On the Macroeconomic Impact of the August, 1999 Earthquake in Turkey: A First Assessment

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Abstract

The devastating earthquake that struck the most densely populated and industrialized area of Turkey on August 17, 1999 was one of the most damaging natural disasters during this century. This paper is a first attempt to estimate the transition path of the Turkish economy to its new equilibrium after the earthquake. We utilize an Applied General Equilibrium Model to provide an initial assessment, and to obtain the second best policy options to mitigate the negative effects of the earthquake. The analytical foundations of the model rest upon intertemporal dynamics as laid out in the neoclassical growth theory. Our simulation results suggest that the initial impact of the earthquake on GDP may range from -4.5 percent to + 0.8 percent of GDP, conditional upon policies followed by the government and international donors. The policy implication of the paper is that a negative indirect tax (a subsidy financed by foreign aid) to individual sectors to recover the capital loss yields the best outcome. On the other hand, an indirect tax to finance the extra fiscal spending would result in an output loss, further deepening the impact of the earthquake on the economy.

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1. Introduction

The devastating earthquake that struck the most densely populated and industrialized area of Turkey on August 17, 1999 was one of the most damaging natural disasters during the last quarter of this century. The earthquake, with a magnitude of 7.4 on the Richter scale, resulted in a calamity in a large area, claiming more than 15,400 thousand lives (as of September 10, 1999) and injuring more than 40,000 people. Another 5,000 thousand is believed to be missing. Furthermore, at least 100,000 residential units were totally collapsed, several miles of roads were ruined, and the main power transmission network in the region was totally destroyed.

The earthquake brings up many important questions for the Turkish economy: What is the extend of the damage? What are the optimal policies that will allow the most rapid recovery of the physical capital loss? And, given such policies, how will the transition path of the economy evolve during adjustments to a new (long run) equilibrium? Even though there are numerous guestimates in the popular press on the extent and macroeconomic implications of the damage, based on hindsight and extrapolation, we feel that a theory-based analytical assessment is yet to be provided. This paper is the first attempt to make such an initial assessment on the macroeconomic impact of the earthquake on certain macroeconomic variables from an immediate to a long run. To this end, we utilize an applied general equilibrium (GE) model.[1]

Our modeling exercises reveal that the initial impact of the earthquake on GDP may range from -4.5 percent to +0.8 percent of GDP, conditional upon the policies followed by the government and the international donors. The major policy implication of the paper is that a negative indirect tax (a subsidy financed by foreign aid) to individual sectors to recover the capital loss yields the best outcome. On the other hand, an indirect tax to finance extra fiscal expenditures would result in an output loss, further deepening the impact of the earthquake on the economy.

The paper is organized as follows. The GE model and its underlying structure are explained in section 2. Section 3 reports the main results. We conclude in section 4.

2. The General Equilibrium Model

With some modifications, the model utilized in this study is an extended neoclassical growth model with intertemporally optimizing agents (see, e.g. Blanchard and Fischer, 1989; Barro and Sala-i-Martin, 1995). The antecedents of the current model rest upon the recent contributions on intertemporal General Equilibrium modeling by Diao, Roe and Yeldan (1998), Mercenier and Yeldan (1997), Mercenier and de Souza (1994), Go (1994), and Goulder and

[1]After we had completed this paper, the State Planning Organization and the World Bank announced their initial assessments. It appears that both studies were conducted under the assumption of what we call "no policy change" below.

Summers (1989). Data used to calibrate the model parameters and to conduct our simulation experiments are drawn from Köse and Yeldan (1996) and the most recent Input-Output Table of Turkey (SIS, 1994).

We aggregate production activities into six production sectors (agriculture, consumer manufacturing, producer manufacturing, intermediates, private services, and public services), employing labor and capital to produce the respective single outputs. With a fixed endowment[2], labor is mobile across sectors (but not mobile internationally).

