

### Midterm Examination

October 30, 2007

**Instructions.** Answer all the questions in your bluebook. You have 90 minutes to complete the exam, which consists of 6 problems. The first problem is worth 32 points, the second 16 points, the third 8 points, the fourth 14 points, the fifth 10 points, and the sixth problem is worth 20 points, for a total of 100 points. This exam has 3 pages. Good luck!

**Overview:** Sir Nicholas Stern recently presented the British government with the “Stern Review of the Economics of Climate Change.” The executive summary of the report argues that:

The scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response ... Climate change threatens the basic elements of life for people around the world - access to water, food production, health, and use of land and the environment ... The benefits of strong, early action considerably outweigh the costs.

In this exam, we will consider the effects of global warming and the effects of some potential responses by governments and the private sector.

1. (32 points) It is commonly believed that climate change will increase the frequency of catastrophic events such as hurricanes. At the aggregate level, this can be modelled as an increase in the depreciation rate. To see the effects of higher depreciation, consider the Solow model. Total output ( $Y$ ) is given by

$$Y = zK^{0.35}N^{0.65},$$

where  $K$  is the aggregate capital stock,  $N$  denotes the work force (measured in millions), and  $z$  denotes total factor productivity. Assume that  $z = 10$ , and  $N$  equals 3,000. Investment is equal to 20 percent of output. Capital depreciates at a rate of 8 percent per year, while the work force grows at a rate of 2 percent a year.

- (a) Derive the per worker production function,  $y = zf(k)$ , where  $y$  and  $k$  are output and capital per worker, respectively.
- (b) In the Solow model, the steady-state capital stock,  $k^*$ , will satisfy

$$s \cdot y^* = (n + d)k^*,$$

where  $s$  denotes the saving rate,  $n$  denotes the growth rate of the labor force, and  $d$  denotes the depreciation rate. Find the steady state quantities  $k^*$ ,  $y^*$ ,  $i^*$  and  $c^*$ .

- (c) Suppose that the climate change permanently increases the depreciation rate from 8 to 10 percent. Find the revised values of  $k^*$ ,  $y^*$ ,  $i^*$  and  $c^*$ .
- (d) Use a graph to illustrate how  $k^*$ ,  $y^*$ ,  $i^*$  and  $c^*$  have moved from their values in part (b).

2. (16 points) The effects of climate change will probably vary by product. Suppose that “high tech” products such as computers are more sensitive to climate changes than “low tech” products such as haircuts. Consider how this might affect measured real output, by completing the following table:

	<u>2007</u>	<u>2057</u>
Quantity Cell Phones (billions)	6	5
Quantity Haircuts (billions)	15	30
Price Cell Phones (\$/phone)	50	250
Price Haircuts (\$/haircut)	25	75
Nominal GDP (\$billions)		
Real GDP Using Year-2007 Prices (billions of year-2007 \$)		
Gross Growth Rate	NA	
Real GDP Using Year-2057 Prices (billions of year-2057 \$)		
Gross Growth Rate	NA	
2-year Geometric Averages	NA	
Chain-Weighted Real GDP (billions of year-2007 \$)		

3. (8 points) The impact of climate change is likely to be most pronounced in developing countries, many of which are well-described by the Malthusian Model. Using the Malthusian Model, describe how climate change is like to affect total population and per capita consumption. Be succinct.
4. (14 points) Climate change will arguably increase the cost of producing goods and services. As such, it can be treated as a negative shock to total factor productivity. Using the Social Planner’s framework, consider the effect of a TFP decrease in the one-period macroeconomic model, where consumers choose labor supply and firms choose labor inputs. Use a graph to illustrate your findings and briefly explain your results.
5. (10 points) Consider how climate change would appear in the National Accounts.
- Ignoring any responses, how would the **effects** of climate change—higher temperatures, higher sea levels, different weather patterns—be captured in the National Accounts? Would all the effects be accounted for? Briefly explain.
  - Any response to climate change will almost surely involve the installation of new technologies, both by the private sector and by governments. In which expenditure categories would the resources spent on these technologies appear? Be succinct.

6. (20 points) Suppose that governments respond to climate change by imposing an output tax on firms, and then refunding the proceeds to consumers as lump-sum transfers. (Assume that individual consumers take the transfer as given, and that government spending is unchanged.) Analyze this tax/transfer scheme with the one-period macroeconomic model, where consumers choose labor supply and firms choose labor inputs.
- (a) Using the labor demand-labor supply framework, determine how this tax/transfer scheme will affect aggregate output, consumption, employment and the real wage. Use a graph to illustrate your findings and briefly explain your results.
  - (b) Suppose that in the absence of this tax/transfer scheme, the economy has no distorting taxes, and markets are fully competitive. Would the tax/transfer scheme move the economy closer to a Pareto Optimum (an efficient allocation of resources)? (**Hint:** Consider the welfare theorems, and all the conditions required for them to hold.)