Philippine Journal of Development
Volume 43 (2018) | Number 2

Economic Impact of Typhoon *Ondoy* in Pasig and Marikina Cities Using a Multiweek CGE Model Analysis

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ABSTRACT

The adverse effects of extreme flooding caused by Typhoon *Ondoy* in Pasig and Marikina Cities in 2009 are significant. This paper estimates that both cities may have lost PHP 22.54 billion, 90 percent of which represent the loss of Pasig City. Estimates of willingness to pay to avoid the adverse effects of flooding, as measured by the equivalent variation (EV) of income, is positive for Pasig City. Its residents and businesses may want to pay up to PHP 12 billion, the cumulative EV throughout the adjustment period, to be resilient. On the other hand, Marikina City residents appeared to have increased their real consumption because of reduced prices brought about by an appreciation of the real exchange rate. Their EV is PHP 11.19 billion. Their willingness to pay is negative. These results depend on how the city's economy is modeled relative to the rest of the world and the exchange rate policy. The study's estimates are obtained using a multiweek, local economy computable general equilibrium analysis which assumes weekly market clearing. Some suggestions for improving the methodology are provided.

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INTRODUCTION

The economic effects of natural disasters have been acknowledged in literature. However, most of the studies done were on developed countries and involved assessments of such events at the national level. Very little information is available about their impacts in developing countries, and more so at the city level. A typical economic assessment of natural disasters in the Philippines is on the damage to agriculture and infrastructure facilities (WB 2005, 2011). However, more significant than the actual damage is the opportunity cost in terms of reduced productivity and, in turn, forgone income induced by natural calamities. While there have been assessments of the effects of major typhoons in the country,[2] measurements of the damage caused have not been undertaken.

This research developed and used a multiweek computable general equilibrium (CGE) economic model of a city. The framework allows for economic analysis of climate-related disasters affecting subnational economies over a time period that is typically less than a year. It was applied to two coastal cities in the National Capital Region, which had been submerged for several days by Typhoon Ondoy in 2009 and coped with its effects for a total of about 29 weeks. The procedure preserved the general equilibrium theoretic relationships among the different variables of an economy. It developed a weekly social accounting matrix (SAM) of a city-level economy based on an estimated national annual SAM, the city's contribution to the national gross domestic product (GDP), and the assumption that the city's GDP is equally distributed across all the weeks in a year.

The research involved getting information from a group of businessmen in the city to identify disruptions suffered by their businesses from the extreme flooding, including both the extent and duration of adjustments. The suspension of their businesses, in turn, was introduced as shocks to the supply of productive factors in the city CGE economic model in order to simulate the economy-wide effects of extreme flooding. The simulation was sequentially done for a total of 29 weeks, which the experts determined to be the length of the adjustment period.

MEASURING THE COST OF NATURAL DISASTERS

The economic cost of natural disasters globally is estimated to be large and rising. Benson and Clay (2004) reported that the average total loss in the 1990s caused by natural catastrophes in the world reached USD 66 billion per year, which was 15 times higher compared to the 1950s. In the 1994–2013 period, 6,730 disasters have been recorded, killing over 1.35 million people or 68,000 globally each year, and costing the world economy about USD 2.63 trillion (CRED 2015). In the Philippines, natural disasters have been estimated to affect 4–6 million people each year. Using data from the Center for Research in the Epidemiology of Disasters (CRED),[3] the International Federation of Red Cross and Red Crescent Societies (2012) reported that almost 20,000 people have died, while 2.7 million people have been directly affected and 94 million indirectly affected by natural disasters from 1992 to 2011.

The economic impacts of natural hazards are classified according to direct, indirect, and macroeconomic or secondary impacts (Pelling et al. 2002; Benson and Clay 2004; Hallegate and

[2] See for example, the postdisaster study on the economic effects of Typhoon Ondoy in 2009 by the World Bank (2011).

[3] The center was established in 1974 with the mandate to examine the socioeconomic and long-term effect of large-scale disasters. Its headquarters is in Geneva, Switzerland.

Pryzluski 2010). Direct impacts are the immediate consequences of natural disasters. These cover deaths or injuries to the population, damages to physical assets, machinery and capital equipment, crops and livestock, inventories of raw materials and final outputs, as well as to infrastructure facilities such as irrigation systems, roads, and bridges. Damages are estimated at market prices or based on agreed-upon replacement costs.

Pelling et al. (2002) noted that the measurement of the direct losses has typically been the focus of most studies on disaster effects. The estimated damages have been used in disaster mitigation, preparedness, and risk insurance programs. The typical immediate effects of natural disasters are damages to housing, business facilities, industrial production, crops and livestock, and infrastructure. Human deaths and injuries are naturally present due to drowning and other accidents caused by water level rise and subsequent adverse outcomes.

The indirect impacts are costs associated with reduced productivity resulting from the damages to productive capacities of business establishments, forgone household incomes, and lower expenditure over a period of time until productive assets are fully recovered. These effects reflect the extent by which the direct impacts of disasters have spread to the economic system.

The impairment to critical infrastructure such as road networks, bridges, ports, electricity, telecommunications, and water systems reduces productivity of agricultural, industrial, and service industries in the economy. Even if firms had not sustained any asset damage, their productivity is affected. Disruptions to the flow of labor and raw materials as markets fail to function temporarily due to lack of transportation, power, and other critical services take their toll on the economy. On the household aspect, jobs are temporarily lost, and without adequate income, so does protection insurance. In turn, this lowers household incomes and expenditure. Exports decline due to reduced productive capacity.

Economy-wide 'secondary' impacts are losses in overall output and incomes as measured by changes in national, sectoral, or subnational GDP, as well as in other macroeconomic indicators such as capital investments, trade flows, balance of payments, inflation, fiscal deficit, employment, and level of indebtedness. The economic effects of disasters have wider and longer adverse impacts on production, distribution, and consumption of goods and services. Overall output falls and prices of basic commodities increase, pushing inflation. The overall unemployment and underemployment may temporarily increase as businesses stop production. The balance of payments may be adversely affected given the disruptions in export capacity and the need for short-term imports that would cover interruptions in production. Fiscal deficits may rise as tax revenues fall, and public expenditure goes up to pay for short-term relief and rehabilitation of the economy.

The analysis of the economy-wide or secondary impacts is typically carried out using economic input-output (IO) and CGE models. IO studies can assess the reduction of industrial output following the damages to infrastructure, machinery, and other productive assets in key sectors that are directly affected by natural hazards. These effects ripple throughout the whole economy as output losses deprive other productive sectors of intermediate inputs.

A more comprehensive analytical technique involves CGE models which can examine the impacts of natural hazards in both the production and consumption sides of the economy. Relative prices of goods, services, and factors change which, in turn, affect household incomes and expenditure. Unlike in IO models, productive factors are substitutable with each other in CGE models.

Few studies examine the impacts of climate change in geographical areas, specifically that on infrastructure, health, energy use, and water availability (e.g., Hunt and Watkiss 2011). However, most of the studies on climate-related disasters are on the effects on households and vulnerable sectors (e.g., Zoleta-Nantes 2002; Porio 2011; Israel and Briones 2014). None of these studies, however, assessed the economic impacts of climate change at the city level.

