APPENDIX XVI
MACROECONOMIC EFFECTS
OF THE EARTHQUAKES IN EL SALVADOR IN 2001

1. Summary of damage

Total damage is the equivalent of 12.1 percent of 2000's GDP. It is also the equivalent of 43.5 percent of exports, 29.3 percent of imports, and 42.3 percent of gross fixed capital formation. These figures highlight the challenges facing public finances and the external sector.

2. The situation before the earthquake

General features

El Salvador's GDP grew by 2 percent in 2000, marking the third consecutive year of falling growth rates.[5] To a large extent, this performance was associated with a slack export sector, where a fall in international coffee and sugar prices combined with a rise in fuel prices to worsen the terms of trade. A slowdown was also experienced in the construction and trade sectors, as well as in agriculture for domestic consumption.

Public finances weakened in 1999; together with the external sector, this constituted the most vulnerable area of the economy. The deterioration occurred in spite of efforts to apply a conservative fiscal policy in spending, as well as measures aimed at broadening the taxpayer base and reducing tax avoidance and evasion. Some of the government's basic assumptions about the economic situation before the earthquake are shown in Table 1.

At the close of 2000, a central government fiscal deficit of 2.3 percent of GDP was reported; this was slightly higher than in 1999. For 2001, without the effect of the earthquake, the fiscal deficit had been estimated at 2.8 percent. Had the trend in revenue collection continued, the fiscal deficit was expected to come under more pressure, largely because of the government's obligation to pay more than a billion dollars in pensions over the next five years. Income from customs duties was also expected to fall as a result of free trade agreements entered into by the country.

5 According to official estimates in December 2000.

Table 1

SELECTED ECONOMIC INDICATORS

	1999	2000	2001 (before the earthquake)
Targets			
Real GDP (%)	3.4	2.0	3.5 - 4.5
Inflation (%)	-1.0	4.3	2.0 - 4.0
Assumptions			
Coffee crop 1999/2000 (hundreds of millions of pounds)	3.2	-.-	-.-
Coffee crop 2000/01 (hundreds of millions of pounds)		2.9	3.2
Coffee exports (hundreds of millions of pounds)	2.5	3.1	2.6
Average price of exported coffee (dollars per 100 pounds)	99.0	96.5	75.0
Exports of goods FOB (millions of dollars)	2,500.4	2,981.9	3,603.1
Imports of goods CIF (millions of dollars)	4,119.9	4,908.1	5,782.0
External inflation (%)	2.6	3.7	2.0- 3.0

Source: El Salvador Central Reserve Bank.

In the private sector in 2000, the highest growth was to be found in the transport and communications (6.2%), banking and insurance (5.1%) and manufacturing (4.5%) sectors. In the external sector, exports of goods and services increased by 17.3 percent and imports by 18.1 percent, taking the deficit on the trade balance of goods and services to 26 percent. The current account deficit was the equivalent of 3 percent of GDP, compared with 2 percent in 1999. Before the earthquake, it was estimated that the deficit in 2001 would be reduced to 2.5 percent, because of expected improvements in exports of maquila products (especially textiles) following the broadening of the Caribbean Basin Initiative.

Trade deficits continued to be offset by family remittances, which totaled 1.751 billion dollars in 2000. In addition, the Central Reserve Bank had amassed net international reserves of almost 1.9 billion dollars, the equivalent of four and a half months of that year's imports.

December-to-December inflation in 2000, measured by the national consumer price index (CPI), was close to 4.3 percent, reversing the previous year's -1 percent. Before the earthquake, a December-to-December inflation rate of 3 percent had been projected for 2001.

In late November 2000, the Monetary Integration Project was announced. When it came into effect on January 1, 2001, the prevailing exchange rate, which had been in effect since 1994, was set at 8.75 colóns to the dollar. Other currencies were allowed to circulate freely alongside the colón, and the dollar was made the unit of account for the financial system. Prior to the earthquake, the government had hoped that this process would promote the flow of capital and increase foreign direct investment.

It is important to emphasize that the macroeconomic mechanisms used to adjust to external shocks (e.g., the January 13 earthquake) in a dollarized scenario are totally different from those used in a national currency scenario. In the former scenario, adjustments can be made through fiscal measures and through the labor market; in the latter, it can be made by modifying the nominal exchange rate. A dollarized scenario calls for strict control of public finances, together with greater external resources and considerable flexibility in the labor market.

3. The accumulated effects of the two earthquakes: post-earthquake projections for 2001 and the following years

The assessment of the macroeconomic effects of the second earthquake for 2001 and the following years uses the estimates contained in the document on the 13 January disaster to focus on the impact on growth, inflation and the deficit, both in the current account of the balance of payments and in public finances.

Some post-earthquake projections of the most probable 2001 macroeconomic scenario measure the role of economic policy and, as a result, the future reconstruction challenge.

