Macroeconomic impact of natural disasters on a small island economy: evidence from a CGE model

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Natural disasters are common in the Pacific Island countries. Fiji has been affected by many of these disasters. The most recent cyclone exerted substantial damage to infrastructure, agricultural and industrial activity in Fiji. The aim of this article is to incorporate these damages into Fiji's computable general equilibrium model and examine the short-run macroeconomic impact. Among the key results, it is found that cyclones negatively impact private income, consumption, savings, real GDP and real national welfare.

I. INTRODUCTION

This article examines the short-run macroeconomic impacts of the most recent cyclone in Fiji. Fiji is a small island country located in the pacific region. It has a population of less than 800 000 and the economy depends on only a few commodities, such as tourism, sugar, garments, fish and gold, for its exports. The village and coastal areas are particularly dependent on agriculture for their livelihood. The fact that these areas are low lying and coastal in location exposes them to the full brunt of natural disasters. In Fiji, the natural disaster season runs from November to April and the brunt of any disaster is normally felt in the agricultural sector. As a result, other sectors dependent on agriculture are also affected, which has economy-wide effects.

In January 2003, Fiji was devastated by one cyclone 'Ami'. It is described as one of the most destructive cyclones in Fiji's history for it claimed 14 lives. It caused damage to infrastructure by some F\$15 million; sugar cane – a major agricultural activity – and mills have incurred F\$10 million damage. Damage to other crops has been estimated at F\$10 million; and losses to business and private property has been estimated at around F\$20 million. The aim of this article is to examine the short-run macroeconomic impact of these damages on Fiji's economy. To achieve this it uses a Fiji computable general equilibrium model (CGE). CGE models are at the forefront of impact studies because the general equilibrium nature of the model ensures that all sectors are incorporated into a single model; hence, it is regarded as an advance over the widely used input–output models.

The organization of the article is as follows. The next section discusses the methodology and the theoretical structure of the CGE model. Section III presents the short-run macroeconomic effects of cyclone 'Ami' on Fiji's economy. Section IV concludes.

II. THEORETICAL STRUCTURE OF THE FIJI CGE MODEL

The Fiji CGE model, initially developed by Levantis (1999) and extended by Narayan (2003), is based on the ORANI model of the Australian Economy. A complete description including the theoretical structure of the ORANI model is provided in Dixon *et al.* (1982). The Fiji model, like ORANI, can be described as an economy-wide, comparative static CGE model of the Johansen class (Johansen, 1960). The Fiji CGE model consists of $m = 35$ domestic industries, $n = 34$ commodities and $q = 2$ occupational types. In total, there are 13 agricultural sector industries; 10 industrial sector industries; and 12 service sector industries including hotels, cafes and restaurants.

Each commodity corresponds to an industry except for gold, which is split into two different industries because of the different cost structures of the industries. Further, the non-agriculture informal sector is grouped as a separate industry. This is important in Fiji's context given that the informal sector accommodates the school dropouts and the unemployed that do not find jobs in the formal sector. A full list of the 35 industries and 34 commodities are in the Appendix.

Schematically, the model takes the following form:

$$F[Z_1(t), Z_2(t), Z(0)] = 0$$

where $Z_1(t)$ and $Z_2(t)$ are vectors of values of endogenous and exogenous variables at time t and $Z(0)$ is a vector of initial conditions. At the economy wide level, the equations of a typical Johansen model can be classified into five groups:

(1) equations that describe household and other final demand for commodities;
(2) equations that describe industry demand for primary factors and intermediate inputs;
(3) equations that describe prices;
(4) market clearing equations for primary factors and commodities; and
(5) other equations, e.g. equations defining GDP, aggregate employment, the consumer price index and investment price index.

The equations of the model are derived from neoclassical microeconomic assumptions about the behaviour of price taking economic agents. Put differently, consumers maximize utility subject to their budget constraints and producers choose their inputs so as to minimize costs of production. Resources are limited hence are distributed by market forces, and market imperfections can lead to unemployment. Increasing government expenditure is contingent on raising taxes or borrowing, which has implications on other economic agents such as consumers and firms; this in turn induce other economic effects. The economy is linked to the rest of the world via a foreign exchange market; an increase in exports in one sector leads to a rise in the exchange rate; hence, discouraging other exports and encouraging imports.

An important feature of ORANI type models, given that they are static in nature, is that both short-and long-run effects of shocks or policy changes can be deduced. The short-run effects are simulated by holding capital stocks at their pre-shock levels. Cooper *et al.* (1985) and econometric evidence in favour of short-run equilibrium established in about two years, i.e. $T = 2$. On the other hand, the long-run effects are derived on the assumption that capital stocks will have adjusted to restore (exogenous) rates of return, which might take 10 or 20 years, i.e. $T = 10$ or 20. The model is solved using the GEMPACK software package, developed by the Centre of Policy Studies

and the Impact Project, Monash University. GEMPACK is a flexible model for solving CGE models (Codsi and Pearson, 1988).