The private household owns labor and financial wealth and allocates income to consumption and savings to maximize an intertemporal utility function over an infinite horizon (consumption smoothing a la Ramsey), given market prices and wage remunerations. Physical capital is the only cumulative factor and the economy is open in the sense that the agents have free access to world capital markets at a given interest rate. Technological change is assumed not to be influenced by the policies considered in the paper, and hence is ignored.

The representative firm in each sector carries out both production and investment decisions so as to maximize the value of the firm. In each sector, the firm chooses the level of capital and labor employment to maximize the present value of all future profits, taking into account the expected future prices for sectoral outputs, the wage rate, and the rental rates.

The government has four interrelated functions in the model: to collect taxes, distribute transfers payments, purchase goods and services, and to administer domestic public debt. The model distinguishes three types of tax structures. *Direct income taxes* are set at a given ratio of private income; *indirect taxes* are levied on the gross output value in each sector; and *trade taxes* are implemented *ad valorem* on imports. Basic government spending includes the transfer payments to households, public consumption expenditures (inclusive of wage costs of public employees) and interest costs on outstanding public debt. To avoid the difficulties that would result from modeling the government as an intertemporal optimizing agent (see Mercenier and de Souza, 1994), we assume that the transfer payments are proportional to aggregate government revenues, while the total public consumption of goods (excluding public services) is set as a constant share of the gross domestic product. Similarly, sectoral purchases are distributed given fixed expenditure shares.

Following the traditional CGE folklore, the model incorporates the Armingtonian composite good system for the determination of imports, and the constant elasticity of transformation (CET) specification for exports. In this structure, domestically produced and foreign goods are regarded as imperfect substitutes in aggregate demand, given an elasticity of substitution/transformation. The economy is small, hence the world prices are regarded as given constants. However, the composite prices do change endogenously as domestic prices adjust to attain equilibrium in the commodity markets. In each period-equilibrium, the difference between the household savings and aggregate investment gives the amount of new foreign bonds held by households. The time path of private foreign assets has two components:

[2]This specification has no real effects on the model since, alternatively, we could normalize all variables in per capita terms.

trade surplus (or deficit) and interest income received from the accumulated foreign assets (or interest payments to accumulated foreign liabilities).

An intra-temporal equilibrium requires that at each time period, (i) domestic demand plus foreign demand for the output of each sector equals its supply; (ii) producers' labor demand equals total labor supply; (iii) the gap in aggregate investment and domestic savings equals foreign deficit and is covered by foreign borrowing; and (iv) government spending equals government revenues plus new issues of public debt instruments.

The inter-temporal equilibria are further constrained by additional steady state conditions warranting that (i) the value of firms should become constant and hence the profits would simply equal to the interest earnings from the same amount of riskless assets; (ii) in each sector, investments just cover the depreciation of sectoral capital; hence the capital stock remains constant; and (iii) foreign asset holding is constant, implying that the economy has to have a surplus on its trade balance to pay off the interest payments on its foreign debt.

As for the implementation of our model for policy analysis, we make the following restrictive assumption: we assume that *only 10 percent* of the existing capital stock and *only 15 percent* of the employed labor force in the *core quake area* are damaged permanently. We are aware that there is an inevitable fall in overall productivity in the region, as well as in other parts of the economy. However, we do not make any further assumptions on the possible *rate* effects on the production technology, and limit our analysis to the discussion of the Rybczynski-like *level* effects. Therefore, our results should be viewed as a "conservative estimate" of the possible losses caused by the earthquake disaster.

Table 1: The Share of Core Earthquake Zone in Manufacturing Sector

Province	Output Share	Employment Share
Kocaeli	15.3	5.1
Sakarya	0.8	1.2
Yalova	0.8	0.6
Total	**16.9**	**6.9**

Source: The State Institute of Statistics

Table 1 lists the share of the core earthquake region in total manufacturing. The output share of the region in total manufacturing production is 16.9 percent. Given the absence of reliable estimates of capital stock for Turkey, we assume that the proportion of the capital stock in this region is directly reflected in its output share. Therefore, assuming a 10 percent loss in the capital stock of this region implies a 1.7 percent capital loss in the aggregate economy.

