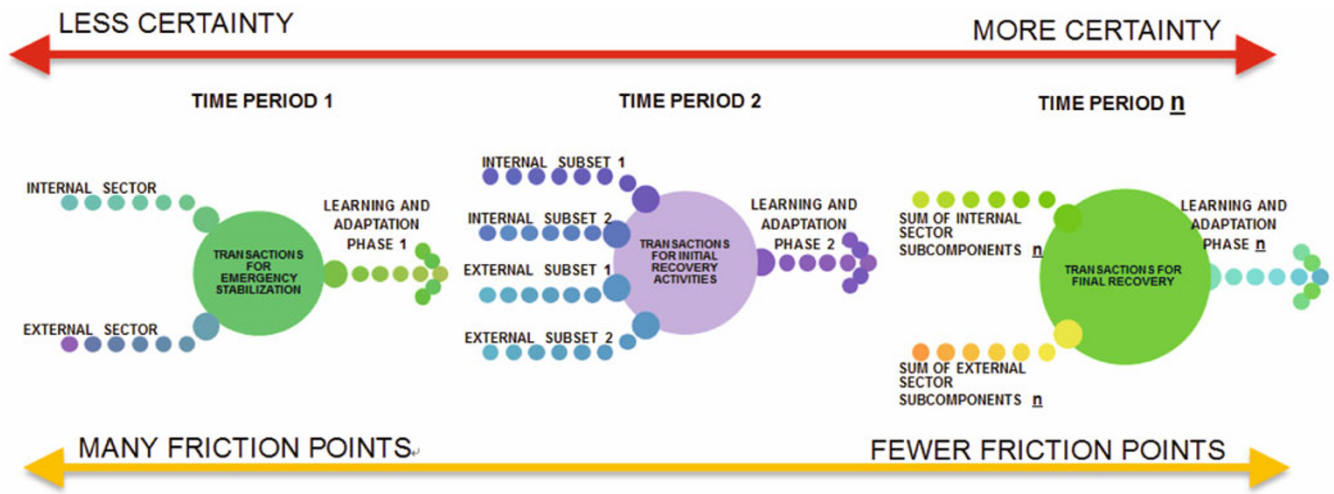

Figure 1. Sector transactions and adaptation over time in recovery processes

worsening after each event and leading to rolling decisions to abandon the rebuilding process for at least 7000 residential land parcels. The uncertainty level in this remained high for a long time, adding to the friction between the community and the recovery agency.

Just as the work of the 2010 Nobel Prize winners explain the ways in which unemployment and job vacancies are affected by regulation and economic policy, there are also external influences on the internal recovery process that need to be examined. One example of this is the withholding of United States Federal housing replacement funds in New Orleans until a different Federal agency established the base flood elevation (BFE) for certain flood impacted neighborhoods. Delay, distrust, and a great deal of friction resulted from this external versus internal sector's view of outcomes and needs (Olshansky and Johnson 2010). This is an example of the external sector (the central government) requiring technical information from one ministry (height of the base flood elevation) be completed before reconstruction housing funds be released to victims. The technical studies required months to complete. Internal sector actors had a need for rebuilding damaged houses and wanted to begin work quickly and also to preserve as many houses as possible from demolition and deterioration. The central government's need to provide minimum levels of safety controlled the transaction formation and the process outcomes.

5 Agents and Transactions

Using the job seeker and employee seeker model, recovery becomes a process of completing transactions between at least two sectors (the set of internal agents and the external agents).[iii] The transaction is the course of action the actors agreed to follow.[iv] The unit of analysis (what we are examining) is the transaction itself. How was the course of action determined? When was it determined? Who was involved in the transactions? For example, the Chilean town of Dichato, destroyed by the tsunami of 27 February 2011, needed a buffer (or barrier) to be constructed to protect it from future hazard events. A transaction was made between the town council and the central government to expropriate 40 private house parcels located on the beach, and then use the land to create a large natural buffer zone through expansion of adjacent parkland. The central government provided the funds to acquire the parcels, and the local government supported this project. The people whose houses were expropriated were in favor of a new seawall option for protection, without expropriation. The seawall would have taken many years to build and was costly. The course of action chosen (the transaction) was to protect the entire town quickly but with the loss of 40 residential parcels. This transaction between the city, the central government, and the landowners was completed within one year of the tsunami event.

