

UNIVERSITY OF TORONTO AT MISSISSAUGA  
DEPARTMENT OF ECONOMICS

ECONOMICS 336Y5Y – FALL/WINTER 2011

PUBLIC ECONOMICS –Fall Term Test Solutions

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Please fill in your full name and student number in the spaces below.

NAME: \_\_\_Robert McMillan\_\_\_\_\_

**Question 1: Government Smoking Policy** (worth 7 points)

a) Suppose the government of Ontario was considering banning smoking *in all public places* with a view to reducing exposure to second-hand smoke. If you were to give policy advice to the government, which aspect of the costs of this policy do you anticipate would be especially large (and so worthy of quantification)? Please explain, justifying your answer. [Two sentences.] (3 points)

The costs of policing such a ban would be likely to be especially high, given that so many people like smoking. To enforce the ban effectively would require considerable sums to be spent on policing virtually unlimited public spaces.

b) A more extreme policy option would entail banning smoking entirely; under such a policy, the production, distribution and consumption of cigarettes would be made illegal. Consider a government deciding between this sort of *total* smoking ban and an alternative policy that simply raised the duty on cigarettes (thereby raising cigarette prices). In what main respect do you think the policy that increased cigarette duty would be preferable, if the government's objective was to eliminate the adverse health effects of smoking at reasonable cost? [Two sentences.] (4 points)

Raising the duty on cigarettes would be preferable in the sense that it would not prevent people from doing something they clearly like to do. Thus, it would involve much lower enforcement costs.

**Question 2: Climate Science** (worth 6 points)

- a) Factual question: currently, what is the concentration of carbon dioxide in the atmosphere (expressed in parts per million ('ppm'))? (1 point)

Carbon dioxide currently has a concentration of 389 parts per million (ppm) in the earth's atmosphere.

- b) Why is this fact thought to be a problem by climate scientists studying climate change? [Hint: 350 ppm.] [Two sentences.] (3 points)

A concentration of 350ppm carbon dioxide is thought to be the upper limit of the safe range in the atmosphere. Beyond that level, there is a concern that the planet's major climate systems will start to change in an unstoppable, irreversible way.

- c) Through what mechanism are gases like carbon dioxide thought to contribute to global warming? [Hint: 'greenhouse' gases...] [One sentence.] (2 points)

So-called greenhouse gases such as carbon dioxide and methane serve to trap the sun's radiation in the atmosphere, causing the atmosphere to warm up.

**Question 3: the Carbon Tax** (worth 6 points)

In the absence of any policy intervention, the concentration of atmospheric carbon dioxide is expected to continue to rise in the coming decades, given the projected growth of the world's population and the current reliance on carbon-based fuels to generate energy. One policy that has been advocated to combat carbon emissions is a so-called carbon tax. This would be levied on fuels as they entered the economy – either through domestic production or import – according to their carbon content.

- a) Is the carbon tax an *indirect* tax? Please explain your answer. [Two sentences.] (2 points)

The carbon tax is an indirect tax. It is not levied on the individuals who ultimately bear the tax.

- b) A carbon tax is likely to lead to higher prices, at least for some goods. Why, in general, might that actually be desirable from an economic perspective? [Three sentences.] (4 points)

In the absence of a carbon tax, some goods are cheaper than they should be. That is, usage of such goods generates external costs that are not being adequately taken into account, and so reductions in usage are desirable from an economic perspective. A carbon tax would re-align incentives, making firms and consumers account for the full costs of carbon-intensive products, and helping to spur innovation.

**Question 4: the Economics of Global Warming** (worth 18 points)

a) Stern's highly influential 'Review' carries out a cost-benefit analysis of the policy responses to climate change, conducted using a certain discount rate. What is the chosen rate, exactly? [Hint: an exact number.] (2 points)

The chosen rate is 1.4 percent.