The earthquake's main impact on the GDP growth rate, in terms of the GDP percentile structure, was on the social (40 percent), infrastructure (32 percent) and production (20 percent) sectors . The most badly affected part of the social sector was housing. In infrastructure, roads suffered the most damage, and their restoration and reconstruction may raise the country's low level of public and private investment. In the production sectors, the greatest damage was caused to small and micro - businesses, many of which have begun to recover on their own initiative, although many others will disappear permanently or will only be revived with the assistance of directed credit programmes to provide them with working capital and inventory capital.

Table 2 shows overall supply and demand at current prices. The post-earthquake projection column includes the increase in imports that might occur because of reconstruction work.

Table 3 shows overall supply and demand at constant 1990 prices. The projection for 2001 was estimated by the Central Reserve Bank for a pre-earthquake scenario with 4.5 percent growth in GDP. All post-earthquake estimates were made by ECLAC and show a GDP growth rate of 4 percent in the first year (2001), with stronger growth in 2002 and 2003.

In short, the conclusion is that an earthquake in a small open economy like that of El Salvador puts increased pressures on public finances, since the additional expenditure, added to import requirements (especially for construction and housing) can culminate in simultaneous internal and external deficits. These will turn the adjustment process into a cause of higher unemployment rates, unless the international community provides additional financing. Such new funding must be provided on concessionary terms to ensure that the increase in the country's foreign debt does not increase its external weakness.

When added to those contracted after the previous earthquake, the new loans provided by multilateral institutions to lessen the fiscal gap caused by the magnitude of the reconstruction expenditure (an estimated 336 million dollars for this event) a total of 1.94 billion dollars.[6] It is considered that reconstruction will call for average annual investments of 390 million dollars over the next five years (a total of 1.9 billion dollars)

Table 2

OVERALL SUPPLY AND DEMAND AT CURRENT PRICES
(Millions of dollars)

	1999 Preliminary	2000 Projection rev. Dec.	2001 Projection pre-quake	2001 Projection post-quake	Percentage of GDP		
					2000	2001 before	2001 after
Overall demand	149,779.1	163,730.2	180,767.7	182,163.7	141.6	145.0	146.8
Consumption	104,605.4	111,988.5	121,514.9	121,503.2	96.8	97.5	97.9
Private	93,624.4	100,411.5	108,649.9	108,569.6	86.8	87.2	87.5
Public	10,981.0	11,577.0	12,865.0	12,933.6	10.0	10.3	10.4
Gross domestic investment	17,741.6	19,574.9	21,310.2	22,588.3	16.9	17.1	18.2
Fixed capital formation	17,618.9	19,436.2	21,083.3	22,406.1	16.8	16.9	18.1
Private	14,376.1	16,011.2	17,148.1	18,216.4	13.8	13.8	14.7
Public	3,242.8	3,425.0	3,935.2	4,189.8	3.0	3.2	3.4
Inventory variations	122.7	138.7	226.9	182.2	0.1	0.2	0.1
Export of goods and services	27,432.1	32,166.8	37,942.6	38,072.2	27.8	30.4	30.7
Overall supply	149,779.1	163,730.0	180,767.6	182,163.7	141.6	145.0	146.8
Imports of goods and services	40,693.6	48,062.9	56,108.5	58,108.5	41.6	45.0	46.8
Gross Domestic Product	109,085.5	115,667.1	124,659.1	124,055.2	100.0	100.0	100.0
Farming	11,725.9	11,806.7	12,414.4	12,086.2	10.2	10.0	9.7
Mining and quarrying	435.2	461.7	499.3	499.3	0.4	0.4	0.4
Manufacturing industries	24,545.9	27,092.3	29,476.9	29,412.6	23.4	23.6	23.7
Water and electricity	2,020.4	2,350.9	2,551.8	2,444.5	2.0	2.0	2.0
Construction	4,773.6	5,037.0	5,484.0	5,799.8	4.4	4.4	4.7
Commerce, hotels, and restaurants	20,740.6	21,462.6	22,857.8	22,632.3	18.6	18.3	18.2
Transportation, storage, and communications	9,209.3	9,955.6	10,858.2	10,858.2	8.6	8.7	8.8
Banking, insurance, and other financial institutions	4,606.9	4,952.7	5,417.8	5,417.8	4.3	4.3	4.4
Real estate and business services a/	4,544.3	4,704.7	5,000.9	5,050.9	4.1	4.0	4.1
Housing rentals	8,634.9	9,027.4	9,649.4	9,699.4	7.8	7.7	7.8
Community, social, personal, and domestic services b/	7,191.5	7,751.1	8,143.1	8,034.7	6.7	6.5	6.5
Government services	8,071.2	8,491.7	9,084.5	8,898.5	7.3	7.3	7.2
Minus							
Attributed banking services	4,506.6	4,845.4	5,225.4	5,225.4	4.2	4.2	4.2
Plus							
Customs duties and VAT	7,092.4	7,418.1	8,446.4	8,446.4	6.4	6.8	6.8

Source: ECLAC, preliminary estimates based on figures provided by the Central Reserve Bank.
a/ Includes leasing and use of non-residential properties; professional legal, accounting, and audit services; preparation of data, computer services, architectural services, and advertising.
b/ Includes private education and health services, entertainment services (cinema and television) and other services such as veterinary services; trade, professional, labor, and religious associations; electrical and motor vehicle repair shops.