III. SHORT-RUN MACROECONOMIC RESULTS

Table 1 presents the key macroeconomic impacts of cyclone 'Ami' for Fiji – based on a simulation that incorporates the infrastructure, industrial and agricultural damages done by the cyclone. It finds that the fall in total exports (-1.04%) will outweigh the fall in total imports (-0.94%), contributing to a worsening of the balance of payments by F\$101,000. Further, private investment levels will fall by 0.67%. There will be a 1.6% fall in revenue from value added tax due to the decline in economic activity as reflected by the fall in investment and exports. This slack in economic activity will also reduce revenue from other sources for the government. Income tax revenue, for instance, will fall by 2.8%, production revenue will fall by 2.3%, and company tax revenue will fall by around 0.9%. The fall in imports will obviously induce a fall in tariff revenue, which will fall by 0.7%. All these developments will have a negative impact on real GDP, which will fall by over 0.5%.

Table 1. *Macroeconomic effects of cyclone 'Ami' for Fiji*

Variables	% increase
Private savings	-1.7580
Private consumption	-1.7682
Balance of payments surplus	F\$101.9[a]
Total government consumption	-1.7906
Total government investment expenditure	-0.6021
Imports	-0.9422
Exports	-1.0434
Consumer price index	-0.9514
Investment price index	-0.5745
Private disposable income	-1.7581
VAT revenue	-1.6056
Income tax revenue	-2.8122
Company tax revenue	-0.8766
Production tax revenue	-2.3473
Excise tax revenue	-1.6689
Tariff revenue	-0.7123
Real GDP	-0.5470
GDP deflator	-0.0370
Real consumption	-0.8140
Real national welfare	-0.7050
Labour market	
Net after tax rural wage rate for unskilled labour	-1.6273
Net urban wage rate for unskilled labour	-0.9555
Wage rate for informal sector labour	-5.5727
Aggregate demand for informal unskilled labour	3.2637

Note: [a] is in thousands of dollars.

Additionally, declining economic activity due to the cyclones will reduce private disposable incomes by 1.7% – this will negatively impact on private savings and consumption: private savings will fall by some 1.75% while private consumption will fall by 1.77%. Real consumption is expected to fall by 0.8% together with the wage rates for the rural and urban unskilled labour. All these will add to a deterioration of the real national welfare by around 0.7%.

IV. CONCLUSION

One of the main shocks to Fiji's economy is natural disasters. Fiji is prone to natural disasters – hurricanes, cyclones, floods, drought and earthquakes have severely affected, particularly, the agricultural sector in Fiji. The fact that agriculture has linkages with the other sectors in the economy implies that the economy-wide impacts may be significant for a small island country dependent on only a few sectors for its growth and development. Against this background, in this article investigated the short-run macroeconomic effects of the most recent cyclone in Fiji. It used the Fiji computable general equilibrium model for this purpose. Among the key results, it was found that both exports and imports fall, the former by a greater percentage, contributing to a balance of payments deficit. This is reflected in the fall in real GDP. Private consumption, income, investment and savings all decline – consistent with declining economic activity. All these are reflected in a fall in the real national welfare of Fijians.

The empirical findings here have implications for other Pacific Island countries (PICs). They, like Fiji, are often devastated by cyclones. A good recent example is the Solomon Islands. For these PICs, it is impossible to measure the economy-wide macroeconomic effects of natural disasters since there are no CGE models for these countries. In this light, the key results for Fiji provide a rough guide as to what ramifications can be expected from natural disasters for PICs at the macro level.

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APPENDIX

List of industries and commodities in the Fiji CGE model

Industry	Commodity
Sugarcane	Raw sugar
Coconuts	Coconuts
Rice	Rice
Ginger	Ginger
Dalo	Dalo
Root crops	Root crops
Kava	Kava
Fruit and vegetables	Fruit and vegetables
Other crops	Other crops
Dairy	Dairy
Livestock	Livestock products
Forestry	Forest products
Fishing	Marine products
Emperor gold mine	Gold
Mt Kasi gold mine	Gold
Quarrying	Quarrying
Sugar manufacturing	Sugar products
Beverages and tobacco	Beverages and tobacco
Food processing	Processed foods
Clothing, footwear and textiles	Clothing, footwear and textiles
Other manufactures	Other manufactures
Electricity and water	Electricity and water
Construction	Construction services
Commerce	Retail/wholesale services
Hotels, cafes, restaurants	Hotels, cafes, restaurants
Transport and communication services	Transport and communication services
Finance	Financial services
Insurance	Insurance services
Property services	Property services
Business services	Business services
Other private services	Other private services
Health	Health services
Education	Education services
Other government services	Other government services
Non-agriculture informal sector	Informal services

Source: Levantis (1999).