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Abstract

The purpose of this study is to investigate the impacts of a natural disaster on a developing country's economy. In that sense, we look at the impact of August 1999 earthquake in Turkey on two important macroeconomic indicators of the Turkish economy (Real Output and Employment) with recovery policies followed by the government and international donors. Our results indicate that the earthquake had a significant immediate negative impact on both output and employment growth in Turkey. While output growth reverted back to its pre-disaster pattern after the initial shock, employment growth did not recover. The earthquake had both a short run and long run influence on the Turkish economy. This study will develop understanding of the possible effects of future earthquakes. Also, it will help the Turkish Government evaluate already-applied mitigation measures (like Turkish Catastrophe Insurance Pool etc.) and guide the preparation for forthcoming disasters since scientists have reached a consensus that a major earthquake is expected in Istanbul.

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I. INTRODUCTION

When it comes to the assertion that the costs associated with natural disasters have risen dramatically in the past fifty years, there are no dissenters. "During the past decade, the economic costs of rainstorms, floods, earthquakes, volcanoes, droughts, and other extreme events have increased about 14-fold from the decade of the 1950s" (Munich Re, 2001). The growing magnitude of economic losses goes hand-in-hand with technological development and urbanization. Lists of major disasters appear to be dominated by those that occurred in highly developed countries such as Japan and the United States with economic loss estimates in the tens of billions of dollars. However, the effect of natural disasters on less developed countries can be far more dramatic in relative terms. Andersen (2002) reports the economic losses due to catastrophe for 38 less developed countries over the time period 1990-2000. For some small countries, the loss ranged as high as 15% of GDP with a mean loss of 2.13% of GDP for the group. In the same way that poor people are more vulnerable to natural disasters, less developed countries are more vulnerable than highly developed countries. Managing hazard risk becomes more challenging for the developing countries since they are less able to absorb the losses. For the period 1990-2000, whereas roughly half of the losses were covered by formal insurance contracts in industrialized countries, only 5% of reported damages were covered in developing countries (Andersen, 2002). In the absence of standard risk management instruments such as insurance, developing countries must rely on international emergency support or are forced to divert funds from existing development programs to fund temporary disaster relief efforts (Andersen, 2002).

As a result of this negative effect of disaster loss on the economy of the developing countries, it becomes crucial for them to (1) mitigate the possible loss from the future disasters (2) be prepared for the possible losses (3) have appropriate budget planning for post-disaster rehabilitation and reconstruction as "risk management strategies" (Freeman and Kunreuther, 2002). In formulating risk management strategies, the first step should be to clarify the impacts of previous natural disasters on the developing country's economy. In addition, by investigating the trend of economic indicators pre- and post-disaster, we can address the question of whether the financial support provided by international funds does affect that country's economic situation and expectations. In Bender (1991), the Organization of American States (OAS) noted, "funds intended for development are diverted into costly relief efforts. These indirect but profound economic effects and their drain on the limited funds now available for new investment compound the tragedy of a disaster in a developing country."

The purpose of this study is to investigate the impacts of a natural disaster on a developing country's economy. In that sense, we look at the impact of the August 1999 earthquake in Izmit, Turkey on two important macroeconomic indicators of the Turkish economy (Real Output and Employment) with recovery policies followed by the government and international donors. In terms of lives lost, the 1999 earthquake in Izmit is listed among worst ever natural disasters (Reuters, 2004). However, the effect of the earthquake cannot be measured solely in terms of lives lost but also in its impact on those that survived and their quality of life following the event. A study of Turkish macroeconomic indicators allows us to glimpse the effect on the survivors and their recovery. In so doing, this study will develop better understanding of the effects of future earthquakes. Preparation for forthcoming disasters is very important since scientists have reached a consensus that a major earthquake is expected in Istanbul (Parsons et al, 2000). In addition, it will help the Turkish Government evaluate already-applied mitigation measures (eg. Turkish Catastrophe Insurance Pool).