While studies on the effects of natural disasters at the city level have been undertaken, these are in developed countries (e.g., Hunt and Watkiss 2011; Gertz and Davies 2015). Gertz and Davies (2015) examined the effects of flooding on the economy of Vancouver in Canada using a dynamic CGE model. A similar analysis is undertaken by this study on the effects of extreme flooding on two cities of the National Capital Region (NCR), namely, Marikina and Pasig Cities.

AN OVERVIEW OF THE ANALYTICAL FRAMEWORK

This part of the paper describes the recursive multiweek CGE model of a city's economy used in this study. The model tracks the different payment flows and exchanges undertaken by institutions within the economy. Figure 1 illustrates the range of transactions in the economy involving services of productive resources, intermediate inputs, and final outputs. Payment flows between institutions cover the transfer of ownership of intermediate inputs, products, and primary factor services in the economy.

Agents, incomes, and spending

There are five institutions or agents in the model: households, firms, government, financial intermediaries, and the foreign sector. Except for households, the institutions are represented by one entity. Agents generate income and spend them on the products produced in the economy or provide exogenous net income transfers to other institutions. Households and businesses pay taxes to the government. Agents save part of their incomes.

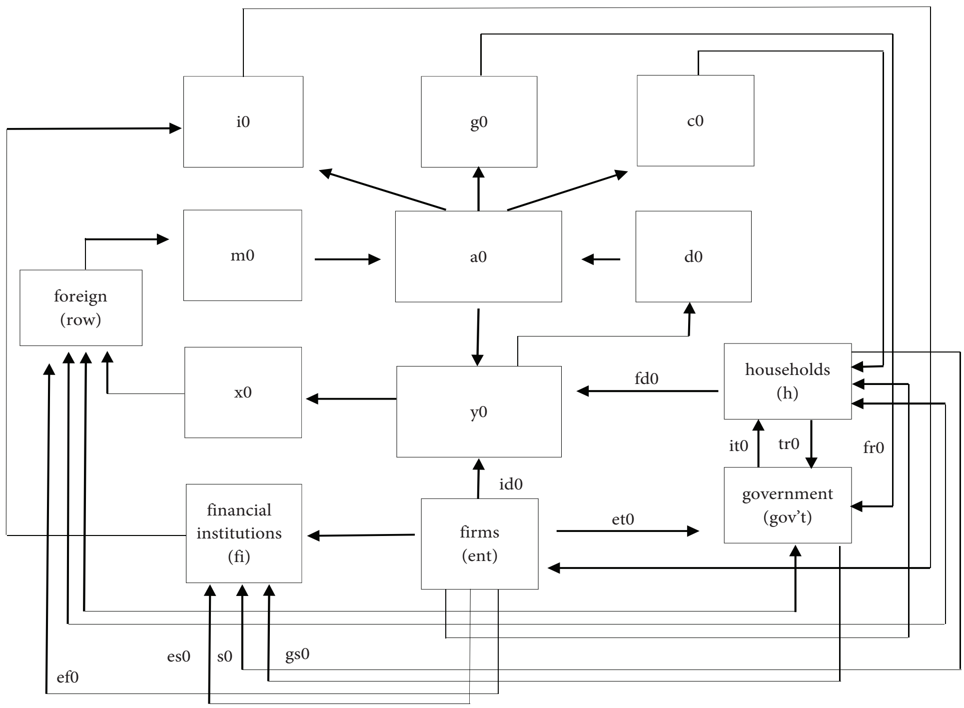
Income levels differentiate the types of households. Households generate their income from selling the services of the primary factors they own (*fr0*) to firms to be used in production. These include wages of high- and low-skilled labor, as well as returns to capital and agricultural lands. Other income components include exogenous transfers from other institutions (*tr0*), particularly from the government. Households pay income taxes (*it0*), purchase goods and services for final consumption (*c0*), including public goods spent by the government (*g0*).

Firms provide intermediate inputs (*id0*) from other firms and factors from households (*fd0*) and firms to produce goods, which are either sold domestically (*d0*) or are exported abroad (*x0*). Locally produced goods to be sold in the home market and imported products and services (*m0*) make up the intermediate inputs as well as products used in the final consumption by households and other agents. A hypothetical composite product of both types of goods, called the 'Armington good' (*a0*) (Armington 1969), conveniently represents the transactions involving local and imported products.

Net income transfers between the economy and the foreign sector are exogenous. These transfers include net remittances of incomes of the labor force working abroad, profits of the capital that is invested overseas, and net purchases of financial assets. The exchange rate is endogenous, its level changing depending on the net flows of merchandise and services trade between the country and the rest of the world.

On the other hand, government receives taxes from households (*it0*) and from enterprises (*et0*), and spend these on transfers to households. The representative financial intermediary receives savings from different institutions including households (*hs0*), business enterprises (*es0*), government (*gs0*), and the foreign sector (*fs0*). It uses the aggregate savings to invest in new capital assets in the economy (*i0*), thereby increasing the stock of capital available for use in the following time period. In the short-run model used in this paper, the time period being a week, there is no savings and investment in new capital.

Figure 1. Illustrative flow of transactions in a general equilibrium model



Note: Institutions include households (h), firms (ent), government (gov't), financial sector (fi), and foreign sector (row). Stocks include production output (y0), Armington supply (a0), exports (x0), imports (m0), domestic supply (d0), investment (i0), government consumption (g0), and consumption (c0). Flows include factor demands (fd0), factor returns (fr0), transfers (tr0), income taxes (it0), intermediate demand (id0), government savings (gs0), household savings (s0), enterprise savings (es0), and enterprise factors (ef0).
Source: Modified from Markusen and Rutherford (2004)

The interdependencies of the agents in the economy depicted in Figure 1 confirm that any disruption in one part of the economy will affect the rest of the economy. For example, a loss of productive factors, due to a disruption in the flow of capital, will reduce output in the economy and therefore will reduce the total amount of goods available for household consumption, firm investment, and government spending. This will lower household incomes and total investment in the economy.

Equilibrium conditions

The CGE model used in this study takes after that of Rutherford (1999) and Rutherford and Paltsev (1999). The firms maximize their profits subject to technology and input constraints. Endowed with primary factors, households maximize their respective satisfaction levels consistent with their budget constraints. Both households and firms are pricetakers and markets are perfectly competitive. The optimization in production and consumption produce the market supplies of products and demands for primary factors, intermediate inputs, and Armington goods.

Three types of equilibrium conditions apply. The first requires that total spending by all agents equals exactly the aggregate income, i.e., the model is Walrasian. The second is that the revenues generated from each production activity defray exactly the production costs. The last type of equilibrium conditions of the model is market clearing, i.e., excess demands are zero. Each of the three types of conditions is associated with a particular endogenous variable, namely, incomes of agents, scale of production, and prices of products, respectively.

The second and third types of conditions are formulated as complementarity problems, i.e., for the second, the profit equation is expressed as less than or equal to zero, with each inequality associated with the scale of production. If in equilibrium the profit of a given activity is zero, then production scale is nonnegative. Otherwise, the activity is shut down.