The employment share of the region in manufacturing industry is 6.9 percent. A conservative 15 percent loss in employment in this region as a result of the earthquake implies a 1.03 decline in employment in the national economy. Therefore, we further assumed a one percent fall in overall employment in our calculations.

3. The Results

We study four issues and conduct four simulations under different assumptions: (i) no policy change; (ii) reliance on indirect taxes to finance the extra government expenditures for public investments to replenish the losses in the capital stock; (iii) endogenous adjustments on the existing indirect tax rates to recover the loss in the capital stock; and (iv) invigoration of foreign aid to recover the capital loss.

3.1 No Policy Change

Figure 1 presents the adjustments of GDP, consumption, investment, external deficit, and private sector foreign borrowing under the assumption that there is no policy change in the economy following the earthquake.

We find that the effect of the earthquake is a 1.3 percent decline in GDP on impact. The aggregate value-added recovers slightly and converges to 1.2 percent less than its initial base path. In a present value sense, this corresponds to 26 percent of the long run equilibrium (steady state) value of the total GDP.[3] Similarly, total consumption goes down by 1.4 percent on impact and converges to a level 1.3 percent less than its initial path. On the other hand, aggregate investment first decreases by 0.8 percent and converges to 1.3 percent less than its initial base path.

The earthquake causes an immediate 4.2 percent increase in the external deficit. Since we impose a "no ponzi game" condition in the model, the calculations show that the economy must give an external surplus of 1.6 percent more than what it would have given before the earthquake.[4] The initial external deficit is partially financed by the private sector foreign borrowing (PSFB). We see that PSFB increases by 3.3 percent after the earthquake and converges to 1.2 percent *negative borrowing* at the new steady state.

3.2 Discretionary Adjustments on Indirect Tax Rates

Next, we model an active government which aims at a recovery of the losses in the aggregate capital stock. For this purpose it is assumed that the government imposes an additional

[3] Assuming 5 percent discount rate. This ratio amounts to 52 billion US dollars at 1998 prices.

[4] Here we assume that the economy already has a stock of foreign liabilities

indirect tax at the rate of 1 percent in all sectors to finance its additional investments. [5] Figure 2 plots the time path of the variables after the tax.

We find that the indirect tax magnifies the impact of the earthquake disaster on the economy. There is a 4.5 percent decline in GDP from its initial base run. This result clearly is an outcome of the distortionary nature of indirect taxation, causing a divergence of domestic relative prices from their efficiency counterparts. The worsening effect reveals itself the most under the long run equilibrium. We see that the GDP converges to 5.8 percent below its initial path. The indirect tax has also significant adverse effects on aggregate investment. Aggregate investment falls immediately by 18 percent. Under the new long run equilibrium, it is 12 percent less than its initial base path. On the other hand, the total consumption responds in a very sluggish manner to the tax. An initial 0.8 percent decline in consumption is followed by a permanent fall of 1.9 percent. We can conclude that the indirect tax has strong crowding out effects on total investment. The external deficit is reduced by 48 percent, causing a 47 percent decline in PSFB at impact.

3.3 Flexible Indirect Tax Adjustments to Recover the Capital Loss

In this part, we introduce a *flexible* indirect tax aiming to recover fully the initial capital loss caused by the earthquake. Technically, we set as an additional constraint that the capital stock loss has to be fully recovered, and introduce an endogenous adjustment rate on indirect taxes as a slack variable serving as the shadow price of this constraint. We rely on laboratory characteristics of the model to solve for the necessary adjustment. The results are given in Figure 3. The capital loss recovering adjustment of the indirect tax turns out to be negative 3.3 percent upon impact, and is gradually phased out. This implies that the government should give an instantaneous 3.3 percent tax break to all sectors. We find that total GDP in the economy does not change significantly (a 0.4 percent increase on impact and 0.08 percent increase permanently). However, total consumption falls by 2.7 percent initially. The long run equilibrium indicates a permanent decrease of 1.1 percent in consumption in comparison to the initial base path. We therefore conclude that a capital-loss-recovering subsidy is still associated with a welfare loss although the output is back to its initial base path.