6 Plus the sum of 112 million dollars needed for the reconstruction of housing whose loss was reported after 31 January, but before the second earthquake.

Table 3

OVERALL SUPPLY AND DEMANDS AT CONSTANT PRICES

	1999 Preliminary	2000 rev. Dec.	2001 Projection pre-quake	2001 Projection post-quake	Relative changes 2000/99	Relative changes 2001/00 pre-quake	Relative changes 2001/00 post-quake
Overall demand	84,898.5	89,439.8	96,081.2	97,100.6	5.3	7.4	8.6
Consumption	55,411.1	56,273.4	58,777.6	58,776.9	1.6	4.5	4.4
Private	50,710.6	51,557.7	53,749.1	53,720.7	1.7	4.3	4.2
Public	4,700.5	4,715.7	5,028.5	5,056.1	0.3	6.6	7.2
Gross domestic investment	10,594.8	11,149.5	11,957.8	12,630.6	5.2	7.2	13.3
Fixed capital formation	10,488.3	11,054.0	11,670.8	12,400.2	5.4	5.6	12.2
Private	8,829.3	9,421.4	9,851.4	10,463.2	6.7	4.6	11.1
Public	1,659.0	1,632.6	1,819.4	1,937.0	-1.6	11.4	18.6
Inventory variations	106.5	95.5	287.0	230.3	-10.3	200.5	141.2
Exports of goods and services	18,892.6	22,016.9	25,345.8	25,693.2	16.5	15.1	16.7
Overall supply	84,898.5	89,439.8	96,081.2	97,100.6	5.3	7.4	8.6
Imports of goods and services	29,015.1	32,455.2	36,550.4	37,855.7	11.9	12.6	16.6
Gross Domestic Product	55,883.4	56,984.6	59,530.8	59,244.9	2.0	4.5	4.0
Farming	7,205.1	7,145.9	7,403.0	7,207.0	-0.8	3.6	0.9
Mining and quarrying	242.6	249.9	262.3	262.4	3.0	5.0	5.0
Manufacturing industries	12,655.3	13,225.8	14,109.9	14,079.8	4.5	6.7	6.5
Water and electricity	350.2	354.3	374.4	358.6	1.2	5.7	1.2
Construction	2,176.6	2,126.5	2,243.4	2,373.1	-2.3	5.5	11.6
Commerce, hotels, and restaurants	10,940.9	11,030.8	11,370.7	11,259.9	0.8	3.1	2.1
Transportation, storage, and communications	4,554.8	4,836.6	5,124.8	5,124.2	6.2	6.0	5.9
Banking, insurance, and other financial institutions	2,098.4	2,205.2	2,337.5	2,337.3	5.1	6.0	6.0
Real estate and business services a/	1,811.4	1,838.6	1,893.7	1,912.5	1.5	3.0	4.0
Housing rentals	4,719.4	4,790.2	4,876.4	4,901.2	1.5	1.8	2.3
Community, social, personal, and domestic services b/	2,889.7	2,928.3	2,982.1	2,942.0	1.3	1.8	0.5
Government services	3,093.1	3,099.3	3,145.8	3,081.2	0.2	1.5	-0.6
Minus							
Attributed banking services	1,825.6	1,918.7	2,005.0	2,005.1	5.1	4.5	4.5
Plus							
Customs duties and VAT	4,971.5	5,071.9	5,411.7	5,410.9	2.0	6.7	6.7

Source: ECLAC, based on official figures
a/ Includes leasing and use of non-residential properties; professional legal, accounting, and audit services; preparation of data, computer services, architectural services, and advertising.
b/ Includes private education and health services, entertainment services (cinema and television) and other services such as veterinary services; trade, professional, labor, and religious associations; electrical repair shops and workshops for motor vehicles, watches, jewelry, etc.

In other words, the effect of the second earthquake was to further strain not only public finances, but also domestic savings and investment capacity. Such a significant increase in reconstruction expenditure will only come about if external resources can be obtained on preferential terms through loans made mainly by the Central American Bank for Economic Integration (CABEI), the Inter-American Development Bank (IDB) and the World Bank.[7]

7 According to the Central Reserve Bank and the IMF, the preferential terms for these loans are a 20-year period, a 5-year grace period and an annual interest rate of 7.5 percent (LIBOR). This suggests that there will be no significant rise in short-term debt during the three years following 2001.

