Spring 2003

Solution Set to PS #2

When problem sets are corrected, if a mark S is made that means that you should refer to these "**S**olutions" for more explanation. Total points: 100

Problem 1 (50 points)

Part I (16 pts) Uncertainty about Demand

Q is ecological services or area of the park. MC is the marginal cost of running the park or of displacing farmers. MB is the benefit of watershed protection to farmers, such as drought mitigation. We can think of taxes in this case more as consumer taxes on the farmers because they are the ones who benefit from the park. The positive externalities of the park to farmers can thus be captured and a tax in this case can be used to cover the costs of running the park. As in real life, alternative interpretations are possible such as producer subsidies to the provider of the park so that we can increase the quantity of the park (a public good.) Alternative interpretations of the problem are valid and will be given full credit.

(a) **Standard** -- 3 pts for graph, 3 pts for calculation of DWL. Total **6**

To calculate the DWL of the standard, we need to find first where the economy will be if it is regulated by a standard. First, if policy makers believe that MB is at MB^L, then they will set the standard where MB^L intersects MSC. This is point B in graph 1. Similarly, if policy makers use MB^H, they will set the standard at the quantity corresponding to point C. The deadweight loss of being at point B, as opposed to the social optimum p. E, is triangle ABE (Note! Take the true MB curve to calculate DWL). Similarly the DWL of being at C is triangle CDE. We can calculate the area of these two triangles by taking the base of each times the height.

To find the quantity at this intersection point, we equate the expressions for those two functions:

MB^L = MSC

$10 + Q^L = 80 – 5\,Q^L$ from this Q^L= 10

Similarly Q^H= 16.6

To find the actual MB for Q^L and Q^H acres of park, we need to find the corresponding price from MB^T.