Most previous studies of the impact of the 1999 earthquake on the Turkish economy were based on initial assessments done by institutions like the World Bank and State Planning Organization of Turkey (SPO). Selcuk and Yeldan (2001) provided the first empirical attempt to investigate the macroeconomic impact of the earthquake using a general equilibrium model to simulate the economy under four possible government recovery policies and levels of international support. The data were drawn from Kose and Yeldan (1996) and input-output table of Turkey (State Institute of Statistics, 1994). The results were based on four cases: (1) no policy change, (2) discretionary adjustments on indirect tax rates, (3) with flexible indirect tax adjustments, and (4) with foreign aid. They concluded that the initial impact of the earthquake on the value of GDP may range from -4.5% to 0.8%. Based on their measurements of expected consumer welfare, Selcuk and Yeldan recommend a policy of subsidies to individual sectors financed by international donors. Further, they find that an indirect tax generates further losses in output.

Other studies have concentrated on earthquake risk mitigation measures, including earthquake insurance policies in Turkey (Gulkan, 2002; Freeman and Kunreuther, 2002). In addition to an already existing required insurance called Turkish Catastrophe Insurance Pool (TCIP) these studies suggest supplementary mitigation measures that reduce the risk to new buildings as well as retrofitting to mitigate risk to existing structures.

In sum, the negative impact of the earthquake on the Turkish economy is estimated intuitively and with the assumption of “no policy change” by the World Bank and SPO, and using theory-driven simulation methods. However, the degree of the impact after the earthquake has not been analyzed with real data. This study represents an initial attempt to address the question, “What happened to the Turkish economy in general pre and post earthquake with already existing recovery policies and mitigation measures?”

The rest of the paper follows with recent history of Turkey's experience with earthquakes, initial assessments of the August 1999 earthquake, available recovery policies and mitigation measures, statistical analysis of the impact, and finally conclusions.

II. RECENT HISTORY OF TURKEY'S EXPERIENCE WITH EARTHQUAKES

Turkey is geographically located at one of the most earthquake-prone areas of the world. A brief summary of recent urban earthquakes that have occurred in Turkey is presented in Table 1. According to Gulkan (2001) approximately 20,000 people have died in five urban earthquakes in Turkey during the past 10 years. As a result of these earthquakes, 70,000 buildings were damaged and 20,000 buildings were destroyed. The cost of the damage assigned only to the buildings that were destroyed is US$20 billion. Gulkan claims that the type of the construction of the multi-story apartments in Turkey is a very important factor and has exacerbated the losses.

17 August 1999 an earthquake that centered near Izmit was the most terrifying disaster in recent Turkish history. The earthquake had a moment magnitude of 7.4 in Richter measurement. The impact of the earthquake on the population and the economy was mainly felt in seven cities in the Marmara Region (Kocaeli, Sakarya, Yalova, İstanbul, Bolu, Bursa, and Eskisehir). The death toll was 18,373 with injuries to another 48,901 people. Reportedly 93,000 housing units and 15,000 small business units collapsed or were badly damaged. Another 220,000 housing units and 21,000 small business units sustained damage to a lesser degree (Erdik and Durukal, 2003).

INSERT TABLE 1 (Gurkan, 2002)

III.INITIAL ASSESSMENT ON THE IMPACT OF THE EARTHQUAKE ON TURKISH ECONOMY[1]

The Marmara Region, where the major impact of the earthquake occurred, is very important to the Turkish Economy both in terms of production and consumption capacities. This area accounts for 23% of the total population of Turkey. The seven cities Kocaeli, Sakarya, Yalova, İstanbul, Bolu, Bursa, and Eskisehir represent 34.7 % of Turkish GNP, further these cities produce 46.7% of total industry value added. The Marmara Region, mainly Kocaeli, Sakarya, and Yalova is the center for the Turkish oil, raw material for textile, automobile, petrochemical, and tire industries.