Our results further indicate that aggregate domestic investment expenditures have to be increased by 17 percent after the earthquake, converging later to 1.6 percent above its initial path. The external deficit and PSFB are up by 84 and 65 percent, respectively, at the beginning. In other words, the economy finances the capital loss mainly by foreign borrowing.

[5] This scenario exactly matches the policy discussions within the Finance Ministry. It is reported that a one percent increase in the value added tax is being debated to countervail the expected burden on the budgetary outlays. Note that our scenario here goes one step further, and directs the proceeds of the tax only to fund capital investment by the public sector

3.4 Foreign Aid to Recover Capital Loss

Our final exercise asks the following question: How would the economy adjust if the capital recovering indirect tax (subsidy) is financed by foreign aid and how much foreign aid is required? The results are given in Figure 4. The only difference between our previous exercise (a subsidy to all sectors financed endogenously) and this case is in consumption. Although the total consumption falls 1.3 percent at the beginning, it reverses itself immediately and converges to 0.3 percent above its initial path. This case is the only one in which the welfare loss is fully compensated following the earthquake. The total foreign aid required to put the economy to its pre-earthquake path is calculated as 5.6 percent of total GDP upon impact (11 billion US dollars at 1998 prices), to be followed by reduced inflows amounting to 2.2 percent in the period two, and 1.1 percent in the period three, then gradually stabilizing at 0.4 percent.

4. Conclusion

In this paper we have attempted to an initial assessment of the massive August 17 earthquake in Turkey on the macroeconomic balances of the country. Utilizing an intertemporal GE apparatus, we tried to obtain estimates of the extent of the damage on the domestic macro balances and seek out viable policy lessons for recovery. Starting from very conservative assumptions on the loss of aggregate capital stock and employment, and ignoring likely negative rate effects on productivity, we find that the initial impact of the earthquake on the GDP may range from -4.5 percent, to +0.8 percent, conditional upon the policy stance of the government and the international community. One major finding of our analysis is that the currently debated increase in indirect tax rate to fund the increased public expenditure is likely to generate further contractionary effects on the already distorted economy, deepening the impact of the crisis. We also find that a policy of production subsidy to individual sectors financed by foreign aid to recover the capital loss yields the best outcome from the point of view of consumer welfare.

References

[1] Barro R.J. and X. Sala-i-Martin (1995), *Economic Growth*, New York: McGraw Hill.

[2] Blanchard, O.J. and S. Fischer (1989), *Lectures on Macroeconomics*, Cambridge: MIT Press.

[3] Diao, R. and E. Yeldan (1998), Fiscal Debt Management, Accumulation and Transition Dynamics in A CGE Model for Turkey *Canadian Journal of Development Studies*, 19(2), 343-376.

[4] Go, D.S. (1994), External Shocks, Adjustment Policies, and Investment in a Developing Economy: Illustrations from a Forward-looking CGE Model of the Philippines, *Journal of Development Economics* 44, 229-261.

[5] Goulder, L. and L. Summers (1989), Tax Policy, Asset Prices, and Growth: A General Equilibrium Analysis, *Journal of Public Economics* 38, 265-296.

[6] Köse, A. And E. Yeldan (1996) "Cok Sektorlu Genel Denge Modellerinin Veri Tabani Uzerine Notlar: Turkiye 1990 Sosyal Hesaplar Matrisi", *METU Studies in Development* 23(1): 59-83.

[7] Mercenier J. and M. da C.S. de Souza (1994), Structural Adjustment and Growth in a Highly Indebted Market Economy: Brazil. In J. Mercenier and T. Srinivasan (eds.) *Applied General Equilibrium Analysis and Economic Development*, Ann Arbor: University of Michigan Press.

[8] Mercenier J. and E. Yeldan (1997), On Turkey's Trade Policy: Is a Custom Union with Europe Enough?, *European Economic Review*, 41, 871-880.