We considered it useful to present three scenarios based on the estimated damage caused by both earthquakes. They are based on the following increases to the economy's historical investment rates: Scenario 1) 150 million dollars in the first year and an average of more than 400 million dollars a year for the following four years until reconstruction is completed; Scenario 2) an average of 380 million dollars for five years; and Scenario 3) 400 million dollars in the first year and an average of 375 million dollars a year for four years.[8] This will determine the level of public expenditure and investment. It will depend on the terms of the country's debt in the next few years and its feasibility will be associated with the national productive structure's ability to expand. The length of time that the reconstruction phase lasts is another factor that might change, and with the cumulative effect of the second earthquake, it could easily continue for more than five years

Table 4

SUMMARY OF MAIN ECONOMIC INDICATORS IN THREE RECONSTRUCTION SCENARIOS FOR 2001 AFTER THE EARTHQUAKES OF 13 FEBRUARY

	Scenario 1 (pessimistic)	Scenario 2 (probable)	Scenario 3 (optimistic)
Real GDP growth	3.0%	3.5-4.0%	4.0-5.0%
Inflation	4.3%	3.0%	3.0%
Fiscal deficit	5.0-5.5%	4.8-5.0%	2.7-3.0%
Current account deficit/GDP	4.0%	3.5%	2.5%
Public debt/GDP	35%	33%	32.3%

Source: prepared by ECLAC All the scenarios assume that loans will be made on preferential terms, especially with regard to interest rates and grace periods: 7½ percent annual interest over 20 years with a five-year grace period.

Pessimistic Scenario: prepared on the basis of 150 million dollars for reconstruction in 2001, with a further 1.750 billion dollars in 2002-2005. Although real GDP growth is greater than in 2000, the reduced flow of resources for reconstruction in 2001 would not be enough to give a boost to the production sector and would cause a marked deterioration in the main economic indicators.

Probable Scenario: prepared on the basis of 380 million dollars for reconstruction in 2001 and 1.520 billion dollars in 2002-2005. This scenario would double 2000's GDP growth rate and reduce annual inflation. New reconstruction work and higher imports would increase the fiscal and current account deficits, respectively. It is estimated that the underlying deficit would be 2.7 percent of GDP, while reconstruction expenditure would be 2.1 percent of GDP, for an overall deficit in 2001 of 4.8 percent of GDP.

Optimistic Scenario: prepared on the basis of 400 million dollars for reconstruction in 2001 and 1.5 billion dollars in 2002-2005. Under this scenario, GDP growth would increase, inflation would be lower than in 2000 and the fiscal and external sector accounts would be kept at prudent levels.

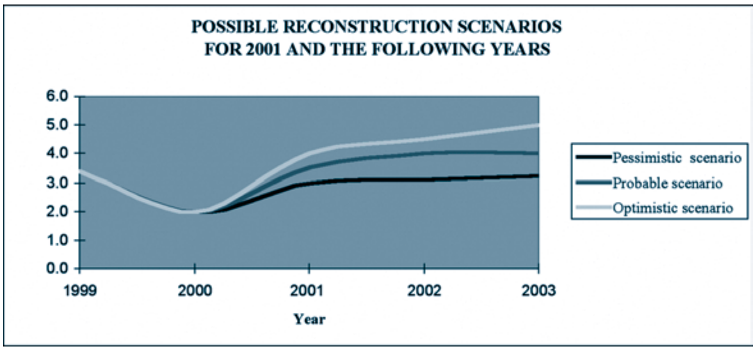
8 Changes in interest rates and reconstruction loan conditions could cause changes in the cost of servicing the fresh debt. The concessions obtained may not only favour a swifter reconstruction process, but also create fewer pressures on the basic macroeconomic balances.

These scenarios are of assistance in measuring possible impacts on the main economic indicators. However at the time of preparing the second assessment, it was still not possible to specify the amount of aid that might be received, the financing that would be available for 2001, when disbursement and implementation will take place or whether these loans would be made on the preferential terms mentioned previously.

This assessment does not include the effect of the possible use of alternative means of partially financing reconstruction, such as the sale of concessions or shareholdings in privatized businesses. Another possible source of financing should be increased domestic savings and tax revenues. This would lessen the strain produced by increased public expenditure –both current spending (in the emergency and for immediate rehabilitation) and investment spending (during the five or more years that reconstruction is expected to last).

Figure 1 shows GDP growth rates for each of these three scenarios.

Figure 1



As noted, the costs of reconstruction are over 1.9 billion dollars. This adds to the challenge already posed to economic policy by the first earthquake. Additional resources and appropriate management of public finances are needed to finance the national reconstruction plan and, at the same time, keep international reserves at an adequate level, control debt servicing costs and avoid further risks of macroeconomic instability.[9] All this has to be done without producing any negative effects on production capacity and employment, which have already been harmed by the earthquakes.

9 These funds could be generated by a basket that could be made up of concessionary loans from multilateral bodies, bond issues, own resources and fiscal measures designed to broaden the taxpayer base and improve tax collection and the efficiency of the revenue authorities. The recent amendment to the tax code, which tackles the country's traditional problems of tax avoidance and evasion, might make tax collection more efficient.

Surveys of business activity carried out after the two earthquakes, together with the expectations of different business sectors, do not conclusively support the view that an increase in tax revenues can be obtained in 2001.[10] Their stated perception was that internal demand could fall unless there were a recovery in income and employment. In addition, a potential increase in demand for resources for reconstruction could reduce demand in other areas. Reconstruction would bring a relative increase in current expenditure that could have a negative effect on the forecast rates of growth in social and capital expenditure, precisely because of the costs incurred during the emergency stage of the earthquakes and the financing of the 2001 “winter plan” (emergency measures to provide temporary housing and stabilize hillsides before the start of the rainy season).