Point A on the graph corresponds to $MB^T(Q^L)$ = 50 and point D – 16.66

E is at the intersection of MB^T and MSC Q (at point E) = 13.3

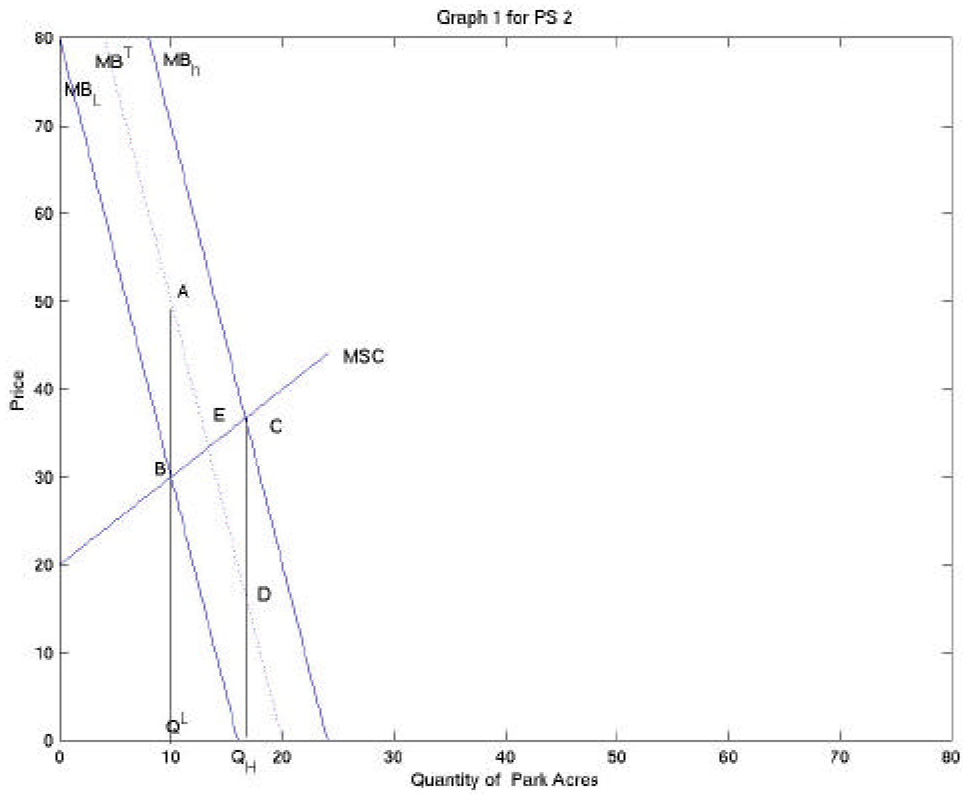
Therefore AB = 50 – 30 = 20

The height is the vertical distance from p. E to AB = 13.3 – 10 =3.33

DWL^L = 33. 3

Similarly DWL ^{H} = 33.3

EV (DWL) = .5 DWL^H+ .5DWL^L = 33.33



(b) **Tax** - 3 pts for graph, 3 pts for calculation of DWL Total **6**

For tax regulation, it is important to remember that the policy makers set the price in the market and the actual quantity of acres demanded will be determined from the true MB curve. Therefore after we find the regulated price, we need to find the corresponding quantity in order to estimate the DWL. Refer to graph 2.

P^L= 30

P^H= 36.66

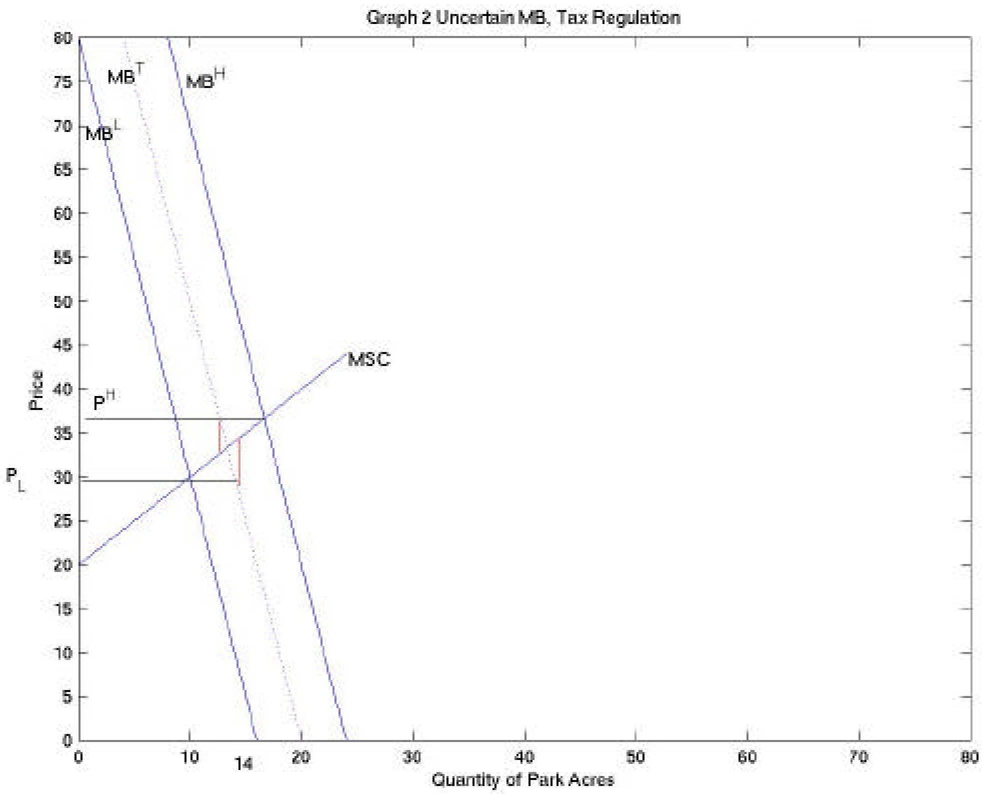
$Q^L = MB^T (P^L) = 14$ and $Q^H = 12.66$

The deadweight loss is the area between the MB^T, MSC and the red lines, indicating the quantity of the park under the different price regimes.

The area of each one of these small triangles is :

base == 4 height == . 66

DWL ^{L} = DWL ^{H} = 1.33 and the EV (DWL) = 1.33



(c) **Comparison b/ standard and tax** 4 pts
Tax is preferred because demand is inelastic and a mistake in price leads to very little quantity distortion. The DWL under tax is much smaller as well.