In the case of the third type, excess demands in equilibrium can be zero in which case the price of the product is nonnegative. However, they can be negative and the associated prices are strictly zero, or the products are free.

Modeling climate-related disasters affecting a city

The application of the CGE model in measuring the secondary effects of natural disasters reflects the observations documented in existing literature on the nature and dynamics of such catastrophic events like extreme flooding (e.g., Aufret 2003; Skoufias 2003).

The extreme flooding in Metro Manila in 2009 had affected not only the household but also the business sectors. According to key resource persons, 90 percent of Pasig City's geographical area was reportedly inundated during the day of the typhoon, while 85 percent was the case for Marikina City.[4]

As explained earlier, this shock in the capital and labor stock arising from citywide flooding reverberates in the economy through constraints in the supply of goods from affected industries (Gertz and Davies 2015). For the case of Metro Manila, the damages to offices, plants, and machinery, as well as the inability of personnel to report for work, were the main constraints. The interruptions in the production of goods and services due to the flooding, therefore, increased trade constraints faced by each city in Metro Manila.

It becomes imperative to equip the model with features that relate the economy with the impacts of natural disasters to analyze the effects of climate-related shocks through time. Reduced factor services availabilities are introduced as shocks to the benchmark equilibrium of the model in week t. Equilibrium is computed consistent with reduced labor or capital stocks. In week $t+1$, adjustments to the factor stocks are computed and introduced as the current shocks to the model's equilibrium.

The effects on sectoral outputs, prices, agents' incomes, and economic welfare of households are then assessed in each weekly equilibrium. All these secondary effects are computed by sequentially computing the general equilibrium of the model from the initial period of the disaster to the time the local economy would have resumed its normal operations. In the following section, the data used in calibrating the model is discussed.

DATA AND EMPIRICAL IMPLEMENTATION

The data used in numerically specifying the CGE model is the SAM. In its simple version, the SAM traces the circular flow of income and expenditure in the economy, i.e., from factor payments by producers to households and product purchases of the latter from the former. Additionally, it tracks

[4] Based on interviews by the research team with the Pasig Business Center, May 10, 2016, and with PCCI Marikina Chapter, May 27, 2016. See the next section.

income and spending of institutions including businesses, government, financial intermediaries, and the rest of the world. The SAM is assembled from various data sets of the economy in a way consistent with the specifications and general equilibrium conditions of the CGE model. The assembly is made in a particular year, which is the period the model is calibrated to.

National, regional, and city SAMs

Conventionally, CGE models are calibrated with annual data sets. Thus, adjustments are made to a country's SAM in order to produce its counterpart for a city's economy. A national SAM of the Philippines was constructed for the year 2009.[5] It was adjusted in two ways to come up with the NCR regional SAM and from it to produce the two city SAMs of Pasig and Marikina. First, the national SAM was scaled down to NCR using the proportion of the regional to the national GDP. In 2009, the NCR's GDP was 31.7 percent of the national (PHP 2.53 trillion versus PHP 7.97 trillion, respectively). From the NCR's SAM, the separate city SAMs of Pasig and Marikina were assembled, applying the shares of the respective cities in the NCR's GDP. The other adjustment was extracting a weekly SAM from the city's corresponding annual SAM by dividing the data in the SAM by 52.

Accordingly, the two city SAMs of Marikina and Pasig reflect the specification of the national SAM. Thus, it is useful to describe the latter to know what is in the former. The assembled national SAM comprises 16 production sectors, the selection being guided by the configurations of the city economies of Pasig and Marikina. Accordingly, the SAM has two primary production activities, five industrial sectors, and nine services industries:

Sector Description	Code
Agriculture, which includes crop production and agricultural services	Agri
Natural resources, including fishing and forestry	Natr
Food processing	Food
Textile and garment processing	Text
Nonmetallic processing, i.e., chemicals, plastics, glasses, rubber	Nmet
Machinery and electronics equipment	Mach
Other manufacturing	Otmn
Construction	Cons
Utilities, i.e., electricity, gas	Util
Transportation services	Tran
Retail and wholesale trade	Trad
Financial services, including banking	Finl
Real estate	Real
Public administration and services, including health and education	Ppsr
Hotel, restaurant, and tourism services	Htrt
Other services	Otsr

The data sources for the 2009 national SAM are the national income accounts, the Budget of Expenditures and Sources of Financing, the Department of Finance government financing tables,

[5] The procedure follows that of Cororaton (2003), who assembled a 1994 SAM.

Foreign Trade Statistics, Balance of Payments account, and the Family Income and Expenditure Survey—all from the year 2009.

To assemble the NCR GDP, two additional data sets were obtained. One is the 2009 Commodity Flow Account, which was used to get information on the composition and level of trade of the region with the rest of the Philippines. The data set, gathered and published by the Philippine Statistics Authority, provides information on the values of inflow and outflow of goods and services to and from a region of the country to another. The other was on the local government receipts and expenditure. The data was sourced from the Bureau of Local Government Finance. It includes local expenditure on public goods and services and local income sources including real estate taxes, business taxes, and internal revenue allotments from government.

The city economies of Pasig or Marikina are modeled as small open economies with respect to the world and the rest of the Philippines. As a small open economy, its domestic prices are linked to the corresponding prices of the products in the larger markets of the rest of the world and the rest of the Philippines.

In summary, the two city SAMs have 16 production sectors, 2 production factors (labor and capital), and 7 institutions—households, enterprises/firms, financial intermediary, national government, local government, the rest of the Philippines, and the rest of the world.[6]

Business sector consultations

The cities of Pasig and Marikina were selected for the study. Pasig City is mostly industrial, while Marikina City is mostly residential. Both were heavily inundated by Typhoon Ondoy, with an estimated 90 percent of Pasig City and 85 percent of Marikina City flooded at the height of the typhoon.[7]

Years of infrastructure development had made Marikina less flood prone. The volume of water Typhoon Ondoy brought, however, was unexpected even by the Marikina residents. The flood heavily damaged much of the micro, small, and medium enterprises (MSMEs) near the Marikina River.

In Pasig City, areas most badly affected were those near the Manggahan Floodway and in the border of Marikina. A difficult challenge faced by city residents and business locators was the persistence of floodwaters months after the typhoon onslaught. As in Marikina, the MSMEs were the ones more badly hit. Some of the larger firms, on the other hand, have either the mechanisms to mitigate the adverse effects of flooding, or business continuity protocols, or both.

Consultations with business organizations in the two cities were undertaken to develop a more nuanced understanding of the temporal impacts of Typhoon Ondoy on business establishments. They were asked how they had coped with the flooding, particularly how they scaled down their business operations from the first week of flooding to the time when the city in general had fully recovered from the disaster. These consultations produced information on the length of the recovery period, as well as useful data for producing the city SAMs.