In any of these possible reconstruction scenarios, the public sector deficit would be financed by the new loans, even in a scenario in which the Central Bank continued amassing international currency because of the potential increase in family remittances. The previous situation will be aggravated the more that reconstruction is financed by increasing the level of medium- and long-term debt. In the probable scenario, the overall cost of debt servicing could reach 33 percent of annual GDP, which is a reasonable level.

4. The impact on employment

Since the impact of the second earthquake was more localized than the first one, the effects on employment are more directly related to damage caused to the productive sectors of San Vicente, Cuscatlán and La Paz (especially small and micro - commerce). It is believed that the second earthquake had a much lower impact on the agricultural and maquila sectors, and damage was concentrated on rural and semi-urban sectors that used their homes as production centers. Consequently, the figures contained in the first assessment can be used as a basic reference, since they do not forecast changes in the major relationships and magnitudes caused by the second earthquake.

According to figures provided by the Coffee Council of El Salvador, more than 8 900 jobs have been lost as a result of the second earthquake, 43 percent of them in the San Vicente department; 13 percent in La Paz; 9 percent in Cuscatlán and other departments, such as San Salvador. Also, according to figures provided by the Chamber of Agriculture (CAMAGRO), more than 400 Lake Ilopango fishermen were affected.

Because a large number of the people engaged in these family, small, and micro - businesses are women, this population group will be particularly affected.

10 The surveys were undertaken by the El Salvador Foundation for Economic and Social Development (FUSADES), the National Private Enterprise Association (ANEP) and the El Salvador Chamber of Commerce and Industry.

The impact on employment was once again concentrated on small and medium-sized enterprises. The second earthquake increased the unemployment rates in San Vicente (7.3%), Cuscatlán (6.9%) and La Paz (6.3%). It also put more jobs at risk in these departments and destroyed production enterprises.

The first earthquake was responsible for the loss of 484 jobs in coffee plantations and 630 in coffee processing plants. Both figures were increased by the second earthquake (see above).

APPENDIX XVII

TWO EXAMPLES OF MODELS APPLICABLE FOR ESTIMATING THE IMPACT OF DISASTERS AND FORECASTING THEIR SHORT- AND MEDIUM-TERM CONSEQUENCES

Model A

Basic theoretical assumptions:

This is a simplified and improved version of the model used mainly by the International Monetary Fund (IMF) to estimate the impact of a natural disaster on GDP and the main macroeconomic variables.[11] The underlying assumption of Model A is based on empirical observation. This shows that although natural disasters usually have a very severe negative impact on the rate of economic growth in the immediate aftermath (a year, say), the growth rate tends to recover relatively quickly in the succeeding period. It is assumed that, other things being equal, the swiftness and size of the recovery in growth rate is a direct function of the capacity to replace the assets destroyed by the disaster and, more generally, of the reconstruction process itself.

In this model, it is assumed that the higher growth rate in the years following a natural disaster does not necessarily replace or return the well - being lost in the disaster within the medium (three to five years) or long (eight to ten years) terms. This is related to the conditional convergence hypothesis of growth theory, which postulates that the poorest countries (with less capital stock) tend to grow more quickly than developed countries (with greater capital stock).[12]

The first assumption in this model is a function of added production for the entire economy at a general level; a different function may be adopted, depending on the type of disaster and the type of economy. For the sake of simplicity, a Cobb-Douglas function with constant scale returns is assumed:

$$Y = AK^{\alpha}L^{\beta}$$

where:

$$y = \frac{Y}{L} \quad 0 \prec \alpha \prec 1 \quad k = \frac{K}{L}$$

Y is the product of GDP, K is the capital stock, L is the labor stock and A is a technological parameter that includes a trend variable as well as variables of external competitiveness and of human capital accumulation levels (total productivity of the factors).

The estimate is made using an error correction model that identifies the growth determinants with panel regression results from the Cobb-Douglas production function described above. The structural factors affect the technological variable and the macroeconomy, while prospects explain deviations from the long-term trend.

11 Some of the improvements to the model were proposed in the course of ECLAC's damage assessment of the earthquakes in El Salvador at the beginning of 2001. The IMF's original model has no error correction mechanism and the GDP growth rate is plotted from estimates of expenditure and the magnitude of the fiscal gap.

12 Robert Barro and Xavier Sala-i-Martin (1995), Economic Growth.

The model makes it possible to include information about long-term balance factors and also allows the information to be given an important role in specifying the dynamic structure. It also identifies the long-term determinants of total factor productivity in a context of balanced relationships provided by a technological production function. Short-term deviations are the result of factors that have been triggered when the long-term balanced relationship has not been fulfilled. Their magnitude is explained by stationary variables.

In general, the model sets certain requirements about the way in which the variables and the parameters are grouped. At the same time, this functions as a test of the reliability of the results and provides information about the growth trend and the nature of the economic cycle.