Consider the following stylized cost-benefit problem. Let the costs (C) of climate change occur today, at a cost of \$C trillion. The benefits (B) of taking the costly action (for instance, from introducing a carbon tax) occur in the future, after a total of N periods, but are twice as high as the costs, so can be written as \$2C trillion.

b) What is the threshold internal rate of return  $r^c$  that would equate the costs and the discounted benefits in this case? Please solve for this rate of return algebraically, and show your calculations. [Hint: obtain an expression for  $r^c$ .] (5 points)

The threshold  $r^c$  solves

$$-C + 2C/(1 + r^c)^N = 0, \text{ implying}$$

$$r^c = 2^{1/N} - 1. \quad (1)$$

c) If  $N=2$ , what is the threshold internal rate of return  $r^c$ , which we can write as a function of N,  $r^c(N)$ ? And what happens to the threshold  $r^c(N)$  as N gets even bigger (when  $N=4$ )? Please give precise answers in each case. (2 points)

$$\text{If } N = 2, \text{ then } r^c(N=2) = 2^{1/2} - 1 \approx 0.414.$$

$$\text{If } N = 4, \text{ then } r^c(N=4) = 2^{1/4} - 1 \approx 0.189.$$

One can show using calculus (by differentiating  $r^c(N)$  with respect to N in equation (1) above) that this pattern persists, with  $r^c$  falling as N rises.

d) Suggested by your answer to part c), what can you say about the relationship between the threshold internal rate of return and the time horizon, N? [One sentence.] (2 points).

As mentioned, there is an inverse relationship between the threshold and the horizon, with  $r^c$  falling as N rises.

e) For a given time horizon N, if the government used an internal rate of return *above* the threshold value when carrying out cost-benefit analysis, would it choose to take action now? Please explain your reasoning. (3 points)

For an internal rate of return (or discount rate) above the threshold, the current cost would exceed the discounted future benefits, so it would not pay to implement the carbon-reducing policy.

f) The likely costs and benefits, both now and in the future, of measures designed to reduce carbon emissions are very difficult to quantify. This makes standard cost-benefit analysis especially challenging, as Martin Weitzman has argued. In the face of such uncertainty, please give an economic argument for taking action now, from the perspective of humanity as a whole (rather than just Canada). [Two sentences.] (4 points)

In the face of uncertainty, it is still possible that catastrophic climate change occurs. Taking action now (for instance, through the introduction of a carbon tax) is thus akin to purchasing insurance against such catastrophic events.

**Question 5: Taxes** (worth 6 points)

a) In 2006, which form of taxation provided the Canadian government with its largest revenue source? (1 point)

The personal income tax provided the largest revenue source.

b) Explain the relevance of the notion of a ‘race to the bottom’ in explaining the fact that a higher proportion of taxes are raised at the federal level than more locally (relative to expenditures)? [Three sentences.] (5 points)

If tax revenues were generated locally, such revenues would be likely to be low, due to local tax competition. In the presence of mobile capital, local governments have incentives to compete for firms in order to attract business, and so have an incentive to undercut the tax rates of their rivals. This leads to a so-called ‘race-to-the-bottom,’ leading to inefficiently low local taxes. By placing the burden of revenue raising at the federal level, this problem can be avoided to a large extent. [Note: some firms are still mobile internationally.]

**Question 6** (worth 12 points)

a) Please circle the appropriate letter (A – D).

Government spending in Canada (in 2006) accounts for what percentage of GDP, to the nearest two percent? (1 point)

A 25 percent

B 38 percent

C 41 percent

D 54 percent

B

b) Gross domestic product (GDP) is defined as the total value of goods and services produced in a country in one year. If policy makers target GDP growth as a policy objective, why might this create undesirable incentives, in turn leading to outcomes that reduce aggregate welfare? [Hint: does GDP have any deficiencies?] [Three sentences.] (4 points)

GDP is an imperfect measure of aggregate welfare, given that it does not account for externalities, and so measures to promote GDP growth will not necessarily be welfare-enhancing for an economy. For example, growth policies may lead firms to take decisions that raise profitability, narrowly defined, while producing spillovers that are more than offsetting. Without including externality measures, it is difficult to know what the full effects of policy will be.