With an average income level per person that far exceeds the national average, the region also plays a very important role in terms of domestic consumption demand. According to published reports (RMS, 1999), the negative impact of the earthquake on capital accumulation and national product was declared to be approximately US$9-13 billion and the total estimated insured loss was US$1.5-3.5 billion. Johnson (2000) reports that direct damage generated 70% of the total insured losses while business interruption accounted for the remaining 30%.

Impact of the Earthquake on Government Budget

The negative impacts of the earthquake on the Turkish government's budget can be summarized in three points: (1) The cost of rehabilitation and reconstruction of public buildings damaged by the earthquake (2) The postponed taxes that should have been paid by the earthquake victims and (3) The increase in unemployment compensation. Under these circumstances, the negative effect of the earthquake on the government's budget is estimated to be approximately US$6.2 billion of which US$3.5 billion went to build housing units or reconstruct the damaged ones for

[1] Most of this section is based on the initial assessments by the State Planning Organization of Turkey, 2001 (**http://ekutup.dpt.gov.tr/deprem/**).

either temporary or permanent accommodations. The government decided not to collect principal and the interest for 3 years from people with loans from the state bank. In addition, low interest loans were offered to assist with the rebuilding effort.

The Impact of the Earthquake on Industry

The main heavy industry of Turkey is located in the Marmara Region for example, "automobile manufacturing, petrochemicals, motor and railway vehicle manufacture and repair, basic metal works, tire manufacturing, textile, sugar processing, paper mills, power plants and tourism" (Erdik and Durukal, 2003). Most of the roads, railways, pipelines, transmission lines, and energy distribution, communication channels were badly damaged and the cost of reconstruction is estimated to be US$200 million in the short-run and US$400 million in the long-run.

As a result of these, the estimated loss in the value added in the manufacturing industry was US$600 to 700 million and growth rate of the manufacturing industry was expected to decline by 1.6 points. The loss in production and sales is estimated to be approximately US$222.1 million in total for manufacturing, most of which are based on oil, coal, and gas production. Although there was no significant direct damage to the agricultural sector, public institutions (like Forestry Ministry, State Water Administration) that are directly involved in agricultural activities experienced a loss of around US$870 billion due to earthquake damage.

For medium and small enterprises, the cost is estimated to be in the range of US$1.1 and US$2.6 billion based on the World Bank report (1999). For the insurance sector with 41 insurance companies, the total industry reserves seemed adequate to cover domestic losses before the earthquake. However, the industry capacity was incapable of covering the losses from the earthquake (roughly 95% of the total losses were covered by international insurers). By September 1999, only 8,500 earthquake-related claims were submitted. "The most significant impact on the insurance sector will be in the form of lost revenues due to increased premiums for Turkey and ……. since most policy coverage is paid by foreign insurance companies, the timing of the payments of claims to the beneficiaries depend upon the funding capacity of foreign insurers. ” (World Bank, 1999)

In the case of the banking sector, the negative impacts can be summarized as:

1. Further worsening of the performance of loan portfolios of the commercial banks.
2. Difficulty of the financial status of state banks because of the increased maturity mismatch and liquidity squeeze due to the deference of the existing loans up to 3 years, providing interest rate subsidies.
3. Increased risk of default.

When we look at the cost of earthquake damage on social sectors like education, health, environment, and employment, the magnitude of the negative impact of natural disasters on a country's economy becomes more obvious but harder to quantify. In the Marmara Region, 43 schools collapsed and 377 schools were badly damaged. The total damage cost to school facilities is estimated to be US$107 million in rehabilitation. The reconstruction cost of hospitals is estimated totaling US$19 million.

The cost of the earthquake on industries can be summarized as: (1) business interruption, (2) loss of labor supply (3) reduction in capital (due to damaged buildings, machines, stocks, etc.), (4) reduction in production and sales when factories had to shut down temporarily, (5) psychological distress, (6) a reduction in tax revenue (7) an increase in unemployment compensation.

