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Fiscal and social costs of recovery programs for an earthquake disaster in northern Taiwan

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ABSTRACT

We investigate the long-run disaster impact of an earthquake hitting northern Taiwan with a nuclear power plant shutdown and the costs and effectiveness of recovery programs using a dynamic computable general equilibrium model. We simulate the losses of capital and labor from the disaster with a nuclear power plant shutdown and then conduct policy experiments of the recovery of Taiwan's three major industries by subsidizing their output or capital use. We find that the semiconductor and electronic equipment sectors could recover with the aid of subsidies. In contrast, the recovery of the chemical sector would be crucially dependent on the availability of nuclear power. This is because the chemical sector is heavily dependent on petroleum products as inputs and thus susceptible to fuel price rises, induced by a fuel demand increase following the shutdown of a nuclear power plant. The fiscal and welfare costs differ by type of subsidy and program duration. Capital-use subsidies would cost less than output subsidies. A longer recovery program duration would cost less by reducing the distortionary effects of the policy interventions.

1. Introduction

The Asia Pacific region is highly prone to natural hazards because of its geological environment, and Taiwan is one of the most vulnerable areas especially to earthquakes. Taiwan hosts world-leading industrial sectors, such as semiconductors and electronic equipment, which are located in the Hsinchu Science Park in the north of the country, close to the capital, Taipei City. This area has two disaster risk factors. The first concerns the Shan-jiao fault, which runs through the semiconductor complex area. The second involves nuclear power stations, which are located in coastal areas within 30 km of the capital. An earthquake could hit not only the industrial center but also the nuclear power stations directly or indirectly.

In Taiwan, the most recent and serious earthquake occurred on September 21, 1999 (the "921 earthquake"). This magnitude 7.6 earthquake hit the center of the island of Taiwan and impacted northern Taiwan, causing serious damage to communities and facilities, including the power network, and disrupting industrial activities for two weeks. The 921 earthquake caused surface faulting and extensive ground deformation, resulting in 132 landslides and severely affecting roads and bridges in many regions. The cost of the direct damage to housing has been estimated at 360 billion TWD (Huang et al., 2005). In terms of economic activity, losses in agriculture reached 8 billion TWD. A national survey of 7200 manufacturers (with 5984 respondents) conducted six days after the earthquake reported a total loss of capital stock of 12

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billion TWD, one-third of which occurred in the information and communication technology industry. Located 110 km from the epicenter, Hsinchu Science Park (2011) reported that the losses of semiconductor and electronic equipment manufacturing exceeded 10 billion TWD. The disaster also severely hit the tourism industry, which lost 4 billion TWD (Huang et al., 2005). Taiwan's power supply system was disrupted because many transmission towers were seriously damaged causing failure in the transmission of electricity. Furthermore, damage to the Chung Liaw switchyards connecting two trunk transmission lines caused a power outage for more than one week (Moh, Hwang, Ueng, & Lin, 2002). Despite no direct damage, two nuclear power plants located in northern Taiwan tripped because of overall system imbalance and were shut down for nearly a week after the earthquake (Dong et al., 2000). The power outage exacerbated the direct impacts of the 921 earthquake on the capital stock and labor availability. The disaster reduced Taiwan's GDP by 3.3% (Prater & Wu, 2002).

The Council for Economic Planning and Development took the lead in the recovery from the 921 earthquake disaster, preparing a five-year reconstruction plan, called the Post-Earthquake Reconstruction Plan. A governmental agency, the 921 Earthquake Post-Disaster Recovery Commission, was formed to undertake the reconstruction with a budget of 212 billion TWD for public infrastructure restoration, economic revitalization, house and community reconstruction, and so on (Moh et al., 2002; The 921 Earthquake Post-disaster Recovery Commission, 2006; Tsai, Chung, & Liu, 2013). These recovery programs were followed by private sector recovery programs prepared by a semiofficial organization, the 921 Relief Foundation. It carried out 21 major projects for regional reconstruction through local specialty and tourism promotion, community activation, industrial exhibitions, aboriginal culture renaissance, and urban planning and regional activation (Huang et al., 2005). These programs focused on promoting the tourism industry by creating agricultural parks of tea, bamboo, flowers, fruit wine, and holiday markets, raising the competitive capabilities of local products and businesses, constructing a living environment in harmony with nature, and continuing to promote community empowerment in 2003–2006 (The 921 Earthquake Post-disaster Recovery Commission, 2006).