Tables 1 to 3 give the results of the consultations showing the level of shock sustained by the availability of labor and capital and the flow of raw materials when the typhoon hit, on a weekly basis, as the industries affected gradually recovered. The numbers in the matrices give the proportion of the three types of production factors that are available in the weeks following Typhoon Ondoy. The

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[6] The SAMs for the NCR, Marikina, and Pasig Cities are not reported but may be obtained upon request.

[7] Based on interviews by the research team with the Pasig Business Center, May 10, 2016, and PCCI Marikina Chapter, May 27, 2016.

number 0 in the table indicates there was no capital, labor, or raw materials available for production for the particular industry in the week indicated.

On the other hand, the number 1 indicates that normal supplies of these factors and raw materials were already available. In most cases, when the representative firms report that their operations had stopped for a month, capital stock is pegged at 0 percent over that time period. The first general assumption, therefore, is that for firms which were affected, virtually all capital assets (i.e., machinery and plant) were deemed not serviceable for production.

Capital availability after Typhoon Ondoy

The average time it took business enterprises in Marikina City to resume normal operations was 1.5 months. In contrast, the estimate for Pasig City was just about one month (see highlighted cells in Table 1). In both cities, firms needed time to repair, replace, or clean up their plants and machinery, which took most of their time and resources due to the muddy nature of floodwater. Hence, it is assumed that the time it took to resume operations is closely related to the availability of capital that can be used for operations, as noted above. Another period of 1.5 months was needed for Marikina firms to be able to go back to normalcy, while Pasig firms needed another six months (Table 1). These scenarios were therefore assumed for most types of firms in both cities.

As shown in Table 1, some sectors were able to resume operations faster than others. For instance, it had taken only two weeks for affected financial institutions and real estate firms to resume operations. Notable for their quick response in repairing damages to their capital were the utility firms and communication firms. Transportation, as well as public services, were also assumed to have continued operations despite the massive inundation. In Pasig, one firm reported that their operations have not been affected despite inundation of the actual plant due to support mechanisms already installed. Hence, many nonmetallic processing firms located in Pasig City are assumed to have had little disruption in their operations.

Finally, it is noted, however, that some MSMEs have no longer been able to recover. This is reflected in the model by disallowing some of the sectors, mostly composed by MSMEs, to resume 100-percent capital availability.

Labor and raw materials availability after Typhoon Ondoy

Within the first work week after the typhoon, workers in most industries in both cities were back at work. Interviews with Marikina firms, for instance, revealed that labor supply has not been affected substantially as workers were willing to go back to work within the first work week after the typhoon. According to one manufacturing firm interviewed, as soon as workers were done cleaning up their own homes, they went to their work site to help clean it up as well, fully aware that they needed to help their companies restart operations. In return, the companies continued to keep them employed even while operations have stopped, and paid them for the cleanup. Interviews with representative firms from Pasig also revealed the same scenario with their employees. Absences have only been common during the first two or three days of the first work week after the typhoon.

Hence, it can be assumed that labor supply has not been substantially reduced even in the first work week after the typhoon except during the first few days (Table 2).

In the case of raw materials supply in Marikina, however, most firms experienced difficulty for two weeks after resuming operations due to the difficult entry and access to Marikina as a result of massive debris. This same scenario is assumed for the entire city. In Pasig, only industries that required agricultural products were assumed to have been adversely affected by the disruption in raw materials supply (Table 3).

Table 1. Capital availability in the cities of Marikina and Pasig

Panel A: Marikina City

Model Sectors	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14	Wk 15	Wk 16
Agriculture	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Natural resource extraction	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Food, beverages, and tobacco	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Textile, garments, and apparel	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Nonmetallic mining and processing	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Machinery and electrical industries	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Other manufacturing	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Construction	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Utilities	0.05	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transport and communications	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trade	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Financial	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Real estate and commercial	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Public and private services	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hotel and restaurant	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Other services	0	0	0	0	0	0	0.14	0.29	0.43	0.57	0.71	0.71	0.99	0.99	0.99	0.99
Average	0.13	0.19	0.31	0.31	0.31	0.31	0.41	0.51	0.61	0.71	0.8	0.8	0.99	0.99	0.99	0.99

Wk = week

Source: Authors' calculations based on interviews with business sector representatives

Table 1. Capital availability in the cities of Marikina and Pasig (continued)
Panel B: Pasig City

Model Sectors	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14	Wk 15	Wk 16
Agriculture	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Natural resource extraction	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Food, beverages, and tobacco	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Textile, garments, and apparel	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Nonmetallic mining and processing	0.99	0.99	0.99	0.99	1	1	1	1	1	1	1	1	1	1	1	1
Machinery and electrical industries	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Other manufacturing	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Construction	0	0	0	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48
Utilities	0.05	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transport and communications	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trade	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Financial	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Real estate and commercial	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Public and private services	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hotel and restaurant	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Other services	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Average	0.19	0.25	0.37	0.37	0.58	0.6	0.62	0.63	0.65	0.67	0.69	0.7	0.72	0.74	0.76	0.77

Wk = week
Source: Authors' calculations based on interviews with business sector representatives

Table 1. Capital availability in the cities of Marikina and Pasig (continued)
Panel B: Pasig City

Code	Wk 17	Wk 18	Wk 19	Wk 20	Wk 21	Wk 22	Wk 23	Wk 24	Wk 25	Wk 26	Wk 27	Wk 28	Wk 29	Wk 30	Wk 31	Wk 32
Agriculture	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	0.99	0.99	0.99	0.99
Natural resource extraction	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	0.99	0.99	0.99	0.99
Food, beverages, and tobacco	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	0.99	0.99	0.99	0.99
Textile, garments, and apparel	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	0.99	0.99	0.99	0.99
Nonmetallic mining and processing	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Machinery and electrical industries	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	0.99	0.99	0.99	0.99
Other manufacturing	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.00	1.00	1.00
Construction	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.00	1.00	1.00
Utilities	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Transport and communications	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Trade	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Financial	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Real estate and commercial	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Public and private services	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hotel and restaurant	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other services	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average	0.79	0.81	0.83	0.84	0.86	0.88	0.90	0.91	0.93	0.95	0.97	0.98	1.00	1.00	1.00	1.00

Wk = week
Source: Authors' calculations based on interviews with business sector representatives

Table 2. Labor availability in the cities of Marikina and Pasig

Model Sectors	Panel A. Marikina City				Panel B. Pasig City			
	Wk 1	Wk 2	Wk 3	Wk 4	Wk 1	Wk 2	Wk 3	Wk 4
Agriculture	0.5	1	1	1	0.9	1	1	1
Natural resource extraction	0.5	1	1	1	0.9	1	1	1
Food, beverages, and tobacco	0.5	1	1	1	0.9	1	1	1
Textile, garments, and apparel	0.5	1	1	1	0.9	1	1	1
Nonmetallic mining and processing	0.5	1	1	1	0.9	1	1	1
Machinery and electrical industries	0.5	1	1	1	0.9	1	1	1
Other manufacturing	0.5	1	1	1	0.9	1	1	1
Construction	0.5	1	1	1	1	1	1	1
Utilities	0.9	1	1	1	0.9	1	1	1
Transport and communications	1	1	1	1	0.9	1	1	1
Trade	0.5	1	1	1	0.9	1	1	1
Financial	0.5	0.5	1	1	0.5	0.5	1	1
Real estate and commercial	0.5	0.5	1	1	0.5	0.5	1	1
Public and private services	1	1	1	1	1	1	1	1
Hotel and restaurant	0.5	1	1	1	0.9	1	1	1
Other services	0.5	1	1	1	0.9	1	1	1
Average	0.59	0.94	1	1	0.86	0.94	1	1

