

⇒ Social and Economic Consequences of the 1987 Earthquakes in Ecuador

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Abstract: On March 5, 1987, northeastern Ecuador was shaken by two earthquakes, which registered 6.1 and 6.9 degrees, respectively, on the Richter scale. Even though the country had experienced stronger earthquakes, the ones that occurred in 1987 hit the economy harder than most. In order to understand how serious the economic and social consequences of this natural disaster were, it is necessary to examine Ecuador's reality prior to these events. Three factors in particular made the country more susceptible to repercussions from the 1987 earthquakes: unfavorable climatic conditions, vulnerable infrastructure and ill-conceived economic policies. This meant that the earthquakes gave rise to an economic crisis that lasted approximately five years.

Keywords: Earthquakes; Economic policies; Oil Economy; Ecuador; 20th Century.

Resumen: El 5 de marzo de 1987, dos terremotos de 6,1 y 6,9 grados en la escala Richter sacudieron en noreste del Ecuador. Si bien el país había vivido terremotos más fuertes, el de 1987 representa uno de los que más golpearon su economía. Para entender la gravedad de las consecuencias económicas y sociales que este fenómeno natural tuvo, es necesario revisar la realidad ecuatoriana previa al desastre. En particular tres factores habrían hecho más vulnerable al país frente a los terremotos de ese año: condiciones climáticas desfavorables, infraestructura vulnerable y malas políticas económicas. El resultado de esta vulnerabilidad fue que un terremoto causó una crisis económica que duró alrededor de cinco años.

Palabras clave: Terremotos; Políticas económicas; Economía petrolera; Ecuador; Siglo XX.

Introduction

This article begins with a description of Ecuador's geography, followed by an analysis of the most serious natural hazards facing the country, especially those related to climate and to earthquakes. The third section analyzes the earthquakes of March 5, 1987, while the fourth examines the economy's vulnerability to the earthquakes and the reasons that the economic damage was so great. The fifth and final section reviews the serious crisis caused by the earthquakes and aggravated by the misguided economic policies applied especially between 1986 and 1988.

1. Ecuadorian Geography: Between Mountainsides and Volcanoes¹

Ecuador is located on South America's northern Pacific Coast. It borders on Colombia to the north and Peru to the south and east. Geographically speaking, the country is located within the Pacific Rim, the area where the world's major earthquakes have historically occurred. Crossed north to south by the Andes Mountains, continental Ecuador is composed of three geological and geomorphological zones: the coastal plains to the west, along the Pacific Ocean; the central highlands also known as the Sierra; and the eastern lowlands that form part of the Amazon Region.² Together, these three zones have a territory of 256,370 km².

The coastal region lies on the country's westernmost edge. It contains a low coastal cordillera that forms an arc starting from the Gulf of Guayaquil and extending to the northeast. This cordillera reaches an altitude of approximately 1,200 meters.

The highlands boast two parallel cordilleras that extend southwards: one is known as the occidental or western mountain range, and the other as the royal or eastern range. The latter is composed of metamorphous rocks, and the former by volcanic-sedimentary rocks. Both form part of the Andes Mountains; and the Inter-Andean Valley lies between them, with elevations ranging between 2,500 and 3,000 meters. It is in that valley that the Sierra's main cities are found, including Quito, Ecuador's political capital. The highlands region is characterized by steep, massive slopes and volcanic structures that become smaller to the south.

The Amazon Region begins at the foot of the eastern side of the Andes Mountains and extends to the border with Peru. The Napo Rise can be found at the northern end of this area; and the Cutucú and Cóndor cordilleras, to the south.

In addition to the diversity of topographical relief in its different regions, Ecuador also has the climatic conditions that characterize it as part of the tropical zone. Ecuador's annual precipitation is over 2,000 mm per year, far exceeding the world average of 1,160 mm (World Bank, 2014). This gives the country an advantage in terms of one of the most important resources for the economy: the availability of water. Alongside the temperate climate, this enables year-round farming and a wide variety of agricultural export commodities. However, the country's propitious location also puts it at high risk for natural disasters.