Risk Management in Turkey

The tremendous loss from the August 1999 earthquake forced the Turkish government to seek out and apply risk management strategies. The risk management program has followed five main courses of action. First, research on monitoring and forecasting the earthquake risk in the area of earthquake engineering has been expanded. Second, with the help of many research centers specified on earthquake and media, public awareness about the risk was propagated. Third, distributing the international donations to proper sectors/places where needed most has been coordinated. Fourth, Indirect taxation has been implemented by the government. Lastly, in terms of market instruments, risk (monetary loss) of earthquake is being transferred by an obligatory government insurance policy called the Turkish Catastrophe Insurance Pool (TCIP).

The first two actions are beyond the scope of this study. As for international funding, according to the World Bank report (1999), US$3 billion is identified to be as "exceptional external financing". In order to compensate the earthquake costs, US$2.5 billion has come from international foundations. "Claims paying capacity of TCIP for year 2002 is approximately US$1 billion including reinsurance (US$840 million), premium reserves and the credit obtained from the World Bank" (Gulkan, 2002). Most arrangements for distributing these funds are made by the Treasury Department of Turkey.

Indirect taxation to increase the rehabilitation budget was unique in many ways. The Turkish military authorities allowed male citizens that have not completed their military obligation to do their service for 28 days (instead of 8-18 months). The only requirement to gain this right is to be willing to pay 15,000 Mark (US$2000 in year 2000 when this law was applied) to the government (SPO Report, 2001).

The Turkish government made earthquake insurance mandatory for residences starting from September 27, 2000 (Decree No.587, Compulsory Earthquake Insurance). The insurance was designed by the Undersecretariat of the Treasury and administered by the Natural Disaster Turkish Authority (DASK in

Turkish). Also, the government rescinded legislation that requires it to extend credit and construct buildings for the public in case of an earthquake as of March 27, 2001. According to TCIP that is sold by 33 authorized insurance companies, "all existing and future privately owned property, except for engineered rural housing and fully commercial buildings, is required to contribute to TCIP" (Freeman et al. 2002). TCIP covers only a portion of the value of a residence and contents of the dwellings are not covered (Gulkan, 2002).

As for the sanction power of TCIP, all new homeowners must present valid TCIP policy to complete ownership process. Starting 15 April 2003, a TCIP policy is required in order to subscribe to water and natural gas supplies in 5 cities. Although it was estimated that 10 out of 14 million households will be under TCIP coverage, until now only 2.4 million homeowners have purchased this insurance (Gulkan, 2002). The total commitment of TCIP through 2002 was US$26 billion. Up through 2002, TCIP has paid approximately 1,634,000 US dollars for claims.

According to Gulkan (2001), there is a need for alternative mitigation measures as a supplement to TCIP. He notes that according to the statistics of the recent earthquakes, the most common type of construction in Turkey (multi-story, concrete frame etc.) is especially vulnerable to damage or collapse. So, he suggests reducing the risk to new buildings with the help of the current Turkish earthquake code and retrofitting existing buildings as well. That way, there will be a reduction not only in the property damage, but also the number of lives lost. At the same time, that may decrease the transaction cost of having earthquake insurance either from TCIP or a private insurance company. In addition, he suggests better coordination between different governmental units as well as laws that emphasize disaster policies and mitigation.

All the recovery policies and mitigation measures described above may not be enough but they are important in a sense that they represent a concerted scientific effort to protect Turkey from future hazards. The justification for such a concerted effort comes from a more complete understanding of the economic impact of the earthquake on Turkey in order to see how important risk management strategies can be for the economic recovery. The next section focuses on the statistical analysis of the earthquake impact on real output and employment of Turkey.

IV. STATISTICAL ANALYSIS

Data and Methodology

Standard neoclassical macroeconomic theory suggests that the output of an economy may be described by a production function as follows:

(1) $$Y = f(N, K, A)$$

where Y denotes real output, N denotes labor, K denotes capital stock, and A denotes technology. In the long run model, output is said to adhere to the notion of potential output. Potential output is the amount that would be produced when the output, financial, money, and labor markets are in equilibrium. For a given state of technology and capital stock, growing levels of employment lead to increases in output. Thus, output and employment are inherently linked and represent two popular measures used to gauge the performance of an economy.