Wk = week
Source: Authors' calculations based on interviews with business stakeholders

The factor supplies in the cities of Marikina and Pasig recovered to their predisaster levels within the same year, and businesses in these cities were able to resume operations as well. In fact, in the case of labor, workers proved to be very resilient. The central business district of Pasig City, the Ortigas Center, had been fortunately spared due to its higher elevation. Labor supply returned to normalcy within the first work week after the typhoon due to (1) the firms' business continuity management and (2) the employees' recognition of the need to rehabilitate their businesses (i.e., their income sources). On the other hand, damage to capital stock has been mainly due to the muddy floodwater. Cleanup of the plants and machinery took considerable time for most companies. Raw materials supply was contingent on the immediate removal of road blockages.

RESULTS OF MODEL SIMULATIONS

This section takes up the results of simulations using the CGE model of the city economies of Pasig and Marikina. The study considered not only the shock but how it had tapered off through time. Thus, the CGE model was set up to attain the weekly equilibria of the respective city economies. This temporal analysis makes use of the information obtained from local businessmen and government officials about the time it took for their city to adjust and recover.

Table 3. Raw materials availability in the cities of Marikina and Pasig

	Panel A. Marikina City									Panel B. Pasig City					
Model Sectors	**Wk 1**	**Wk 2**	**Wk 3**	**Wk 4**	**Wk 5**	**Wk 6**	**Wk 7**	**Wk 8**	**Wk 9**	**Wk 1**	**Wk 2**	**Wk 3**	**Wk 4**	**Wk 5**	**Wk 6**
Agriculture	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Natural resource extraction	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Food, beverages, and tobacco	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Textile, garments, and apparel	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Nonmetallic mining and processing	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Machinery and electrical industries	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Other manufacturing	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Construction	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Utilities	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Transport & communications	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Trade	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Financial	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Real estate and commercial	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Public and private services	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Hotel and restaurant	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Other services	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Average	0	0	0	0	0	0	0	0	1	0.75	0.75	0.75	0.75	1	1

Wk = week

Source: Authors' calculations based on interviews with business stakeholders

Economic effects of flooding in Pasig City

The CGE model was used to simulate the economic effects of primary factor and raw materials availability in Pasig City. The model was solved repeatedly week after week, changing the available supplies of primary factor services as described in Tables 1 and 2, Panel B for Pasig City. The temporary nonavailability of raw materials is modeled by raising the trade cost of moving them into the city week after week as described in Table 3 (Panel B). The number of simulations corresponds to the number of adjustment weeks in Tables 1 to 3.

Production effects

The weekly changes of outputs by industries are shown in Figure 2, which plots the output multiples, with 1 representing the base output of a given industry in the base week (Week 0). The next four weeks pull down the respective production levels of most of the industries, except for two—nonmetallic industries (Nmet) and hotels and restaurant services (Htrt)—that expanded their outputs instead. The expansion of hotels and restaurant services reached 11, which is not shown in Figure 2 to get a better plot of the output changes of the other industries. This result may be explained by the full employment of factors equilibrium condition of the model. If the other industries had contracted, the resources that these industries did not use may have gone to other industries, in this case nonmetallic industries and hotels and restaurant services.

But in most industries, the first four weeks comprise a period of contraction. The recovery starts at the fifth week. However, once again production levels fall in the sixth week. It is only in the seventh week and thereafter that the gradual recovery to their normal levels becomes consistent.

Four industries overshot their recovery. In the fifth and sixth weeks, their respective outputs increased beyond their levels before the shock. Beginning the sixth or seventh week, however, the expansion reverses and converges to the normal level, which is 1, in the 29th week.

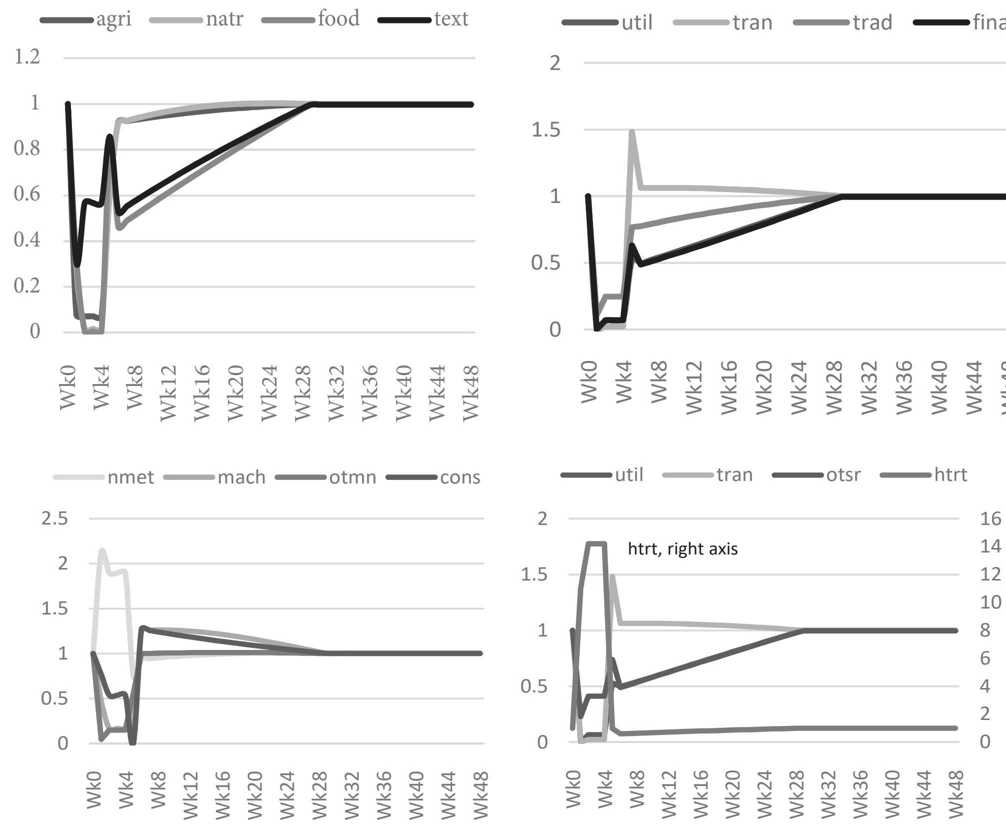
The expansion in output of some of the industries may be explained by the Rybcznski theorem (1955), which notes that as the endowment of a factor is reduced, the output of the industry that intensively uses it falls, while that of other industries that use it less intensively expands. The model used has more than two sectors. Nonetheless, the Rybcznski effect is still reflected in some industries expanding their respective outputs. Note that in the weeks following the disaster, factor endowments are reduced temporarily on a weekly basis and progressively restored to normal levels as described by the business stakeholders (Tables 1 and 2). The deeper adjustments were in capital, while labor endowments recovered in the third week.