2. Natural Hazards in Ecuador

Given its geographical location and the characteristics of its climate, Ecuador is subject to constant threats from natural morphoclimatic and geological phenomena. Some of these are discussed below, and the major natural disasters of the past are highlighted, i.e., those that have caused the greatest social, economic, environmental and infrastructure losses and thus affected the country's development.

¹ Readers interested in exploring Ecuadorian geography in greater depth may consult the Military Geographical Institute (Instituto Geográfico Militar, IGM) (2013).

² Ecuador also has an island region comprised by archipelago of the Galapagos Islands, located some 1,000 km east of the continental territory. However, this region is not relevant to the analysis at hand.

2.1. *Morphoclimatic Phenomena*

Among the morphoclimatic phenomena, the ones that have had the harshest effects on the Ecuadorian economy have been the floods caused by El Niño, which occurs irregularly, not periodically, and usually lasts over four months. During the twentieth century, the most intense episodes took place in the early 1980s and the late 1990s.

The phenomenon of El Niño occurs when cold waters from the Antarctic reach the Humboldt current and are displaced by uncommon warmer waters (0.5C above normal) coming from Indonesia and Australia to the coasts of Chile, Peru and southern Ecuador and causing the sea level to rise as much as 40 cm (Andean Community [CAN] 2013)³.

The floods caused by El Niño are mainly seen on the coastal lowlands, and their greatest impact on the Ecuadorian economy is related to the obstruction of roads as a result of landslides and flooding and to the destruction of crops, which jeopardizes the country's food security. According to estimates by the Andean Development Corporation (CAF), the 1997-1998 El Niño had the most serious impact on the Ecuadorian economy and on the other Andean countries along the Pacific Coast, with losses of almost US\$2.9 billion for Ecuador, equivalent to 15% of the GDP. By comparison, the damages caused in 1982-1983 have been estimated at \$1 billion (see point 4.2.) (CAN 2013).

2.2. *Geological Phenomena*

The geological phenomena that affect Ecuador, whether volcanic or seismic, are generated by the subduction⁴ and constant collision between the Nazca tectonic plate and the South American continent. This subduction occurs at a rate of 6 to 8 cm per year (CAN 2009). The main effects of volcanic and seismic activity are ground movements, ash fallout and other hazards for the country's population, production and infrastructure.

The volcanoes of the Andes Mountains are characterized by violent eruptions that, in addition to lava, produce huge amounts of ash, carbon dioxide, steam and sulfurous gases that reach heights of more than 25 km and are carried long distances by winds, thus affecting distant settlements and crops. The volcanic corridor on continental Ecuador is between 100 and 120 km wide, more than twice as wide as the volcanic corridor in Colombia. However, in general, the Andes Mountains are narrow in Ecuador, particularly when compared to their width in the southernmost region of South America.

In the far eastern part of the Andes Mountains, a chain of volcanoes is aligned north-to-south. The conic shapes of these reveal that they are relatively young volcanic structures. Of these, the historically most active is the Reventador Volcano, whose most recent major eruption process began in November 2002 and has been characterized by ash fallout and flows of pyroclasts, mud and debris (lahars). Located 90 km northeast of the city of Quito, the Reventador Volcano has a diameter of nearly 4 km and rises 3,500 m above sea level.

Volcanic activity represents a constant threat to the country's infrastructure and therefore to its economy. In the case of Ecuador, for example, the oil pipeline and the

³ A phenomenon with opposite characteristics, caused by more intense trade winds, which make the water colder, creates the phenomenon known as La Niña, the most notable instances of which occurred in 1988-1989 and 1998-2000.

⁴ Crushing of one tectonic plate under another or others (in this case, the Nazca plate under the South American plate).

poly-product pipeline that transport hydrocarbons from the country's eastern region to its northern coast could be directly affected by the Reventador Volcano and by the Guagua Pichincha Volcano because the pipelines cross the high-risk area and are close to the lahar zone of the Cotopaxi Volcano (CAN, 2009).

On the basis of records kept by the Geophysical Institute of the National Polytechnic School of Ecuador (IGEPN), it has been possible to determine the area of influence of continental Ecuador's major active volcanoes. The Reventador has an area of influence of 370 km², the fourth largest one nationwide. At just over 1,000 km², the Cotopaxi has the largest area of influence, followed by that of the Guagua Pichincha with 725 km² and the Tungurahua Volcano with 530 km². Sangay, located at the southern end of Ecuador's chain of active volcanoes, has an area of influence of 368 km².