In order to examine how the 1999 earthquake might have affected the economy, we focus the analysis on two macroeconomic indicators: the production index and the average number of production workers. The monthly data are obtained from the State Institute of Statistics. The sample period for the production index is January 1988 through July 2002. The data on employment covers the period of January 1992 through July 2002. All data are seasonally adjusted using the (multiplicative) ratio-to-moving average method. In what follows we use the growth rates of real output and employment computed as the first-difference of the natural logarithm of the production index and the number of production workers, respectively.

[insert table 2]

Table 2 provides some descriptive statistics for the Turkish economy over the sample periods examined. Note that while average output growth was positive and average employment growth was negative, we were unable to reject the null hypothesis that either mean was statistically different from zero using the t-test (t=-0.23 with p-value=0.82 for output; t=0.93 with p-value=0.35 for employment). Both series did exhibit considerable variability over their respective sample periods (standard deviation=0.07 for output; standard deviation=0.01 for employment). Figure 1 displays plots of both series. Finally, results from unit root tests (ADF and KPSS) indicate that each growth rate series is stationary (see Table 2).

[Insert figure 1]

The time series analysis of real output and employment growth proceeds by specifying and estimating autoregressive moving average (ARMA) models of the series under investigation. However, as the earthquake may have changed and/or altered the dynamics of the economy we utilize the intervention analysis described by Enders (2004). The intervention analysis augments the ARMA model with a dummy variable that acts as an indicator of whether or not the series was influenced by the earthquake. There are two types of interventions discussed by Enders (2004). The first type is of the *mean-shift* variety in which the intervention variable takes on the value, zero prior to the earthquake and the value, one starting the month after the earthquake and every period thereafter. This intervention captures a permanent or long run shift in the unconditional mean of the series. Thus, this intervention allows for both a short run or immediate impact and a long run multiplier effect. The other type of intervention is of the *pulse* variety. In this case the intervention variable equals one only in the month immediately following the earthquake and zero in all other months. Provided that the ARMA model converges, then the *pulse* intervention measures the immediate impact of the earthquake. Convergence of the ARMA model implies that the earthquake would have no long run or permanent effect on the series although significant AR (MA) terms indicate that the shock created by the earthquake might be felt for a number of months. Equation (2) shows the ARMA-intervention model:

(2) $$\phi(L)y_t = \theta(L)\varepsilon_t + c_0 + \lambda\pi_t$$

where y is the growth rate variable under investigation, c is a constant term, ε is a well-behaved error term, and λ is the coefficient on the intervention variable, π. $\phi(L)$ and $\theta(L)$ are polynomials in the lag operator.

In the case of the *pulse* type of intervention we have:

(3) $$\pi_t = \begin{cases} 1, & September 1999 \\ 0, & otherwise \end{cases}$$

The *mean-shift* intervention is given by:

(4) $$\pi_t = \begin{cases} 1, & September 1999 - July 2002 \\ 0, & otherwise \end{cases}$$

Examination of the estimated coefficient on the intervention variable in (2) provides information as to how and to what extent the earthquake may had an impact on the Turkish economy.

Results

The first step in the analysis was to choose the best-fitting ARMA specification for employment growth and for output growth. This was accomplished by following standard Box-Jenkins techniques which include examination of autocorrelation and partial autocorrelation functions as well as comparisons of AIC and SBC criteria at various orders of the ARMA model (Mills, 1999). Upon doing so, it was determined that output growth was best represented by an ARMA(1,0) and employment by a simple ARMA(0,0). Furthermore, as there is no way to tell *a priori* which of the two intervention definitions is appropriate for the case at hand, we estimated the chosen model specifications under both definitions. For both employment and output cases, the mean-shift intervention was found to be insignificant. However, this was not the case for the pulse definition of the intervention. Table 3 provides the results of the ARMA-intervention models based on the pulse definition.