[9] State Institute of Statistics (SIS) (1994), *The 1990 Input-Output Structure of Turkey*, Ankara: SIS Publications.

Figure 1: The Effect of the Earthquake (No Policy Change)

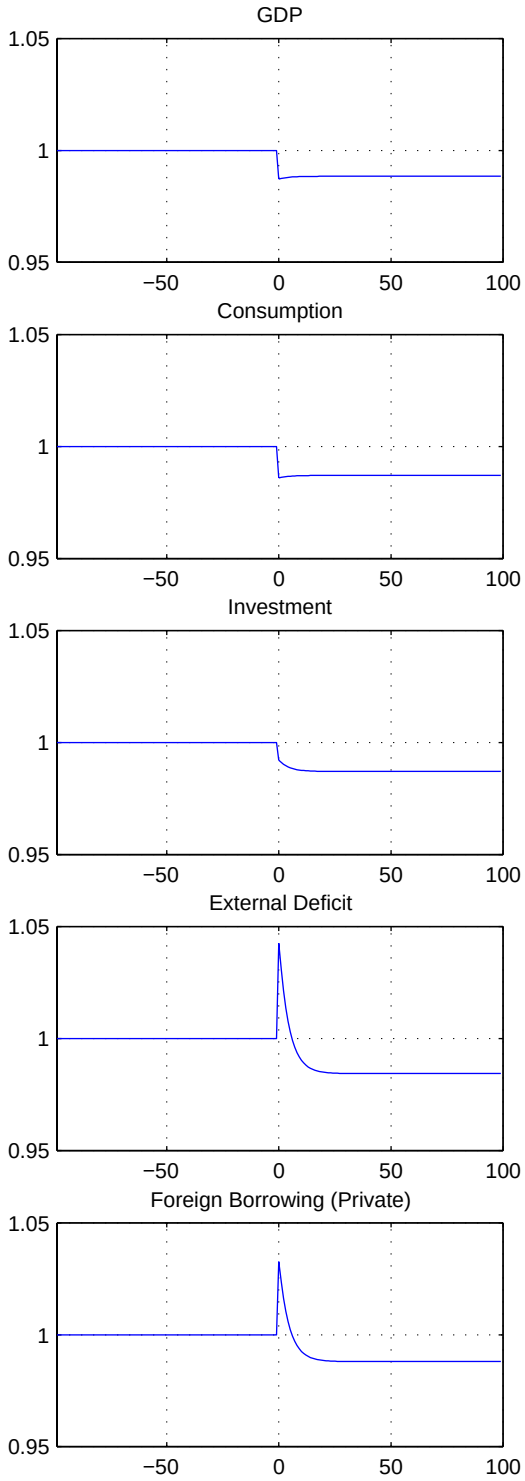