Before construction of the heavy-crude oil pipeline that runs just 7 km away from the volcano's cone, the Reventador did not represent a major threat to the country beyond the ash fallout and the smell of sulfurous gas in Quito and other populations closer to the volcano. However, just one year after that pipeline was inaugurated in June 1972, the Reventador began an eruption process that would last a year, with lava flows and the expulsion of lahars that eventually covered the Quito-Nueva Loja highway but fortunately not the oil pipeline. In 1976 there were new reports of significant activity in the volcano, with moderate explosion levels but no effects on the crude oil transport infrastructure. The last record of volcanic activity in the Reventador was in November 2002, the same year that construction began on the Heavy-Crude Oil Pipeline (OCP) that runs parallel to the Trans-Ecuadorian Oil Pipeline System (SOTE) in the area of the Reventador. During the 2002 eruption, less than one kilometer of the OCP that was under construction was affected, and the SOTE was not affected at all. Neither of these Reventador eruptions produced effects of the comparable magnitude to the 1987 earthquakes.

3. The History of Earthquakes in Ecuador

Ecuador's recorded seismic history dates back to 1541, and records show a cumulative figure of more than 80,000 lives lost (IGEPN 2014). Thus far, there have been 37 earthquakes with an intensity greater than VIII on the International Mercalli scale,⁵ i.e., with released energy comparable to 56 billion kg of explosives. Among these, the 1987 earthquakes reached a maximum magnitude of IX on that scale. In addition to these episodes, there have been 96 earthquakes with an intensity of less than VIII but greater than VI.⁶ These have also led to significant social and economic losses.

Ecuador's earthquakes have destroyed entire cities and caused serious damage to electric power and hydrocarbon infrastructure, as can be seen in the brief summary provided below of some of the earthquakes that have had the greatest impact.

The most destructive earthquake in Ecuador's seismic history occurred in 1797. The material destruction caused by that earthquake was massive, particularly in the city of

⁵ The seismic intensity measured on the Mercalli scale is not equivalent to what is measured on the Richter scale. However, its degrees (expressed in Roman numerals) are proportional, whereas the degrees on the Richter scale have a semi-logarithmic increase and are therefore not proportional.

⁶ The data on historical seismic activity come from the National Seismology and Volcanology Service of the Geophysical Institute of the National Polytechnic School.

Riobamba, which was totally destroyed and partially buried under Cullca Hill during the four minutes that the earth shook and moved in waves. The main costs incurred were related to rebuilding the city on a new site and repairing the partial destruction of other important cities such as Ambato, Latacunga and Guaranda.

In the nineteenth century, the earthquake that had the greatest impact occurred in 1868, in the province of Imbabura. With a magnitude of 7.7, it left several towns and cities in ruins, including Cotacachi, Ibarra and Otavalo. The shifting of the ground and the appearance of large cracks destroyed many communication channels and much of the urban infrastructure in the cities that were affected in that province as well as others in the provinces of Carchi and Pichincha (among these, Quito).

In January 1906, a seaquake with a magnitude of 8.8 degrees on the Richter scale took place in the Pacific Ocean, off the country's northern coast and extended over 500 km. Many coastal settlements in the province of Esmeraldas were totally destroyed by the subsequent tsunami and by the shaking of the earth itself.

In 1949, a large-scale earthquake near Ambato⁷ completely destroyed that city, along with many other settlements in the provinces of Tungurahua and Cotopaxi. The ground movement in this disaster was so great that the landscape changed in many places. In the La Moya neighborhood of the town of Pelileo, it was even possible to see soil liquefaction similar to what happened during the 1797 earthquake in Riobamba. According to statistical records, the Ambato earthquake of 1949 had a magnitude of 7.9 degrees on the Richter scale and left 6,000 dead and more than 100,000 homeless within an affected area covering 1,920 km².

The last earthquake that occurred within the Ecuadorian territory with an intensity of more than VIII degrees on the Mercalli scale was the 1998 earthquake that affected the coastal province of Manabí. The greatest destruction caused by the phenomenon occurred in the city of Bahía de Caráquez, and buildings with structural damage can still be seen there today.