[Insert table 3]

Panel A of Table 3 indicates that output growth converges since the necessary and sufficient condition for stationarity of the AR(1) model is met, that is, the absolute value of the coefficient on the autoregressive term is less than one. The coefficient on the intervention term (earthquake) is negative and statistically significant. The earthquake is estimated to have had an immediate adverse effect on the economy as output growth fell by 12 percent in the month following the event. It is important to note that this decline in output growth is measured relative to what it would have been in the absence of the earthquake. For example, if output had grown at a (positive) 12 percent rate that month, the observed (i.e., actual) growth rate would have been zero as the earthquake would have exactly cancelled out the positive growth. The actual pattern of output growth in Turkey is highly cyclical. This can be seen from Figure 1 as well as the negative AR(1) term. In fact, positive months of output growth in Turkey are typically followed by a month with negative growth. Examining the actual growth rate in the months immediately preceding the earthquake confirms this contention. Based on our analysis of the data, it is likely that output would have been positive in September 1999 and around 12 percent had the earthquake not occurred. Actual growth was near zero (-0.001).

Panel B shows the results for the employment growth model. It is important to note that the chosen ARMA specification was (0, 0) or simply a random walk model. The coefficient on the intervention variable was found to be negative and significant (-0.01, p-value=0.00). The employment growth rate thus experienced an immediate and long run decline following the earthquake.

The results from the ARMA-intervention models indicate that the earthquake was associated with an adverse outcome for the economy. Generally speaking, real output fell immediately after the earthquake before returning to its normal path after several months. Employment growth fell following the earthquake; however, as the employment growth was best characterized, as a random walk the effect was permanent. Thus, the intervention model suggests that both short run and long run negative effects resulted from the earthquake.

It is interesting to speculate as to why employment growth was found to exhibit a long run decline while the decline of real output growth was estimated to be transitory. One explanation is that the earthquake destroyed much of the existing capital stock and infrastructure and the rebuilding process undoubtedly resulted in new and improved capital stock and infrastructure. This being the case, there was likely a relative shift from labor-intensive production to more technology-driven production processes. Consequently, the employment growth has fallen relative to output growth.

V. Discussion

This study represents an initial attempt to use real output and employment data to address the question, “What happened to the Turkish economy in general pre and post earthquake with already existing recovery policies and mitigation measures?” We used econometric techniques to evaluate the effect of this catastrophic earthquake on the time series behavior of two important macroeconomic variables: real output growth and employment growth, with recovery policies followed by the government and international donors. Our results indicate that the earthquake had a significant immediate negative impact on both output and employment growth in

Turkey. While output growth reverted back to its pre-disaster pattern after the initial shock, employment growth did not recover in spite of the policy measures in place to counteract this disastrous shock to the economy. The earthquake had both a short run and long run influence on the Turkish economy. Our results indicate that policy makers should work to identify risk management and recovery strategies that will help to further insulate employment growth from the adverse effect of a future major earthquake. Workfare programs such as those used in Fiji and India may help overcome the permanent decline in employment growth and therefore serve as a strategy to manage the risk of reduced employment growth following a major earthquake.

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Table 1. Earthquake Losses in Turkey: 1992-1999

Earthquake (Date,dd.mm.yy)	Lives Lost	Housing Units damaged	Housing Units Collapsed	# of People Left Homeless	Estimated Total Economic Loss, in $B
Erzincan (13.3.1992)	645	8000	1450	8000	0.75
Dinar (1.10.1995)	100	6500	2043		0.25
Adana-Ceyhan	150	21,000	2000	24,000	0.5
Kocaeli (17.8.1999)	>18000	320,000	26,000	600,000	>20
Düzce (12.11.1999)	812	10,100	800		1

Source: Gülkan, 2002.