As both the internal and external agents adapt they are continuously seeking to communicate and choose paths of actions to complete the transactions. The major sectors can generally divide into subsectors, such as internal agents for economic recovery, agents for health facilities recovery, agents for housing recovery, agents for land-use design recovery, and so on. Larger disaster events generate larger and more complex subsector networks. The more subsectors there are, the more complexity and friction need to be incorporated in the transactions. Not all transactions take the same form, nor do they include the same sector actors. For example, relocation of the entire city of Beichuan in the Wenchuan Earthquake area, China, required a different set of transactions due to the scale and scope of the actions under way (Chen and Booth 2011). Here the central government found a site for 30,000 people within the region and then established the mechanism for the transaction to occur. This transaction involved local farmers who owned the land, but needed new houses, the relocated population who needed to pay for the houses, and the government that provided the infrastructure required of a new town. The local farmers in this case became part of both sectors (actually a subset) needed to complete the transaction.

There is also the question of uncertainty in estimating the level of need in subcomponents and how to get this need met. Certainty is a function of belief that something will happen and it also provides information that can be shared. Again, a Nobel Prize winning economist, this time from 2002, provides some insight.[v] The prize was given for work in developing Prospect Theory that provided a framework to explain how people make decisions, particularly related to gains and losses. People were seen to be more risk averse to losses than interested in seeking gains. This leads to conservative behavior more influenced by intuition than reason. Applying this to recovery theory the greater the level of uncertainty that exists at any time, the greater the likelihood that conservative choices will be made. Under this theory people tend to overvalue what they have and undervalue a similar good they do not have. This may explain why relocation after disaster is so difficult to achieve, given people's preferences to remain where they were after an event. The subjective value of place-based memories is real and relocating to what is considered a safer location may be discounted in value. This may create friction in a set of relocation transactions. The resistance of Sendai, Japan residents to relocate from their high-hazard area is a case in point.

The internal sector consists of all people and organizations (formal and informal) that have suffered loss (personal, or physical), or injury from the disaster event. This sector can be deconstructed into subsectors for purposes of information and aid assistance, and the means of collecting the information needs by subsector will differ. For example, in the Great East Earthquake of March 2011, many coastal community local government buildings were destroyed along with local records on residents, property titles, and so on. This resulted in the need for a higher level of government (the prefecture) becoming involved in gathering information needed to determine recovery requirements for all sector subcomponents. In

Iwate Prefecture, a Victims Recovery Information System was developed by a Japanese university and installed in the prefecture offices to provide a means to track victims' needs and services provided by external subsector groups.[vi] In this instance the lack of a complete victim census (due to people swept to sea by the tsunami) created its own problems in the near term in knowing whom to help, resolving property issues, and establishing recovery service needs.

The internal sector is not static and will change its composition over time as some members reach viable recovery and no longer are involved in any assistance or reconstruction effort. Over time the sector subcomponents change in terms of relations with other internal subcomponents and with the external sector.[vii] The level of certainty increases as transactions are implemented. For example, once JR makes its decision on where to rebuild its stations and the elevation of the stations, then the choices related to where and to what height to install other tsunami protection measures can be made.