3.1. *The 1987 Earthquakes*

The epicenter of the March 5, 1987 earthquakes was a mountainous area of sharp inclines in the far west of the eastern region, 25 km north of the Reventador Volcano and 100 km northeast of Quito. The stronger of the two earthquakes registered a magnitude of 6.9 degrees on the Richter scale and occurred shortly after 11 P.M. (local time), two hours after the first event, which registered 6.1 degrees.⁸ Even though the earthquakes' epicenter was relatively close to the active volcano Reventador, the origin was not volcanic but rather tectonic, i.e., it was due to a shallow intraplate event.

The closest settlements were directly affected by structural damage to their buildings, particularly in the city of Ibarra, located 50 km from the epicenter. However, the seriousness of the 1987 earthquakes lay in the fact that the soil of the steep mountainsides had a high water content and resulted in massive landslides. Thus, the direct social and

⁷ Both authors of this article had close relatives and even forefathers in Ambato during the earthquake of 1949. The destruction caused by that quake left deep marks in the collective memory of Ecuador.

⁸ The first earthquake (6.1 degrees on the Richter scale) was recorded at 8:45 p.m. at a depth of 14 km according to the parameters calculated by the U.S. Geological Survey. The second (6.9 degrees on the Richter scale) occurred at 11:10 P.M. at a depth of 10 km. (Times are always local, GMT -5).

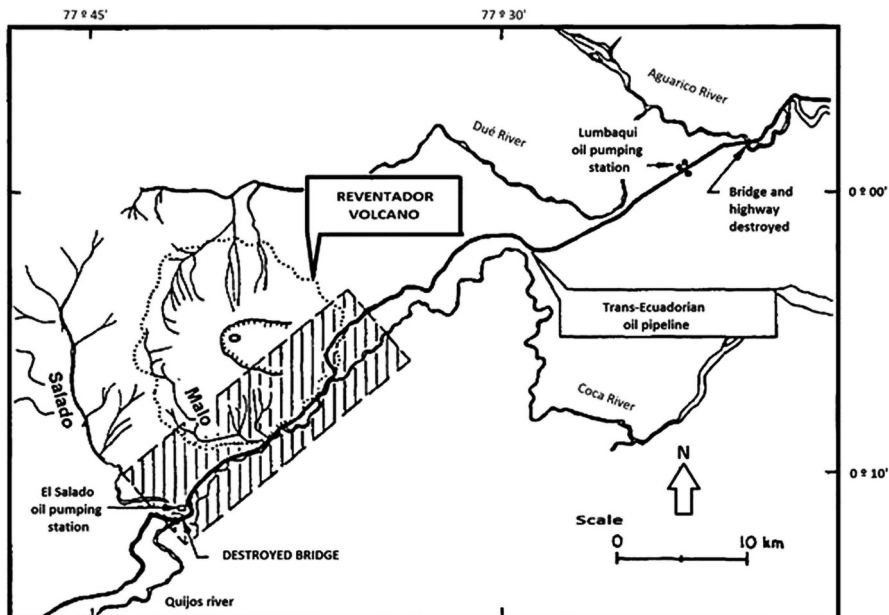
economic losses were comparatively slight, but the indirect effects due to landslides and floods were much greater than those of previous earthquakes.

The area around the Reventador Volcano in the northeastern part of the country has year-round rainfall that intensifies from March to July. Nevertheless, unusually strong precipitation had occurred in this area between January and February 1987. During the month prior to the earthquakes, about 600 mm of rain fell in the region, so that on February 3rd and February 20th the closest gauging station located on the Coca River registered flows of 2,600 and 3,400 m³/sec (8 to 12 times higher than the average river flow). This zone of high peaks with an active volcano at an elevation of 3,562 meters, and heavier precipitation than usual was about to be shaken by two earthquakes, one after the other, and more than 1,200 aftershocks (Hall, 1991).