c) In a striking recent paper, Muller, Mendelsohn and Nordhaus ('MMN' (2011)) propose supplementing GDP (in the national accounts) to provide a more economically informative measure of the contribution that each major industry makes to the national product. What is the additional information they include, and why is that useful? [Two sentences.] (4 points)

MMN provide measures of the costs of air pollution externalities (in terms of the adverse health effects) associated with each industry in a disaggregated way. By deducting off the adverse health costs from the profitability of each industry, the authors provide a means of gauging each industry's net contributions to the economy more accurately.

d) Do MMN consider carbon emissions in their analysis (Yes/No)? And why is that significant? [Two sentences.] (3 points)

MMN do not consider carbon emissions in their analysis. This is significant in that their air pollution externality numbers are likely to understate the full costs of air pollution, given that a potentially very large and important component is being omitted.

### **Question 7: Government Debt and Debt Management (worth 20 points)**

a) The outstanding amount of Canadian government debt is currently which of the following? (2 points)

A \$583 million

B \$236 billion

C \$564 billion

D \$1.38 trillion.

C

b) Suppose a bank offers a nominal interest rate of one percent per year. The current inflation rate is three percent. Assume that investors expect this inflation rate to persist over the coming year. Is the current expected real rate of interest equal to -2 percent? Please explain, making reference to any relevant formulae? (3 points)

No, the expected real rate of interest  $r^E$  satisfies

$$1 + r^E = (1 + 0.01) / (1 + 0.03) = 1.01/1.03, \text{ implying}$$

$r^E = -1.94$  percent, which is less than 2 percent.

c) For this part, please ignore the information given in part b). Suppose you have the option of investing \$1 for one year either in a nominal bond paying nominal interest of 5.5 percent, versus an indexed bond paying 3 percent in real terms. Which should you invest in and why? (4 points)

One actually cannot say, without more information. It would depend on one's inflation expectations, and these are not specified. (To be clear, once one had an estimate of expected inflation,  $\pi^E$ , one could multiply the known real return on the indexed bond (1.03) by  $(1 + \pi^E)$  to get the expected nominal return. And if this exceeded (1.055), and the investor did not care about inflation uncertainty, then it would pay to invest in the indexed bond.)

d) If the government claims to be serious about cutting inflation, why might issuing index debt help the government establish credibility in pursuit of its stated policy objective? [Three sentences.] (4 points)

By issuing indexed debt, the government is unable to take advantage of investors by unexpectedly raising inflation. Thus issuing indexed debt removes a temptation that would otherwise undercut the anti-inflationary policy. (Recall: issuing nominal debt gives rise to that temptation.)

Suppose that the government objective can be represented by the following payoff function:

$$R = G + a S,$$

where  $R$  measures overall government utility,  $G$  is the private payoff to the government,  $S$  represents the welfare of the general public, and  $a$  is a parameter measuring how much weight the government attaches to the general public's interests, ranging between .

Consider two alternative options:

i. Option 1 involves the government issuing nominal debt, then subsequently inflating the economy a lot. The government has a great deal of outstanding debt, so this option yields

especially high private payoffs to the government – specifically,  $G_1 = 10$  – and a payoff to society of  $S_1 = -5$ ;

ii. Option 2 involves the government issuing indexed debt, then subsequently keeping inflation low. This yields a private payoff to the government of  $G_2 = 2$  and a payoff to society of  $S_2 = 2$ .

e) If the government placed zero weight on the public interest (so  $a = 0$ ), which option would it choose, and why? Please show your reasoning. (2 points)

In this instance, given that  $R_1 = 10 > R_2 = 2$ , so the government would choose to issue nominal debt.

f) Realistically, the government cannot ignore the welfare of society (captured by society's payoff) entirely. But suppose it has sufficient power that it is not forced to place a very high weight on society's welfare, due to imperfections in the democratic process. Specifically, let the parameter  $a$  take on values between zero and 1 (but not higher than 1).