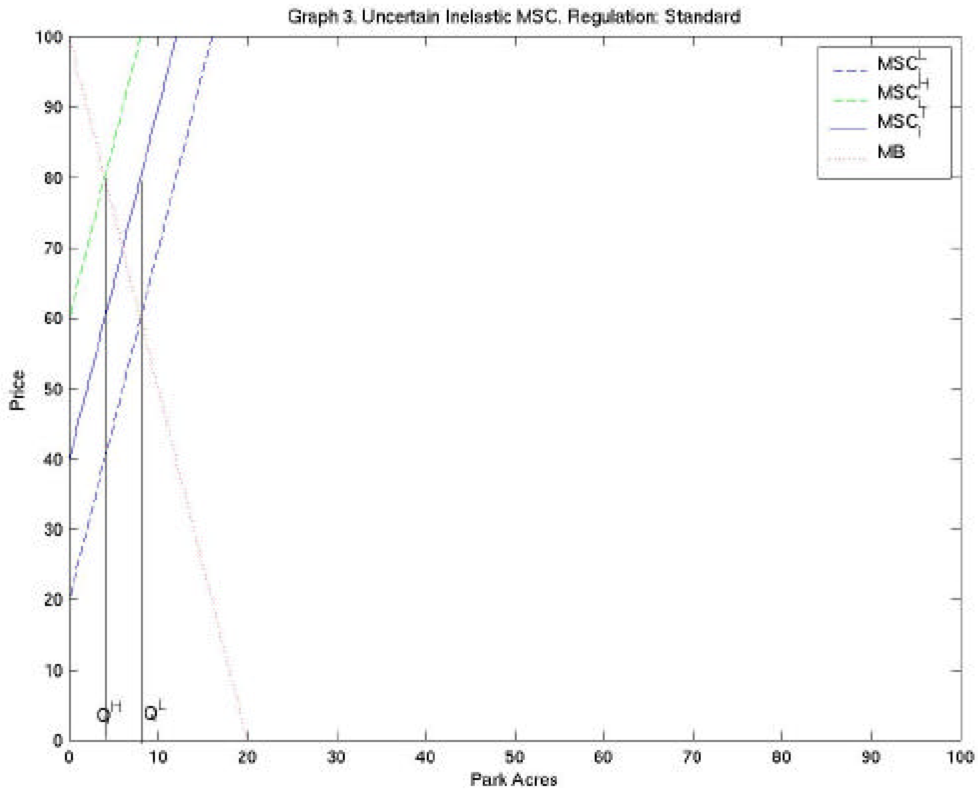
Part II. Uncertain MSC (34 pts)