The following is a brief explanation of the error-correction model:

- A fundamental characteristic of co-integrated variables is that their short-term deviations tend to diminish in the long term. Therefore, it seems reasonable to suppose that there must be a co integration relationship between, for example, two variables Y_t and X_t:

$$Y_t = \beta X_t + \varepsilon_t \qquad (1)$$

- There will probably be short-term imbalances between the variables, which the following VAR model of autoregressive vectors could explain (unless they are white noise, short-term changes can be estimated using an ARMA model):

$$\Delta X_t = \Sigma^n{}_{i=1}\alpha_{11}(i)\ \Delta X_{t-1} + \Sigma^n{}_{i=1}\alpha_{12}(i)\ \Delta Y_{t-i} + \varepsilon x_t \qquad (2)$$

$$\Delta Y_t = \Sigma^n{}_{i=1}\alpha_{21}(i)\ \Delta Y_{t-1} + \Sigma^n{}_{i=1}\alpha_{22}(i)\ \Delta X_{t-i} + \varepsilon Y_t \qquad (3)$$

However, since the variables function over a long term, the previous VAR does not include this knowledge and might not correctly identify the way that they should behave in the short term. Therefore an error correction model should be included:

$$\Delta X_t = \alpha_S(Y_{t-1} - \beta X_{t-1}) + \Sigma^n{}_{i=1}\alpha_{11}(i)\ \Delta X_{t-1} + \Sigma^n{}_{i=1}\alpha_{12}(i)\ \Delta Y_{t-i} + \varepsilon X_t \,(4)$$

$$\Delta Y_t = \alpha_L(Y_{t-1} - \beta X_{t-1}) + \Sigma^n{}_{i=1}\alpha_{21}(i)\ \Delta Y_{t-1} + \Sigma^n{}_{i=1}\alpha_{22}(i)\ \Delta X_{t-i} + \varepsilon Y_t \,(5)$$

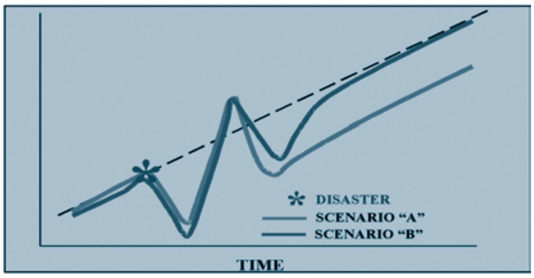
With this correction, a differential between the short and long-term variables should be corrected when the value of the variables t-1 to t is changed, provided there is equilibrium between the variables. For example, if Y_t rose in relationship to X_t in t-1, then in equation (4), X_t in t would be expected to rise ($\alpha_x>0$). In equation (5) Y_t would be expected to fall ($\alpha_y<0$) in t.

Both α_x and α_y are known as the equilibrium adjustment speed. Either of the two may have a value of zero, but not both at the same time. Therefore if $\alpha_Y = 0$, we can conclude that the imbalance adjustments could only be corrected through X_t and also that if all the $\alpha_{21}(i)=0$, then there would only be Granger causality from Y_t to X_t and not vice versa.

This model is based on the work of J.M. Albala-Bertrand (1993), which proposes a macroeconomic model to measure the impact of a natural disaster.[13]

Under this model it is assumed that the effects of a natural disaster are geographically localized, and that only rarely do they have a negative impact on added output. In fact, at least in the short term, their effects on GDP seem to be positive. Basically, the model postulates that the effects of a natural disaster "are a problem of development, not a problem for development". The central argument is that even when the amount of total damage is large in relationship to GDP, this is not an obstacle to an economy's growth. The model distinguishes between disasters whose impact is immediate (earthquakes, floods) and those with a slow impact (droughts). It is not applicable to man-made disasters (wars, technological failures, etc.). Despite such arguments, ECLAC's experience over more than thirty years of disaster assessment in the developing countries of Latin America and the Caribbean shows that disasters are a problem both for and of development, in the sense that the response capacity and resilience to these events entail changes to existing structures and institutions. Otherwise, the positive effects of disasters on growth and output are constrained by the availability of resources budgeted for these events (disaster or prevention/mitigation funds). Where developing economies were suffering from shortages before the disaster, the resources allocated for attention and reconstruction not only compete with pre-existing development projects, but also add an extra burden that states cannot carry by themselves or that they are incapable of absorbing. The result is that after every disaster the gap between the level of growth expected and that achieved grows wider (see the following figure).

THE EFFECT OF DISTASTERS ON THE GROWTH OF A NATIONAL ECONOMY



Both in the model and analytically, a natural disaster consists of three elements: The impact of the disaster, the response to the disaster and the disaster's incidental interference. The analysis is centered on the disaster's impact on both growth and the loss of capital and output. A disaster is considered to be of great magnitude when the ratio of total damage to GDP is comparable to an economy's growth rate (for example, five percent). However, this parameter should be used with caution, since a smaller damage ratio can also imply severe economic effects if the damage is localized in a key area of economic activity.