Figure 2: The Effect of Indirect Taxation

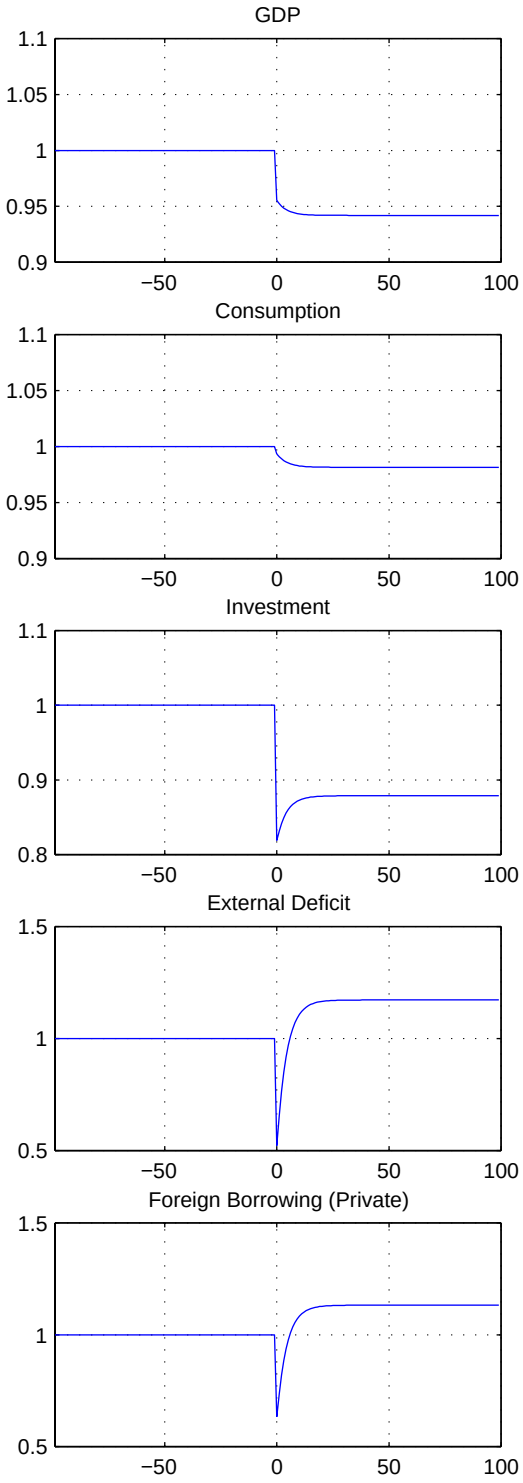

Figure 3: The Effect of Indirect Taxation to Recover Capital Loss

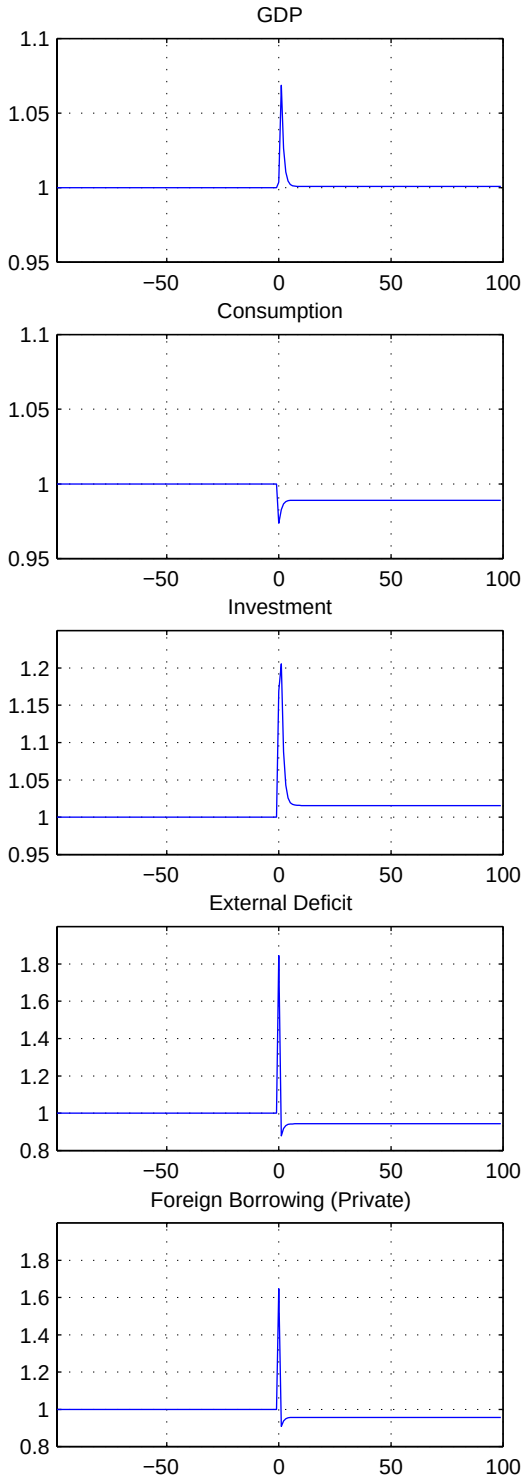

Figure 4: The Effect of Foreign Aid to Recover Capital Loss