(a) MSC Inelastic

Graph 3pts, DWL 3 pts; Tax – Graph 3 pts, DWL 3 pts Examples –2pts, total **14**

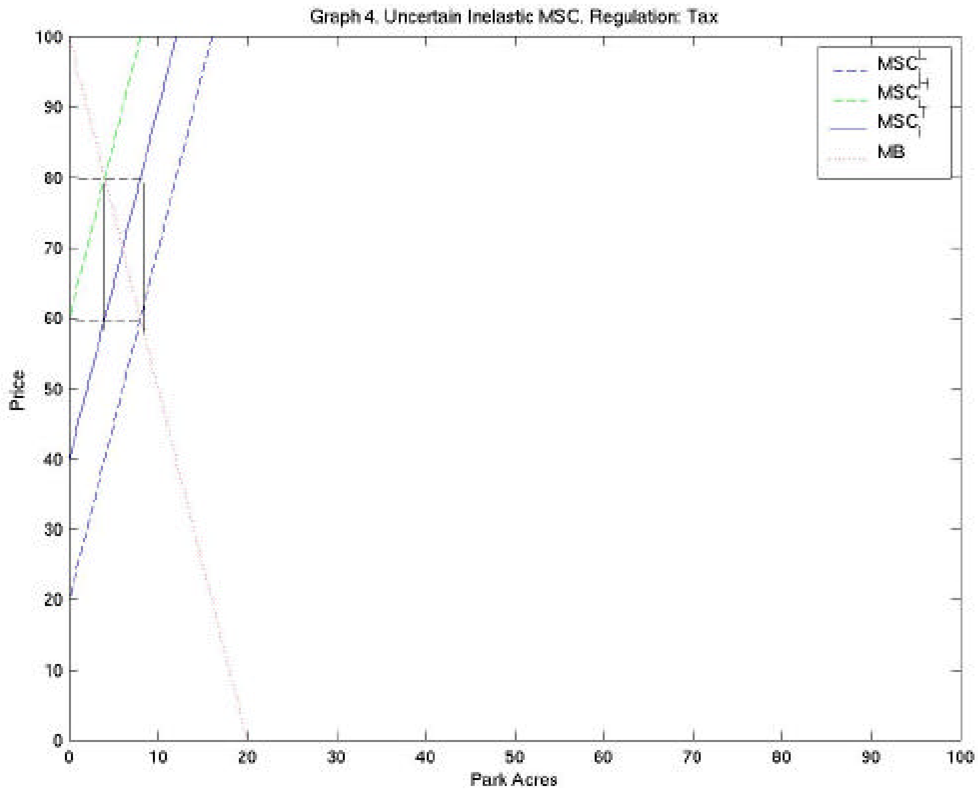
Standard:
Similarly to part I, we find
$Q^L = 8$
and
$Q^H=4$.
The DWL are the two triangles between MSC_i^T , MB and Q^L or Q^H. Refer to graph 3.
The area of one of these triangles is: [(80-50)*2]/2 = 20

EV (DWL) = 20



Tax:
The price regulation is where MSC_i^L intersects MB, which is $P^L = 60$, and where MSC_i^H=MB, which is P^H=80.
This is one of the rare instances, where the price regulation results in the same outcome as the quantity regulation. Under the above prices, the actual quantities will be Q^L=8 and Q^H=4.
The DWL is identical to the standard.
Refer to graph 4.

Examples of MSC inelastic:
-administrative costs of running the park increase dramatically with slight increase in the park area because of corruption of Indonesian government officials;
-The park expands into agricultural areas, pushing farmers off their land, which brings along tremendous social costs with slight increase in the park area.



(b) MSC Elastic

Standard - Graph 3pts, DWL 3 pts; Tax – Graph 3 pts, DWL 3 pts, Example 2 total **14** pts

Examples of MSC Elastic: Just opposite of the inelastic case

- administrative costs – adding a few acres to the park does not really add up any high costs
- If no farmers occupy the area immediately around the park, there are no costs of displacement

The tax part of this problem was a bit tricky but let’s start with the standard.

Standard

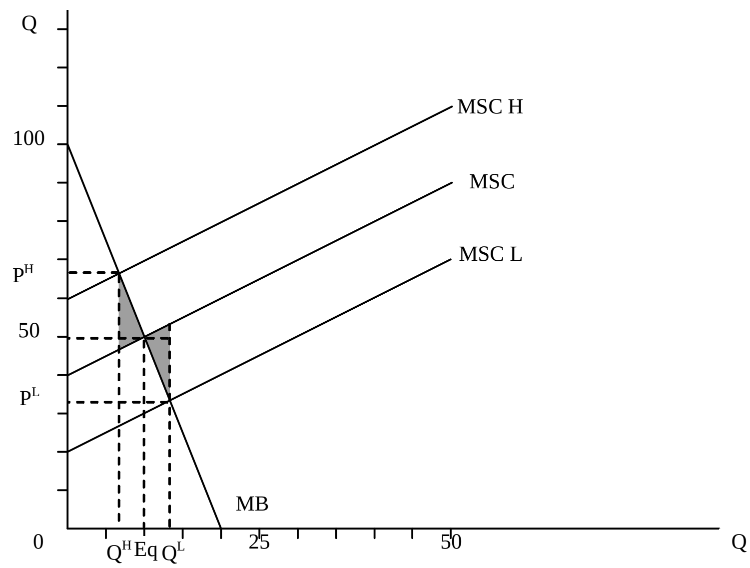
Similarly to the previous problem, we find the quantity regulation by looking at the intercept of MSC H and MB and MSC^L and MB. Refer to Graph 5.