Table 2
Descriptive Statistics for Output and Employment Growth

	Output growth	Employment growth
Mean	-0.001212	0.001102
Standard deviation	0.069931	0.013243
ADF	-19.735*	-9.997*
KPSS	0.070	0.081
Sample period	January 1988-July 2002	January 1992-July 2002
Number of observations	174	126

Growth rates are computed as the first-difference of natural logs of the production index (output) and number of production workers (employment). ADF denotes the augmented Dickey-Fuller test statistic for a unit root (H_0: series contains a unit root). The ADF statistics are significant at the 1% level denoted by *. KPSS denotes the Kwiatkowski, Phillips, Schmidt, Shin test statistic for a unit root (H_0: series is stationary). The KPSS statistics are not significant. Tests for unit roots contained a constant and trend term.

Table 3
Results from the ARMA-intervention Models

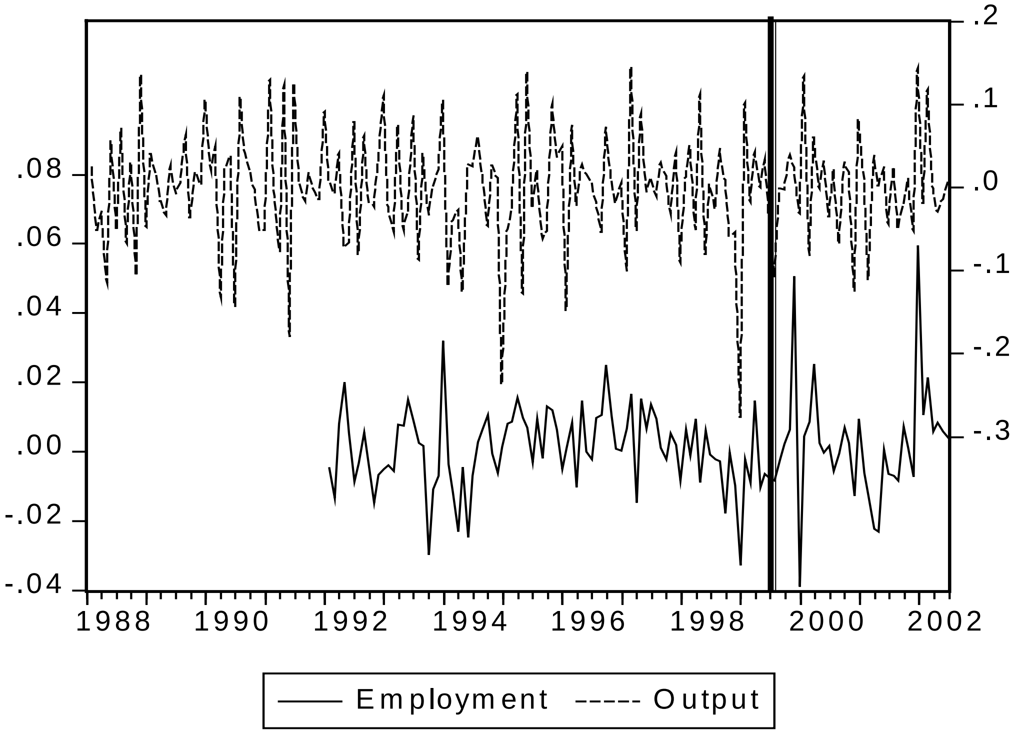
Panel A:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001135	0.004895	-0.231907	0.8169
Output growth(t-1)	-0.398412	0.071447	-5.576292	0.0000
Earthquake	-0.124577	0.006320	-19.71003	0.0000
R-squared	0.171886			

Panel B:

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001113	0.001191	0.934508	0.3519
Employment growth(t-1)	0.098039	0.121384	0.807678	0.4208
Earthquake	-0.008790	0.001531	-5.741658	0.0000
R-squared	0.013834			

Figure 1
Output and Employment Growth



Vertical line designates the August 1999 earthquake.