Product prices and exchange rate

The effects on producer and consumer prices differ negligibly (Figure 3). All products in the model are tradable. All industries with tradable products export the products they make and produce differentiated products destined for the local market. While different from those that are exported, home products are valued not far from the prices of exported products when the economy is in a state of equilibrium. The country imports products that substitute the local ones. All prices of imported products change uniformly through the adjustment period of 48 weeks. Instead of plotting the price of every product, two price indices, one of consumer and another of producer prices, are computed using the industry's share in GDP as weights.

The two price indices are shown in Figure 3. Both rose in a similar manner, from week 0 in the base case and stabilized at 30 in five to six months. The exchange rate drove the results. Local prices of locally produced tradable products would have to be at par with the imported substitute in equilibrium. The model's equilibrium is computed each week, and the weekly equilibrium domestic

Figure 2. Effects on weekly outputs of the industries in Pasig City

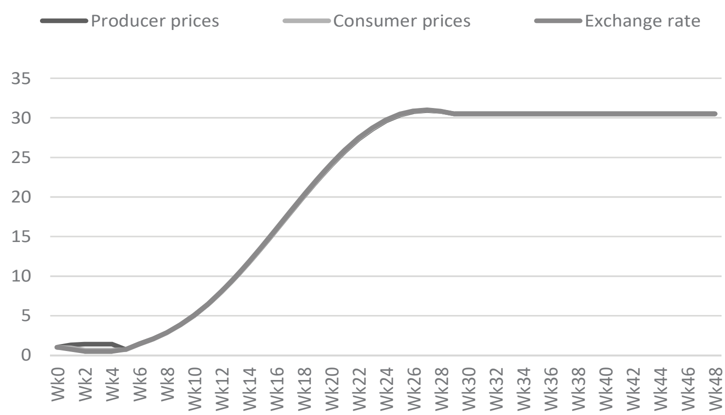


Wk = week
Agri = Agriculture, which includes crop production and agricultural services
Natr = Natural resources, including fishing and forestry
Food = Food processing
Text = Textile and garment processing
Nmet = Nonmetallic processing, i.e., chemicals, plastics, glasses, rubber
Mach = Machinery and electronics equipment
Otmn = Other manufacturing
Cons = Construction
Util = Utilities, i.e., electricity, gas
Tran = Transportation services
Trad = Retail and wholesale trade
Fina = Financial services, including banking
Htrt = Hotel, restaurant, and tourism services
Otsr = Other services

Source: Authors, based on interviews conducted with representatives from the business sector prices closely mirror the movement of the exchange rate (also plotted in Figure 3). Again, as a small open city economy, the economy of Pasig City should have a closure in the sense that its exports are equal to its imports in value terms vis-à-vis the rest of the world. The exchange rate is flexible to ensure that this is so. Figure 3 provides information on how the exchange rate had moved through the adjustment process following the disaster.

Domestic factors influence product prices as well. The disruption of raw materials supply chain in the first few weeks increased producer prices of import substitutes. This is reflected in Figure 3. However, after raw materials supply stabilized in Pasig City in the fifth week, producer prices moved as both consumer prices and the exchange rate.

Figure 3. Producer and consumer weekly price indices and exchange rate, Pasig City



Wk = week
Source: Authors' computation

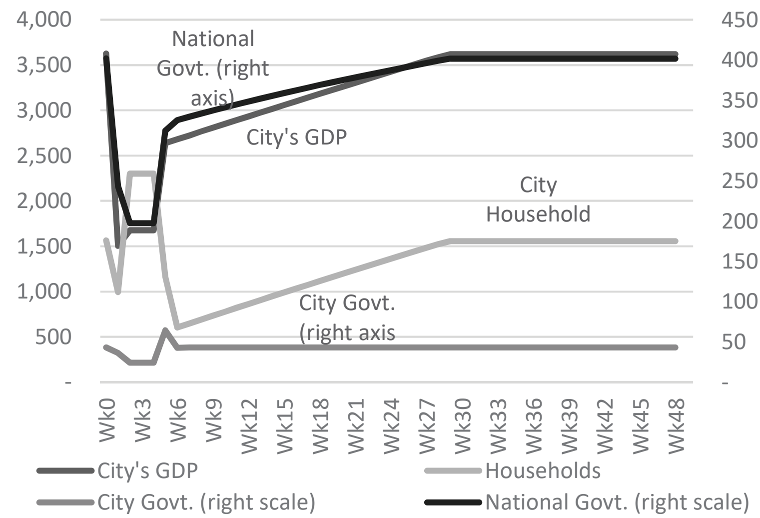
GDP, consumption, and public spending

Figure 4 portrays the weekly GDP of the city, real consumption of the representative households, and the public spending of the national and city governments. On average, the city's industries produce about PHP 3.2 billion of GDP each week. About 31 percent of this amount goes to the private households for final consumption.

The city's GDP contracted in the first week, but started to recover gradually in the third week. By the fifth week, the GDP level had jumped to about 70 percent of its predisaster level and expanded gradually, nearly completing the recovery in the 29th week. By the 48th week, the city's GDP was back to where it used to be. The big recovery process appeared to have occurred in the first five weeks of the adjustment period. Overall, the city lost a total of PHP 20,352.98 billion in GDP.

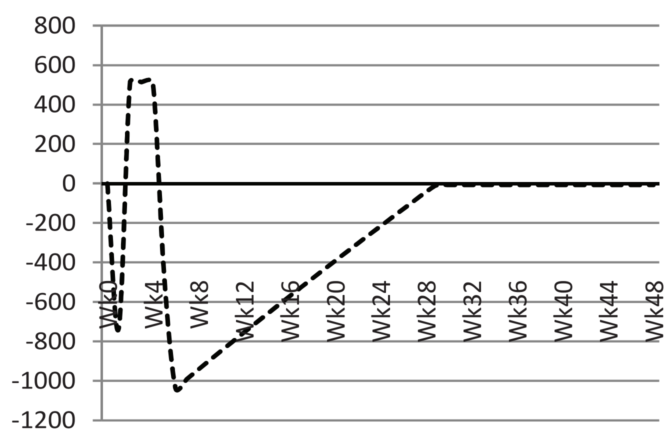
Households' final consumption likewise dropped in the first week and expanded in the second and third weeks. It overrecovered with private consumption levels higher by 48 percent compared with its preshock level. The change may be traced to falling consumer prices as real exchange rate appreciated in the first three weeks. Imported products, already in demand as local outputs fell, became more competitive and kept local consumer prices down. After these first few weeks, final consumption by households fell as consumer prices rose with a depreciating real exchange rate. Like the GDP, final consumption stabilized in the 29th week.