3.2. Immediate Damage from the Earthquakes

The immediate damage caused by the earthquakes included approximately 1,000 deaths, practically all of which were due to landslides and floods. In addition to the social losses, the rock, soil, mud and debris slides destroyed some 70 km of the trans-Ecuadorian oil pipeline and the only road that connected Quito to the Amazon oil fields, whereas the flooding in nearby rivers was the main cause of property destruction. The economic losses totaled approximately US\$ 1 billion (ECLAC, 1987), which at the time accounted for 7% of the GDP. This figure included the paralyzation of oil exports for five months because of the damage to the oil pipeline. The image shown above, taken from the detailed book about the earthquakes of 1987 by Hall Minard, shows the extension of the damage.

Most damaged section of the trans-Ecuadorian oil pipeline



Taken from Hall (2000).

Much of the damage caused by flooding and sedimentation were due to the obstruction of rivers and tributaries by debris. It is estimated that the accumulation of sediments in the Coca River was as thick as 20 m. Meanwhile, near the confluence of the El Salado and Quijos Rivers that flow into the Coca River, the bridge on the trans-Ecuadorian highway upstream of the El Salado River was washed away by the current. Thus, both the highway and the oil pipeline were rendered unusable.

The 1987 earthquakes also affected the El Salado pumping station of the Trans-Ecuadorian Oil Pipeline System (SOTE) due to a landslide that cracked the station's main tank, spilling thousands of barrels of crude oil, and also buried the floodgates' main valve.

Additional impacts on the country's infrastructure were seen in the Trans-Ecuadorian Oil Pipeline System that transported propane gas and followed the same route as the oil pipeline. In addition, the communication channels between Quito and the towns of Cayambe and El Quinche were hampered by landslides and the deposit of volcanoclastic sediments.

4. The Economy before the Earthquakes⁹

At the time of the March 1987 earthquakes, the Ecuadorian economy was in a very vulnerable situation. In order to understand such situation, it is necessary to review Ecuador's major economic expansion in the 1970s, followed by the Latin American debt crisis of 1982.

4.1. The Decade of Growth: 1972-1981

Generally speaking, the decade of the seventies was very dynamic, with an average real GDP growth of 8% between 1972 and 1981, driven by the oil production that began precisely in 1972. During that same period, exports grew 12% annually in real terms. Although imports also grew, Ecuador was able to maintain a positive balance of trade every year during the period except for 1975, thus reversing the endemic trade deficit that had characterized the country in previous decades.

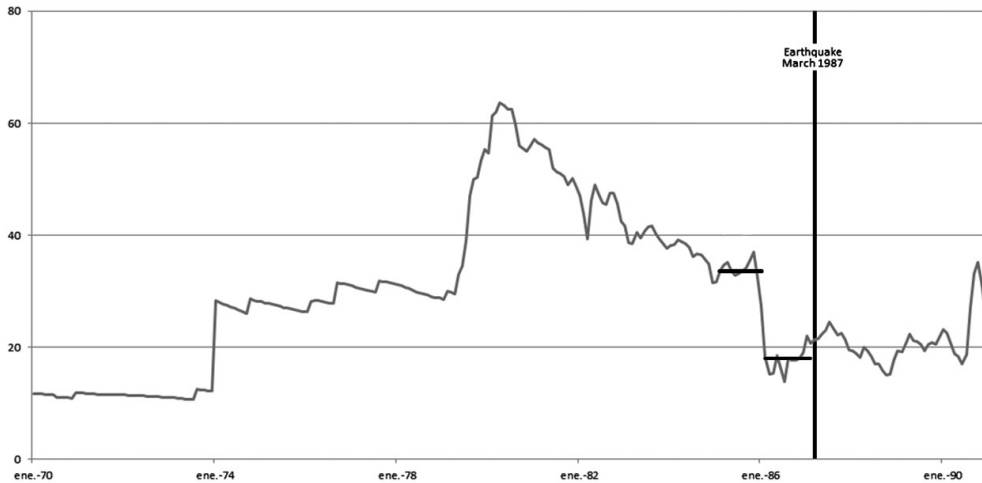
This dynamism also led to qualitative changes in national production; a significant increase in oil's share in the GDP; and a somewhat smaller increase in industry's share. Meanwhile, agriculture lost its role as the driving force for the economy and its share in the GDP plummeted from 22% to 15% between 1972 and 1981.