13 For further information, see World Development, Vol. 21, Nº 9, pp.1417-1434, 1993.

This model assumes several rules for the behavior of disasters and their assessment, the last three of which are rendered questionable or invalid in the light of ECLAC's empirical observation.[14] If recent experience shows anything, it is that damage is not necessarily overstated for political reasons. On the contrary, there are many recent examples of countries which have attempted to minimize the damage in order to maintain strict macroeconomic or fiscal discipline or which, for electoral reasons, have denied the existence of negative impacts, especially on vulnerable social sectors. In cases like that of Hurricane Mitch, the stability of macroeconomic variables was severely strained. It also seems that disasters are happening more often and that their consequences are increasing with every one. This is especially so with hydro-meteorological disasters, which could be linked to climatic change.

Because of the above, in methodological terms, a model enabling the identification of the upper limit of the disaster's impact on output is considered useful. This is a five-part process. The following is assumed that at the time of assessment:

I. The emergency stage is either very advanced or has finished
II. Materials are available;
III. The capital stock lost cannot be replaced in the short term;
IV. All the losses are of capital stock. and
V. Capital stock is homogeneous

Given (IV) and (V):

$$\Delta K = D \Rightarrow \Delta K = Ka - Kb \qquad (1)$$

Where K is the capital, D is the damage or total loss caused by the disaster, b is the impact before the disaster and a is the impact after the disaster. Assuming that the overall capital-output ratio is the same as for the total damage ratio, then:

$$c = K / Y = \Delta K / \Delta Y \qquad (2)$$

where c is the capital-output ratio
$\Delta Y = Ya - Yb$ (daño esperado en el producto)
Y = producto (ingreso)

Solving (2) by ΔY y sustituyendo ΔK por D:

14 The model is based on six "rules" or assumptions:

Rule I: Specific localization. Disasters only affect a "geographically" or "economically" localized area of activity.

Rule II: Internal effect differentiation. Neither the disaster's magnitude nor the social vulnerability at a particular disaster magnitude are the same throughout the disaster area.

14 Corollary II(a): Local sectoral coexistence. In the disaster area, affected economic units will coexist internally, with unaffected units belonging to the same economic sector.

Corollary II(b): Disasters have a greater effect on the poorer sectors (or on the poorest units within the sectors) of society.

Rule III: Differentiated damage to capital stock. The different types of capital stock are not equally affected by disasters. In fact, the distribution pattern for capital loss depends on the type of disaster

$$\Delta Y = D/c \qquad (3)$$

Transforming (3) in growth rate and dividing both sides by Y:

$$y = d / c \qquad (4)$$

Where $\mathbf{y = \Delta Y/Y}$: output growth rate (fall) and $\mathbf{d = D/Y}$ is the total damage/output ratio.

Consequently, the expected fall in the output growth rate (y) is in direct proportion to the total damage/total output ratio (d) and in inverse proportion to capital/output ratio (c). If assumption (iv) is removed, then $\mathbf{\Delta K < D}$, since part of the damage corresponds to loss of output and not only to capital stock. This means that $\mathbf{\Delta K}$ is heterogeneous, and c must be revalued in accordance with the productivities of the different types of capital stock. Therefore, other factors must be included in (4) to set a realistic value for the bottom level and consequently for an interval of the expected fall in the output growth rate:

i. Not all disaster damage is to capital stock;
ii. As a rule, disaster damage is overestimated;
iii. Losses to capital stock are normally estimated at replacement cost;
iv. All types of capital stock are heterogeneous in terms of production;
v. Output growth does not depend exclusively on physical stock.

The first three factors affect the numerator in (4); the others affect the denominator. The resulting equation gives the bottom level of the expected reduction in the GDP growth rate. Removing assumption (iv) and incorporating factor (i):

$$D = D_1 + D_0 \qquad (5)$$

where $\mathbf{D_1}$ is total damage to capital and $\mathbf{D_0}$ is total damage to production. Restating (1):

$$\Delta K = D - D_0 = D_1 \quad (6)$$

Since the cost of capital is calculated at replacement cost (factor iii), depreciation is subtracted to assess the present damage or loss of productive potential resulting from the capital loss. If this were not done, the effect on capital loss would be overestimated. Therefore:

$$D_3 = \pi D_2 = \pi D_1 \qquad (7)$$

14 Rule IV: Overestimation of damage. It is assumed that the total amount of damage is overestimated for political and technical reasons.

Rule V: GDP stability and inflation. It is assumed that disasters do not have a strong negative effect on GDP and inflation.

Rule VI: Probability of disasters. Disasters are scarce and occur only occasionally.

Where $\mathbf{D_3}$ is the present cost of capital loss, **B** is the reciprocal of the rate of depreciation, and **T** is depreciation. For example, $\pi = 1 - \lambda$ and $\lambda = T/D_2$ Correcting $\mathbf{D_2}$ in (8):

$$\Delta K = D_3 = \pi D_2 = \pi\, D_1 \qquad (8)$$

Since capital is heterogeneous in all types of stock (factor iv) and (in accordance with rule III) the least productive types of stock are generally the ones most affected by disasters, the average capital/output ratio where there is capital loss would be greater (i.e., less productive) than the overall average. This differential impact is incorporated by multiplying **c** by a ratio that, if rule II applies, will be greater than 1. However, if empirical evidence makes this rule inapplicable, its value could be equal to or less than 1:

$$c_1 = \alpha c \qquad (9)$$

where $\mathbf{c_1}$ is the capital/output ratio corrected by factor (iv).