Figure 4. Effects on the city's GDP, household final consumption, and national and local public spending, Pasig City (in PHP million)



GDP = gross domestic product; Govt = government; Wk = week
Note: National and local public spending are read from the right axis.
Source: Authors' calculation

Figure 5. Overall well-being of city residents, Pasig City (in PHP million)



Wk = week
Source: Authors' calculation

Public spending, read from the right axis, follows a similar trajectory as the city's GDP. Local public spending dropped at first then recovered fully in the sixth week.

Overall well-being, measured by the equivalent variation (EV) of income, fell in the first week. It recovered to positive levels in the second and third weeks (Figure 5). The change was consistent with the improvements in real consumption of the representative household. In the fifth week, EV went back to negative terrain, indicating that residents were worse off. But in the sixth week, well-being started its recovery until the 29th week, when it stabilized back into its former condition before the shock.

The EV may indicate the affected residents' willingness to pay for programs that make their communities more resilient to climate change-related shocks. It reached a total of PHP 12,048.18 million throughout the adjustment period. Residents may be willing to pay up to about PHP 13 billion for programs that could make them immune to shocks. Resources for this purpose may be allocated from the budget for programs aimed at strengthening resilient communities. A good option would be for the national and local governments to invest in resiliency-promoting interventions using their tax incomes.

Economic effects of flooding in Marikina

Likewise, the CGE model of Marikina's economy was used to simulate the economic effects of flooding in that city. The dimensions of the shock are described by the adjustment durations described in Tables 1 to 3. The industries in Marikina reached their predisaster output at week 12 (Figure 6). Some industries reached their respective predisaster outputs earlier, recovered significantly, but then declined once again. For example, the output of the other manufacturing sector (otmn) improved by the second week and continued its recovery for the next 10 weeks, before falling to its preflooding level. This is also true for the construction and public and private services sector.

Similar to Pasig, the Marikina economy should have a closure in the sense that its exports are equal to its imports in value terms vis-à-vis the rest of the world. The exchange rate is flexible to ensure the closure.

Producer and consumer prices fell significantly, and by the 12th week settled at about a quarter of 1, their preflooding levels. The pattern is driven by changes in the real exchange rate or the price of domestic goods relative to the price of foreign goods. Weak demand for local products in the city deflated their prices.

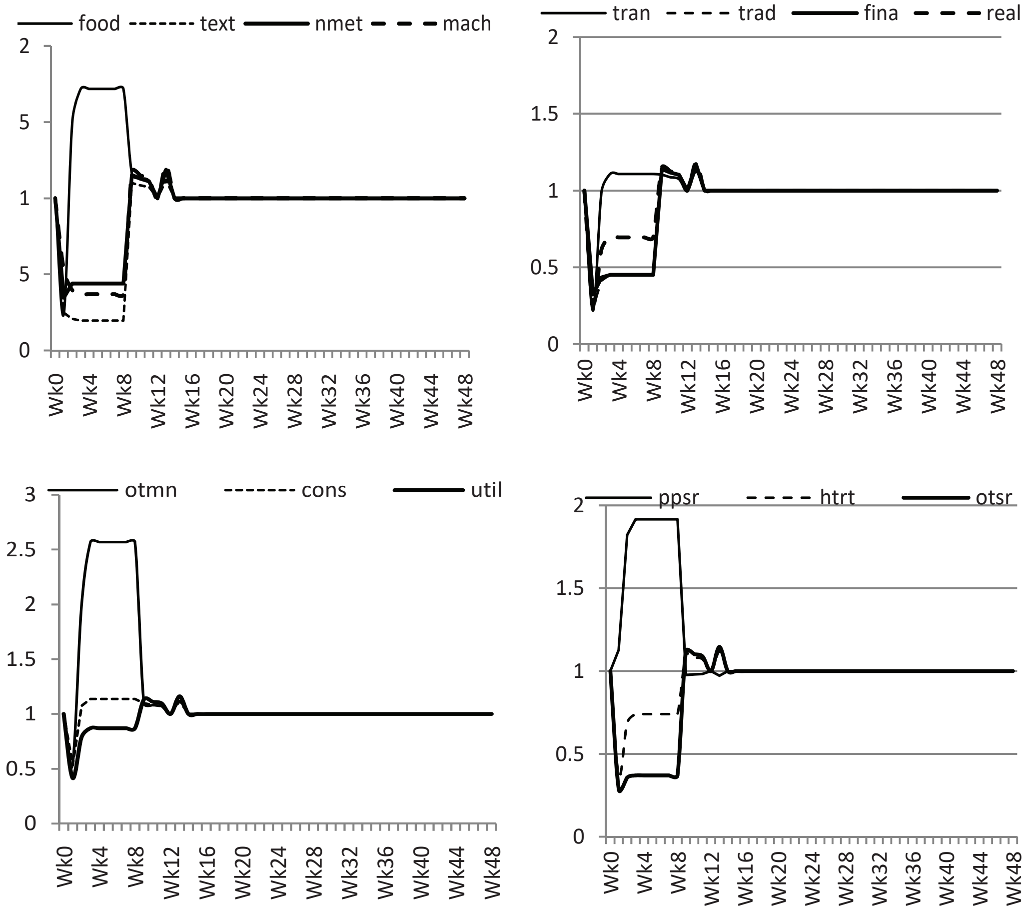
Figure 8 portrays the weekly city GDP, the income of the representative household, and the national and local government spending. On average, the city's industries produced about PHP 1.2 billion of GDP each week. The city's GDP contracted in the first week, and recovered gradually up to the seventh week. It went back to its preflooding level by the eighth week, with a total loss of PHP 2.18 billion throughout the adjustment period.

Surprisingly, household final consumption increased. It slightly dipped in the second week, and spiked to about PHP 2.6 billion a week between the third and the eighth week. It then dropped to largely its predisaster level, netting a gain in final consumption of about PHP 10.655 billion. This result may be driven by the deflation of consumer prices, which in turn followed the appreciation of the currency (Figure 7). Lower prices boosted household consumption, and residents are better off.

It follows from this result that the EV of Marikina City because of Typhoon Ondoy is positive. That is, its residents may even have more money than they had prior to the flood. While it lost in GDP by about PHP 2 billion, it gained resources from the rest of the world with access to lower-priced consumer goods. Figure 9 shows the EV of Marikina City. The total EV amounted to PHP 11,193.78 million.

The total amount of GDP losses estimated in this paper at around PHP 22.54 billion, 90 percent of which represents the loss of Pasig City, seems a reasonable assessment given the amount of direct losses (infrastructure, property loss) in Metro Manila, which has been estimated at PHP 22 billion by the World Bank (2011). However, the direct losses are significantly different from the indirect, output losses estimated by the paper, which are not usually discussed in damage studies.

Figure 6. Effects on weekly outputs of industries in Marikina City



Wk = week

Note: Predisaster output levels are set to 1.