Within that range, please identify values of the parameter  $a$  for which the government would choose to issue indexed debt. Show any relevant calculations. (5 points)

The answer here is clear if one plots the relevant payoff curves as a function of  $a$  on the half-open interval  $(0, 1]$ . For all such  $a$  values,  $R_1 = G_1 + a S_1 = 10 - 5a > R_2 = G_2 + a S_2 = 2 + 2a$ . Thus there are no values of the parameter for which the government would choose to issue indexed debt.

### Question 8 (worth 9 points)

a) Take an allocation of goods to consumers in an economy. What would it mean to say that the allocation was *Pareto efficient*? [One sentence.] (2 points)

An allocation is Pareto efficient if no-one could be made better off without making someone worse off through a reallocation of the goods.

b) Consumer preferences over goods A and B can be represented by a utility function,  $U(x_A, x_B)$ , where  $x_A$  and  $x_B$  are the quantities of the two goods respectively. Please write down a precise expression for the slope of an indifference curve of a consumer. (3 points)

The slope of an indifference curve is given by the marginal rate of substitution ( $MRS_{AB}$ ):

$$dx_B / dx_A = - (\partial U / \partial x_A) / (\partial U / \partial x_B) \equiv MRS_{AB}.$$

c) In the context of a firm that seeks to maximize profits by choosing profit-maximizing output  $y^*$ , consider the claim that the first derivative of the profit function with respect to output need

not be zero at the optimum. Comment and explain your answer. [Hint: as a starting point, is the claim true or false?] (4 points)

The claim is false. To see this, consider a *supposedly* profit-maximizing output level  $y^*$  for which the zero-slope condition does not hold. That would mean that by changing output slightly, profits would rise as we moved in the direction of the increasing slope. Thus the original output could not be profit-maximizing, as we have a means of increasing it further (i.e. moving in the direction of the positive slope).

**Question 9: David Schindler and Environmental Regulation** (worth 8 points)

a) Consider the problem of a government regulating mining firms. In general, the task of regulating firms is costly, and the government may choose to set lax (i.e. weak) regulations, even although this will affect the incentives of a firm to pollute. (For example, many mining operations lead to environmental problems that persist long after the mining operation itself is complete.)

Suppose, as is natural, that a mining firm wishes to extract resources so as to maximize profits. In doing so, the firm faces a choice between two technologies, which we will label as ‘dirty’ and ‘clean’ respectively. If the government allows it to choose the cheaper ‘dirty’ technology, then its profits will be higher, but the adoption of such ‘dirty’ technology will have worse environmental consequences.

Is it possible that the adoption of the dirty technology could make society as a whole worse off, even though the mining firm still makes profits? Please explain. [Hint: the MMN (2011) paper is relevant here.] [Two sentences.] (4 points)

As MMN make clear, some industries make contributions to air pollution costs that, remarkably, are in excess of their profits (as measured using conventional accounting practices that fail to take account of externalities). In the case of mining, the production of toxic metals as a side-product of mining activity presents very real health risks, especially if not contained in a careful way, and these may (in extreme cases) more than offset the conventional profits made by a mining firm.

b) If we wish to assess the net social benefit of industrial activity, it helps if we can monitor the level of pollution associated with industrial firms. The University of Alberta environmental scientist David Schindler has been a strong advocate of such monitoring efforts, especially in the context of the Alberta tar sands and water and air pollution in that region.

Suppose there is just one water-pollution monitoring station, placed downstream of a factory. What is the difficulty associated with this in a setting where there is a certain level of naturally occurring ‘background’ pollution, if the goal is to measure the factory’s contribution to pollution? How could this difficulty be overcome? [Two sentences.] (4 points)

With just one monitoring station located downstream, it is not possible to break the total measured pollution out into a component due to ‘background’ pollution and a component due to the factory. However, by placing an additional pollution monitor upstream of the factory, it becomes possible to estimate the factory’s contribution as the *difference* between the total pollution measured downstream and the upstream measure.

**Total:** 92 points