Week Eight

EPA143A

THE ECONOMICS OF GLOBAL WARMING

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ANSWERS

EXERCISE **W-8.1**

1. A higher average propensity to save increases savings. These savings are automatically used for investment (via the loanable funds market). Hence, investment increases and economic growth increases. Therefore: $\frac{\partial g_Y}{\partial \sigma} > 0$.

2. The Cobb-Douglas production function exhibits constant returns to scale if $\alpha + \beta = 1$. The production function exhibits increasing returns to scale if $\alpha + \beta > 1$. In this case, if both labour input *L* and capital input *K* increase by 10%, output will increase by > 10%.

3. The DICE damage functions (eq. (12)) is slowly and continuously rising with the increase in the global mean temperature. Even at dangerous increases in mean temperature (of say >3.5°C) the damage (as a proportion of real global GDP) remains low. Alternative damage function eq. (15) has a "tipping point": it increases steeply once the temperature increases > 4°C; but even earlier, the damage (as a proportion of GDP) is higher than when using eq. (12). Future global warming damage is highly uncertain and we have no/little basis to predict what will happen. But if we accept basic climate and earth systems science, the damage function should reflect higher and escalating damages already with temperature increases of > 2°C. Nordhaus' eq. (12) is a mathematical fiction.

4. If we use a lower social discount rate than Nordhaus' 4%, the social cost of carbon (SCC) will increase in every year (2020-2120). The reason is that by using a lower social discount rate, the present value of future climate damage becomes larger (numerically). This can be seen by looking at the discount factor in year *t*: $1/(1+\delta)^t$. $\delta =$ social discount rate and *t* = time period. The lower is δ, the larger is the discount factor and the larger is the present value and hence the SCC (which is the present value of climate damage per tonne of GHG).

5. The prescriptive approach to the choice of social discount rate argues that δ should be based on ethical principles such as *inter-generational equity* (we do not discriminate against future generations) and/or the *precautionary principle* (we want to avoid low-probability-but-catastrophic-events and, in general, insure against dangerous outcomes). The prescriptive approach is taken by ecological economists and climate-change activists. The chosen social discount rate is low (<1%) which means present values of future damages tend to relatively high; relatively greater weight is given to the interests of future generations and to sustainability. The SCC indicates that there is strong basis for effective climate policy.

   The <u>descriptive approach</u> argues that δ should be inferred from attempts to (*a*) elicit social preferences using stated preference methods; or (*b*) to elicit social preferences from decisions in financial markets regarding long-term (bond) interest rates. Nordhaus bases his choice of $\delta = 0.04$ (4%) on the empirical finding that historical <u>long-term returns</u> to stock market investment, real estate investment and land investment are about 4%. Since we have the opportunity to invest our money in the stock market, in real estate or in land and earn 4% on average, so Nordhaus' argument goes, we should discount future values using 4% as the social discount rate. We have seen that with this social discount rate, future damages become trivial in present-value terms. The SCC suggests that there is basis for strong climate action.

6. The internalisation of the global warming damage in the costs and prices of the economic system can be done by imposing a global carbon tax on producers and consumers. Depending upon their carbon emissions, producers and consumers have to pay the carbon tax (which is equal to SCC); this way, the (discounted) value of global warming damage is given a euro or dollar price and it is included – as a cost – the decision-making processes of producers and consumers. If the SCC is high, the carbon tax will be high, and producers and consumers will react by reducing their emissions.

7. In the neoclassical growth model, the imposition of a global carbon tax (set at the level of the SCC) would lead to a decline in economic welfare (which is defined in terms of real consumption per person), because the (new) tax reduces both consumption now (which is already welfare-reducing) and savings; lower savings mean lower investment and lower growth, which means lower future consumption. It is true that (future) individuals will suffer less global warming damage, but overall, the world economy will grow less – and average income and consumption in 2120 will be lower than without a global carbon tax.

8. The trade-off between consuming today versus consuming tomorrow is a fallacy, because commercial banks are money-creating institutions, and hence there is no need for the prior mobilisation savings. We can now invest in climate-change mitigation and

deep decarbonisation, because this can be pre-financed by credit (new money). There is no inter-temporal trade-off to navigate and no solid economic reason to postpone or slow down effective climate action.

9. Explain how the carbon Kuznets curve can indicate decoupling between economic growth and carbon emissions? Is this relative decoupling or absolute decoupling?

The CKC is based on the following quadratic relationship between CO_2 emissions per person *cop* and per-capita real GDP y: $\ln(cop) = \beta_0 + \beta_1 \ln y + \beta_2 (\ln(y))^2$

The shape of the CKC is an inverse-U. At low levels of per-capita income, per capita carbon emissions are low; this is the situation in low-income countries, where average consumption levels are low and the manufacturing sector is small. At higher per person income levels, emissions per capita are higher; this is the case in the newly-industrialising countries where living standards are rising and becoming more carbon-intensive, and where industrialisation is happening (e.g. China); at the highest per-capita income levels (in the OECD countries), emissions per person are lower.