Since capital is heterogeneous in all types of stock (factor v) and, according to the composition of the capital losses, more or less productive than any type (rule II and corollaries IIa and IIb), the average capital/output ratio for capital loss will be different from the overall average. This is incorporated by multiplying $\mathbf{c_1}$ by a coefficient that will be determined for each case (greater than 1 if damage is caused to the least productive capital; otherwise, less than 1):

$$c_2 = \beta c_1 = \alpha\beta c \qquad (10)$$

Where $\mathbf{c_2}$ is the capital/output ratio corrected in accordance with factor (v).

Finally, since output does not depend exclusively on the contribution of capital, the contribution of the non-capital factors (factor v) is corrected by multiplying $\mathbf{c_2}$ by a actor greater than 1, such that:

$$c_3 = \gamma c_2 = \gamma\beta c_1 = \gamma\alpha\beta c \qquad (11)$$

Where $\mathbf{c_3}$ is the capital/output ratio multiplied by the contribution of the non-capital factor. When all the corrections are incorporated in to (4):

$$y = d_3/c_3 \qquad (12)$$

To state it in another way:

$$y = (\pi\varepsilon/\alpha\beta\gamma)\,(d - d_0)/c \qquad (13)$$

Since this is the lower limit of the expected fall in the output growth rate due to a natural disaster, the interval is expressed as:

$$d_3/c_3 \lesssim y < d/c \text{ (expected loss interval)} \qquad (14)$$

This model enables the estimation of how much investment (or expenditure) should increase to compensate exactly for the expected loss or damage to output. The model includes three additional assumptions:

vi. Since the main purpose of any post-disaster response is to replace capital (reconstruction investment), the contributions made to replace indirect losses (in flows) are limited;

vii. Although reconstruction investment represents autonomous capital expenditure, it nevertheless competes with alternative uses for the resources; and

viii. There has to be sufficient idle capacity in the economy, especially in the construction sector.

Therefore:

$$\Delta Y = m\ \Delta KIr \qquad (15)$$

where **m** is the multiplier, **Ir** is reconstruction investment, **Y** is income (output), **Δ** is the variation and **m≥1**. Dividing equation (5) on both sides by **Y**:

$$y = m\Delta v \qquad (16)$$

where **v = Ir/Y** is the investment ratio. This means that when **m≥1**, for each unit of variation in the investment ratio (v) the output growth rate (y) can be expected to increase by **m**.

If reconstruction work is expected to last for several years, then equation (14) can be made to equal (13) such that:

$$\Delta v = d_3/mc_3 \text{ (compensatory investment ratio)}$$

The above represents the minimum increase in the investment ratio needed to fully compensate for the expected fall in output growth rate (capital lost or damaged) in the first year following the disaster. It is known as the compensatory investment ratio.

To calculate the minimum compensatory investment required, the following assumption is added to the model:

ix. The new capital is at least of the same quality as the lost capital. In fact, if mitigation and vulnerability criteria are included, it will necessarily be of greater quality.

At the end of the first year, the reconstruction investment ratio for that year $\mathbf{\Delta v_1}$ should be deducted from the damage or total capital loss ratio. The compensatory investment ratio for the second year will now be:

$$\Delta v_2 = \frac{d_3 - \Delta v_1}{mc_3} \quad (17)$$

In this way, it can be generalized for the following year or derived as a geometrical series.

The series decreases and converges to zero as it tends toward infinity. The significant thing about this approach is that reconstruction can take place over several years without negative consequences for output or sacrificing funds for other development projects. Of course this will depend on the values of the multiplier **(m)**, the corrected capital/output ratio $(\mathbf{c_3})$ and the corrected capital damage ratio $(\mathbf{d_3})$. With this, it is easy to demonstrate that the greater the value of the multiplier and the capital/output ratio, the smaller the value of $\mathbf{1/mc_3}$ and the nearer to unity the ratio r. The closer this ratio gets to **1**, the smaller the reconstruction investment required for any particular year.

In the first year, in addition to the investment expenditure, there is a part of total damage which corresponds to current GDP and which must be compensated for once only and at the same time. If the income multipliers are symmetrical and the disaster's impact tends to lead to contraction while the response to the disaster promotes expansion, then the same amount of additional expenditure will be needed to compensate for the loss of current income. Nevertheless, as the impact multipliers are expected to be lower than the response multipliers, compensatory expenditure is only a part of the loss of current income. Therefore, the amount of compensatory expenditure required in the first year would be:

$$\Delta e_1 = (m_1 / m_2)\, d_0 + \Delta v1 \quad (18)$$

where e_1 is the total first year expenditure ratio, v_1 is the minimum compensatory investment ratio in the first year, d_0 is the current output loss ratio, $\mathbf{m_1}$ is the impact multiplier and $\mathbf{m_2}$ is the response multiplier.