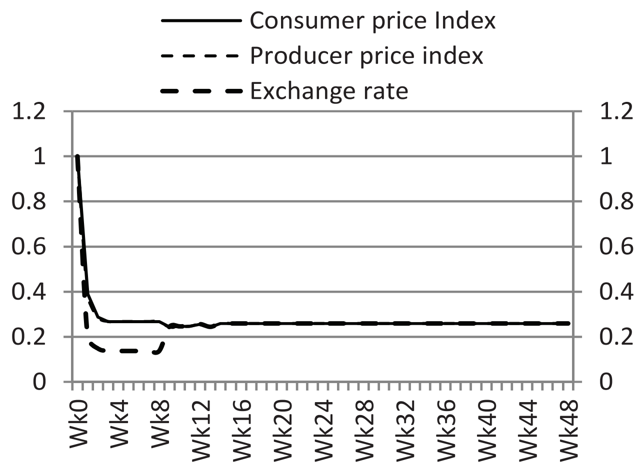
The sectors in the data include food manufacturing (food), textiles and garments (text), machinery (mach), other manufacturing (otm), construction (cons), utilities (util), transport services (tran), wholesale and retail trade (trad), financial intermediaries (fina), real estate (real), public administration (ppsr), hotel and tourism (htrt) and other services (otsr).

Source: Authors' calculation

CONCLUSION AND RECOMMENDATIONS

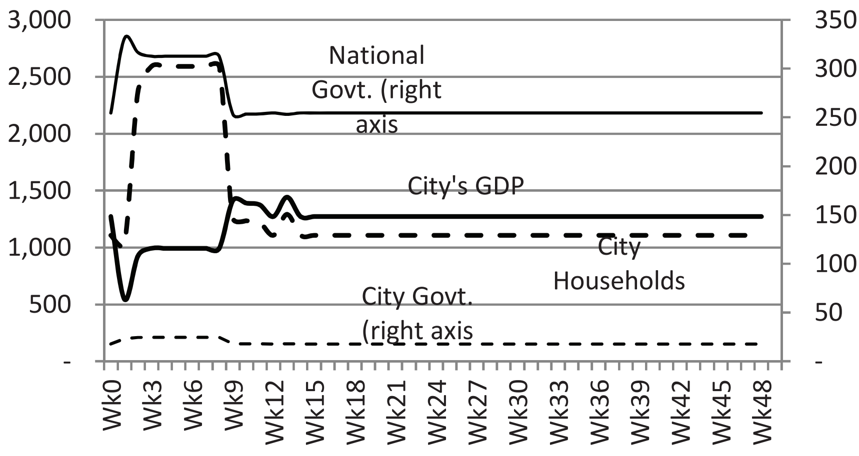
The adverse effects of extreme flooding on large areas of a city caused by Typhoon Ondoy are significant. In this study, the base case GDP of Pasig and Marikina Cities are estimated to be PHP 3.6 billion and PHP 1.3 billion a week, respectively. Using the equivalent variation of income, this study estimates that residents in Pasig City may be willing to pay up to PHP 13 billion for protection against the adverse effects of natural disasters such as Typhoon Ondoy. Marikina City residents, on the other hand, may have to pay a lot less for the same purpose, i.e., PHP 2 billion. The difference may be attributed to the former being more industrial compared to the latter.

Figure 7. Producer and consumer weekly price indices and exchange rate, Marikina City



Wk = week
Source: Authors' calculation

Figure 8. Effects on the city's GDP, household final consumption, and local public spending, Marikina City (in PHP million)

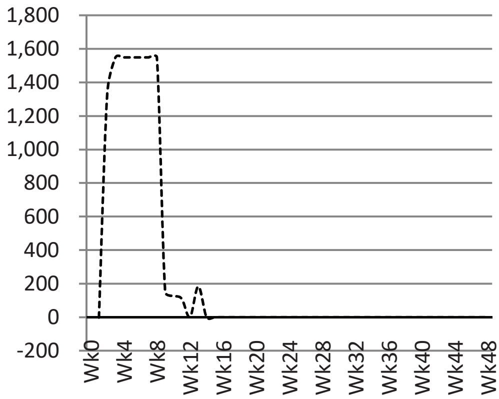


GDP = gross domestic product; Govt = government; Wk = week
Source: Authors' calculation

Differing results between the two cities

It is, however, interesting to note that the model produced different results on the exchange rate adjustments for both cities. A depreciation of the real exchange rate was observed in Pasig, while an appreciation of the exchange rate was noted in Marikina. How this may have come about may be traced to the following: (a) two different accounts of how the cities adjusted to the disaster in terms of factor availabilities, as well as the differences in the two city economies. We note that the focus group discussions with businessmen comprised two different groups of people. Each group may

Figure 9. Overall well-being of city residents, Marikina City (in PHP million)



Wk = week
Source: Authors' calculation

have a different recall of how the city economies of Pasig and Marikina had adjusted; and (b) Pasig is relatively industrial with a larger city GDP, while Marikina is more residential.

This study undertook two separate simulations for each city, but in both, the model has a flexible exchange rate policy. Being industrial, Pasig City has greater stakes in trade. It is a net exporter of goods. Disruption of production activities caused by disasters like Ondoy increased its external payments deficit from the rest of the world, prompting a depreciation of the exchange rate. This, in turn, pushed up prices in Pasig, reducing household consumption.

On the other hand, Marikina City is more residential and is a net importer of goods. When disaster hit the city's economy, incomes fell and with it the demand for goods. With a flexible closure rule, real exchange rate appreciated and consumer prices deflated, boosting household consumption.

In the real world, exchange rate regimes of cities belonging to a national economy like the Philippines follow that of the entire country. Had the closure been one of a fixed exchange rate regime in each model, one would expect income transfers to Pasig City, alleviating the plight of its residents. Such transfers may come in the form of intrahousehold, business transfers to households, or transfers from the rest of the world. On the other hand, resources would flow out of Marikina City, making its residents less better off than what this study's results imply.

Clearly, how the exchange rate market is closed, or better, how the city economies are modeled relative to the rest of the country, is an important determining factor for the results of studies like this.

Recommendation and possible improvements

Local government officials may be guided by this study's results: City residents are willing to invest billions of pesos to reduce their exposure and vulnerability to the adverse effects of extreme flooding. Rather than merely undertaking relief programs following a natural disaster, investing by local authorities in making the city less vulnerable to climate change shocks promises good returns.

This analysis can be improved by getting more objective data on the empirical links between the physical attributes of flooding and the displacement of the productive factors of production, or the flow of raw materials in affected areas. The procedure presented, albeit sufficient, leans on the side of using subjective information through interviews with stakeholders about the adjustment process.

Another important point is the use of weekly CGE models. Existing CGE models are calibrated to annual data because available data sets of national economies in the world are typically gathered on an annual basis. Admittedly, scaling down annual data into weekly quantities and values, and extracting a city's economy data from national using proportionate sizes of local to national economies, have several weaknesses. However, they have been done in this study because of the following: The policy questions in this study concern the impact on a city's economy, and their possible answers make use of businessmen's weekly recall of adjustments made in response to the calamity. Results of analysis would admittedly become more informative had the data, to which the weekly CGE model is calibrated, been gathered subnationally and weekly. However, getting the statistics authorities to do that regularly would be unlikely.

Nevertheless, this study provides a contribution to the literature on the effects of disasters, particularly on the impact of flooding at the city level. The information on the extent of damages could be useful for planning the extent of resources necessary to help mitigate the effects of disasters among the local governments.

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