All of this economic bonanza made Ecuador more creditworthy, and this in turn led to a rapidly growing foreign debt, which increased 17-fold between 1972 and 1981 and became a sad legacy of the decade of growth. It is important to note that most of this debt was taken out in U.S. dollars through private banks in developed countries and at adjustable interest rates (especially based on the prime rate in the United States).

Throughout this period, oil prices rose until reaching their highest level in March 1980 (see Graph 1). This sharp increase made the Ecuadorian economy increasingly dependent on oil, and even more so if it is considered that a significant part of oil revenues went directly to the federal government. Thus, government finances also became dependent on earnings from oil.

⁹ This section is based on Albornoz (2006), Hurtado (2002) and Hurtado (2006).

Graph 1. Price of a WTI Barrel of Oil
(1990 US\$)



Source: Central Bank of Ecuador.

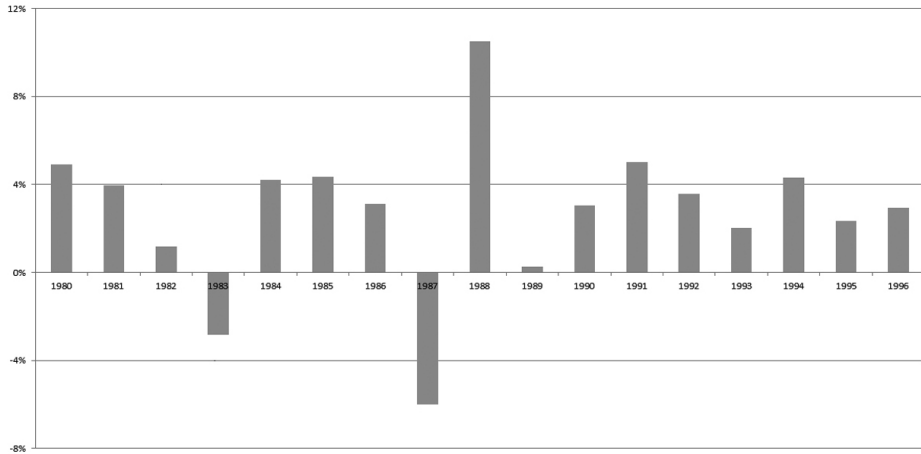
By 1981, the Ecuadorian government was deep in debt, and its income depended on oil sales. It was therefore vulnerable to changes in interest rates (which could make the service on the public debt more expensive) and to drops in oil prices (which could decrease revenues).

In order to make things even more complicated, a short but costly armed conflict with neighboring Peru in early 1981 affected the fiscal coffers.

4.2. The Debt Crisis of 1982 and the Phenomenon of El Niño in 1983

In 1982 the Ecuadorian economy was hit hard by two external shocks: declining oil prices and rising international interest rates. These forced the government to reduce its spending, raise the prices of fuels sold by the government, and devalue the national currency—measures that resulted in a decline in economic growth that year (see Graph 2). All of this occurred in the context of the Latin American debt crisis.

Graph 2: Growth of GDP in Ecuador
(1980-1994)



Source: Central Bank of Ecuador.

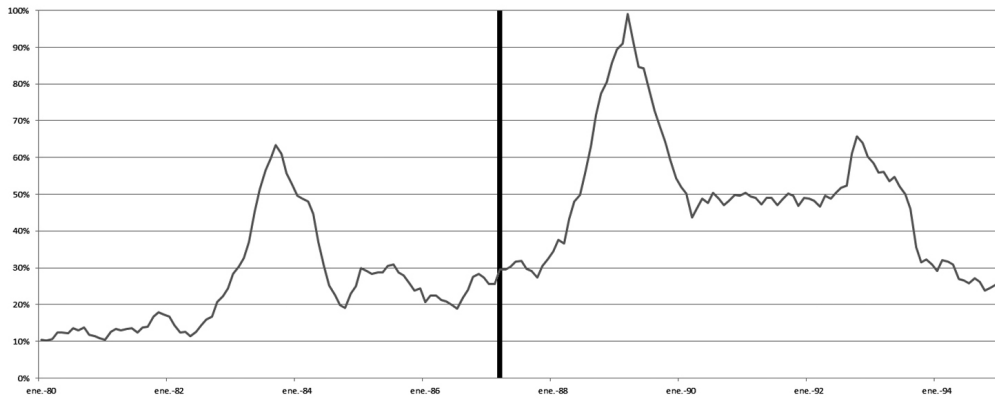
In 1983 the country experienced a third external shock: rains and floods due to the phenomenon of El Niño. Between 1982 and 1983, overall agricultural production fell by 28%; and banana, coffee and cacao production by 35%. This situation was reflected in accelerated annual inflation, which reached 63% in September 1983. Annual inflation in the group of food and beverages rose by 110%, but some subgroups such as fresh vegetables saw an increase of 294%¹⁰ (see Graph 3). In 1983, the GDP fell by 2.8% (Graph 2).