Before the turning point, carbon emissions per person increase as income per person grows. There is ***relative decoupling*** if the growth rate of carbon emissions per person is lower than the growth rate of per capita real income. In this case, the economy grows and GHG emissions grow, but GHG emissions grow less than per-person income.
There is ***absolute decoupling*** after the turning point of the CKC: now per capita carbon emissions decline, while per capita real income continues to grow. This can be defined as delinking.
We must note however that the CKC does not tell us anything about the scale of the economy – the variable of interest is real income per capita $\left(\frac{Y}{P}\right)$ but the scale of the economy is real GDP = $P \times \left(\frac{Y}{P}\right)$ or population x per-capita income. Even if emissions per person decline, if population increases more, total emissions will still grow – as the economy is growing. After all: $C = P \times \left(\frac{C}{P}\right)$, total GHG emissions in a year = population x per-person emissions.

EXERCISE **W-8.2**: a few numerical exercises.

1. Consider the cash flows (in constant 2020 prices) of a public infrastructure project:

Year	2020	2021	2022	2023	2024	2025	2026
Million €	-12	-2	3	3	3	3	4

The NPV of this project using a social discount rate of 4% is – € 0.29 million; using a social discount rate of 1.5% gives an NPV of € 1.08 million. The internal rate of return (= the discount rate at which NPV = 0) is 3.44%.
The negative NPV (at 4%) means that the project is making an average annual rate of return of less than 4%; it does not mean that the project is generating a loss.
The NPV > 0 when using 1.5%, but NPV < 0 when using 4%. The *irr* is the social discount rate at which NPV = 0. It will be a discount rate within the range of 1.5% - 4%.

2. The discount factor (with base-year 2020, at three digits)
   - for the year 2060 using a social discount rate = 3% is $\frac{1}{(1+0.03)^{40}} = 0.307$
   - for the year 2060 using a social discount rate = 5% is $\frac{1}{(1+0.05)^{40}} = 0.142$
   - for the year 2120 using a social discount rate = 1% is $\frac{1}{(1+0.01)^{100}} = 0.370$
   - for the year 2120 using a social discount rate = 3% is $\frac{1}{(1+0.03)^{100}} = 0.052$

Based on these calculations, we can see that the discount factor declines exponentially, if we use a higher social discount rate to discount the same future value in year *t* (say 2060 or 2120). Using 5% instead of 3% to discount a future value of 2060 reduces the discount factor more than half; using 3% instead of 1% to discount a future damage occurring in 2120 reduces the discount factor by 86%. Choosing a higher social discount rate means that we (= the present generation) attach less value to what happens to future generations.

We can see furthermore that the future value of damages in 2120 get discounted by a discount factor of 0.05, compared to a discount factor of 0.31 for damages in 2060, using the same social discount rate of 3%. The more far-off in future the damages occur, the lower will be the present value of that future damage; this means, the less we (= the present generation) care about it.

3. Assume that the future value of climate damage in the 2073 is US$ 3.7 trillion (in constant 2020 prices). GHG emissions in 2073 are projected to be $GtCO_{2eq}$ 24. Calculate the SCC using a social discount rate of 1.5% and of 4%.

   Using a social discount rate of 4% gives the following discount factor: $\frac{1}{(1+0.04)^{53}} = 0.125$. The present value of the future value of US$ 3.7 trillion in 2073 (in constant 2020 prices) is US$ 0.46 trillion. The SCC becomes: US$ 0.46 trillion/ $GtCO_{2eq}$ 24 = US$ 19.29 per tCO_{2eq}.
   Using a social discount rate of 1.5% gives the following discount factor: $\frac{1}{(1+0.015)^{53}} =$ 0.454. The present value of the future value of US$ 3.7 trillion in 2073 (in constant 2020 prices) is US$ 1.68 trillion. The SCC becomes: US$ 1.68 trillion/ $GtCO_{2eq}$ 24 = US$ 70.04 per tCO_{2eq}.

   If we assume that the carbon intensity of electricity is 0.0002 tCO_{2eq}/kWh by how much should electricity prices increase in 2073 in order to reflect the 'true' SCC – in these two cases?

   If the SCC is US$ 19.29 per tCO_{2eq}, the electricity price will increase by 0.4 dollar-cents in 2073.
   If the SCC is US$ 70.04 per tCO_{2eq}, the electricity price will increase by 1.4 dollar-cents in 2073.