The external sector constitutes all agents providing resources to the internal sector. This includes government, donors, faith-based organizations, voluntary organizations, and private interests. The government component of the external sector has unique rights and responsibilities in this system. For example, even if donors wish to supply funds for replacement buildings, the government must decide if the area is safe to build and give permission to do so. The city of Lisbon in 2012 is much safer than Lisbon in 1755 due to the government's (royal decree) action to establish a new system of rectilinear streets and wide major boulevards after the earthquake, tsunami, and fire. In Christchurch, New Zealand, after the 2011 earthquake an area comprising nearly 7000 houses has been declared as non-rebuildable due to soil conditions. The friction caused by this external sector decision (in this case the national government) will result in a complex set of transactions to be completed, and will result in much greater certainty as to where to rebuild residential areas. Friction can also occur between external subsectors. Various competing missions of national ministries for example may not be aligned and cause conflicting actions to occur that confuses the internal sector and causes increased levels of uncertainty. This works itself out through learning where the uncertainty is occurring and then adapting to the needs through the design of appropriate transactions.

6 Concluding Discussion

The questions emerging from this model include: (1) how to assemble the information on what constitutes the internal sector in terms of individual and collective needs and capacity to utilize resources as they become available; (2) how to determine what constitutes the external sector relations that may include state government, national government, and donor sectors; (3) how to lower the uncertainties within and among these sectors that create friction and complicate transactions; and (4) how to estimate and lower the friction costs. The policy question is how to move from complex through complicated to simple transactions in the least amount of time and with the highest outcomes for invested resources (fiscal and human).

There are few studies that address multilocation recovery complexity. This will change as more becomes known about the Japan, New Zealand, Chile, and China experiences. Interest will also change as more such events occur in a more urbanized world.[viii] Multilocational recovery complexity is but one aspect of the more general emergence of interest in the sustainability of cities impacted by extreme events that cause catastrophic damage to life and property. This use of emerging economic theory rests on the belief that cross-disciplinary approaches can yield more information to policy and decision makers than remaining within a single disciplinary boundary. While the use of two general sectors (internal and external) may appear to oversimplify the complexity of what happens in recovery, it does allow for a greater understanding of general system dynamics.

While uncertainty has risen to a high level of concern with the 2011 nuclear crisis at the Fukushima nuclear plant in Japan, uncertainty is also a factor in most contemporary recovery efforts. We need better ways to model uncertainty and design ways to lower its impact and duration.

Multilocational recovery complexity studies may also lead to a better understanding of a general recovery model based on systems theory and capacities of individual urban systems (the city) to achieve recovery over time (Alesch and Siembieda 2011). By examining the outcomes of many cities and towns in different geographic space we can better understand why some cities do recover (reach some acceptable level of viability) while others are not as fortunate. This understanding will inform the shaping of recovery and reconstruction policy.

Notes

i The 2010 Nobel Prize was awarded to Dale T. Mortensen, Professor of Economics at Northwestern University, USA; Peter A. Diamond, Massachusetts Institute of Technology, USA; and Christopher A. Pissarides, London School of Economics and Political Science, UK.

ii An example of uncertainty is the long-term danger the Tempco nuclear plant #1 presents to the population within a 30-km radius of the facility. This is the nuclear plant that suffered earthquake and tsunami damage and radioactive material release due to the March 2011 events in Fukushima Prefecture, Japan.

iii External agents consist of three large groups: government, donors, and nonprofit organizations (NGOs and community and faith based organizations are included in this group). Government takes in the national level, prefecture or state level, and associated ministries and agencies. Internal agents are people in communities, their civic organizations, local governments, and special interests.

iv A transaction requires some degree of mutual agreement. This is different than mandatory requirements where no choice is given. Many recovery processes involve both transactions and mandatory actions.

v Daniel Kahneman, Professor at Princeton University, USA, was awarded the 2002 Nobel Prize in economics for his work on Prospect Theory, the understanding of loss aversion behavior, and contributions to behavioral economics.

vi Haruo Hayashi at Kyoto University created this as an information system tool that would be used by local governments in long-term recovery.

vii In Chile, the coastal towns impacted by the February 2010 earthquake and tsunami needed to get the local fishermen back to work quickly in order to restore economic sustainability. This led to more emphasis on meeting the fishermen's needs than other subsector needs such as housing replacement.

viii Haiti could be added to this list as it fits the multiple location criteria and the model does apply.

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