As of 1981, several adjustment measures were applied and their implementation continued until 1984, when the economy finally stabilized. In August of that year a right-wing president took office. Despite certain populist traits, he provided the business sector with a certain amount of optimism. The sum of the 1984 economic stabilization and that optimism meant that in 1985 the economy would recover and grow at a rate of over 4% annually (for the first time since 1980, see Graph 2).

Inflation also fell, and between late 1984 and March 1987 it remained between 20% and 30%. These figures may seem high, but they are significantly lower than those seen just one year before, during the phenomenon of El Niño (Graph 3). Optimism in the business community, sound economic growth and downward trends in inflation made it possible to believe at that time that the “debt crisis” was over.

¹⁰ ECLAC estimated losses during the 1983 rainy season as US\$640 million, or 6% of the GDP (ECLAC, 1985, p 313).

Graph 3: Annual Inflation in Ecuador
(1980-1994)



Source: Central Bank of Ecuador.

4.3. The February 1986 Drop in Oil Prices

Between February 1985 and January 1986, the price of oil had remained at an average of US\$33.60¹¹ per barrel, far below the record high of 1980. Since public-sector finances had been adapted to that level, in 1985 the budget showed a surplus (0.21% of the GDP, according to ECLAC 1991). However, a deficit began to appear when the price of a barrel of oil fell by nearly half in early 1986. Between February 1986 and March 1987, the average price was US\$18 per barrel.

Despite the decline in revenues that this represented, the government, instead of reducing spending, increased it by three GDP percentage points (ECLAC 1991, p 29). In order to finance the high level of public spending, the government resorted to the inorganic (unbacked) printing of money. In 1986 alone the monetary base grew by 38% and inflationary pressures resurfaced (Graph 3). The fiscal situation was so serious that in January 1987 the country stopped making payments on its foreign debt.

High levels of public spending encouraged imports (which grew in 1986) while income from exports declined due to low oil prices. All of this led to an external trade deficit that reduced international reserves, which went from US\$196 million in late 1985 to -US\$76 million just one year later.

Given the negative balance of international reserves, the fiscal deficit, and the inorganic money issues, the economy was extremely vulnerable at the time of the March 1987 earthquakes. That is why their economic impact was especially strong.

¹¹ All figures for oil prices are in 1990 U.S. dollars.

5. The Crisis after the Earthquakes

Due to the decline in oil exports and the reduction in public spending that depended on those exports, in 1987 the GDP fell by 6%. The government decided to finance its spending through additional money printing, so the monetary base grew by 37% in 1987 and by 62% in 1988. This triggered inflation, which due to the delayed effect of the inorganic issues, reached its record high of 99% in March 1989 (see Graph 3).

The international reserves fell to an all-time low of less than US\$330 million in August 1988; and a new government had to deal with the results of the crisis, most notably nonexistent international reserves, growing inflation, rising poverty levels, and the decision to default on the foreign debt.

Economic indicators continued to be critical at least until 1992, five years after the earthquakes. Annual inflation was over 40% until the end of 1993 (Graph 3), poverty levels did not drop below 50% until 1994 (Graph 4), and payments on the foreign debt were not made until 1995.

Hence, when combined with poor economic policies and a lack of foresight, a natural disaster turned into an economic disaster.

**Graph 4: Incidence of Income Poverty
as a Percentage of Total Population**



Source: SIISE (2014).

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