The risks and potential damage of disasters became a concern again after the Great East Japan Earthquake (GEJE) in 2011. Taipower, Taiwan's national power company, was ordered to conduct special technical examinations of its security and safety systems in the three currently operating power stations with six reactors and continue their operation. However, Taiwan's public aversion to nuclear power led to an extremely negative reaction to a newly developed nuclear power station coming online. Despite the completion of this fourth nuclear power plant in 2014, the government has banned it from operating. Moreover, fears about food contamination by radioactive materials have prohibited food imports from five prefectures in Japan for more than six years (as of August 2017), even if they have been safely screened and tested for radioactive materials.

Impact analyses of these actual and potential disasters have been conducted for Taiwan. Tsai and Chen (2011) developed a risk assessment model for potential disasters for Taiwan's tourism industry, conducting a case study for Hualien City. Huang and Hosoe (2016) assessed the macroeconomic impact of a hypothetical magnitude 7.5 earthquake and a power crisis hitting the manufacturing sectors of northern Taiwan using a static computable general equilibrium (CGE) model. They found that the semiconductor, chemical, and pottery sectors, which are capital- and/or energy-intensive, would be affected most severely, the machinery and transportation equipment sectors would be affected much less, and the power crisis from the nuclear power shutdown would raise power prices by 27% and increase the losses caused by the earthquake by a further 15%.

Estimates of damage and losses associated with disasters are useful in developing disaster-impact mitigation plans and in examining their investment values. However, regardless how precisely and in detail we study the impact of disasters, we can neither prevent them nor avoid their negative impacts on the economy. Following a disaster, a recovery plan must be developed by studying the recovery processes and policies that can minimize the disaster-induced losses and/or achieve a recovery goal at a minimum cost. After the 921 earthquake, the Taiwanese government set up a five-year recovery plan with a large special budget. In future disasters, similar recovery programs would be required. It is therefore essential to assess what would happen during the recovery process after a disaster, what program scheme would be efficient, and what costs would be incurred.

Both the size and scheme of the program budget are important. To promote the recovery of the private sector, the government often intervenes in markets using subsidies. For example, investment is subsidized using a form of tax credit to aid in the recovery process. Production and sales are also supported by subsidies. Subsidized or concessional new loans, as well as rescheduling of existing loans, are offered for the same purpose. The costs and effects of these recovery programs depend on the type of subsidies. The fiscal costs of the subsidies are borne by the government, but ultimately by taxpayers inside and outside of the affected area, and so the recovery program has to be affordable for them. In addition to the fiscal costs, mobilizing resources for the recovery distorts resource allocation in markets and leads to social costs.

The time frame is another issue involved in designing the recovery program. While intensive programs are often preferred for rapid recovery, additional budget and social costs may be incurred to accelerate recovery. More intensive intervention would result in larger distortions in the market and thus more serious inefficiencies. Wu (2009) found that only two-thirds of the budget had been executed at the end of the third year after the 921 earthquake and that it took seven years to execute it fully. In the case of the GEJE, the majority of the special recovery budget was prepared immediately after the event. The Board of Audit of Japan (2013) reported that about 10% of the budget for the first two years was misused or abused. Therefore, a final question to examine concerns how long the recovery program should be.

Studies on the recovery process and impact assessments of recovery policies *after* a disaster are scant for Taiwan. Chen (2013) simulated a no-nuclear situation (but without considering any disasters) using a dynamic CGE model for Taiwan. Huang and Min (2002) investigated a recovery of inbound tourist flows after the 921 earthquake. While no economy-wide studies on disasters and recovery in Taiwan have been conducted, the GEJE strongly motivated researchers to study recovery