Q^H= 6.66 and Q^L=13.33.

The area of one of the shaded triangles is:

.5* (10 – 6.66)*(66.66 - 46.66) = 33.33

DWL = 33.33



Graph 5. Uncertain elastic MSC. Regulation: Standard.

Tax

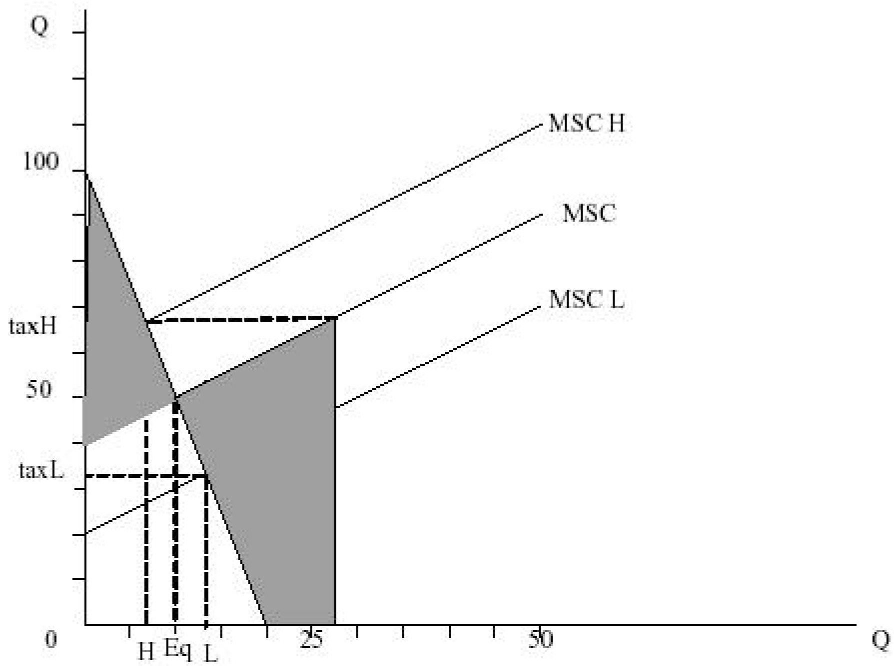
This is a bit tricky. Let's start with MSC^L.

MSC^L intersects MB at Q=13.33 and P =33.33 (denoted by L and taxL on graph 6). Tax L is below the true MSC. When price is below min MC, nothing is being offered on the market. Therefore, quantity of park provided given this price regulation will be 0.
The DWL from moving from the social optimum of Q=10 to Q=0 is the whole left shaded triangle. The area of this triangle is 300.
DWL^L=300

Note: Do not extend this triangle into the negative areas of Q!! Q is always greater than or equal to 0.

Next MSC^H: MSC ^{H} intersects MB at Q=6.66 and P =66.66. If the price regulation is set at 66.66, the quantity provided is Q=80/3=26.67. This is greater than the max quantity of 20 being demanded by the society. Again we do not extend the DWL into negative areas.

The deadweight loss can be calculated by integrals, or by finishing the shaded figure into a triangle into the negative quadrant and calculating the area as the difference b/ the area of two triangles, or by splitting the figure into a trapezoid and a triangle.
DWL^H = 722.33



Graph 6. Uncertain elastic MSC. Regulation Tax

EV(DWL) = .5*300 + .5* 722.33 = 511.11=4600/9

(c) Compare **8 pts**
When supply is elastic, the DWL of tax is greater, and the price and quantity distortions are much higher under tax. A standard should be used in this case. In our case of inelastic MSC, we got equivalent outcomes for standard and tax and policy makers are indifferent between price and quantity regulation. Producers, however, would always prefer quantity regulation.

<u>Essay question</u>

(1) **16 pts. –** 8 graph, 8 discussion. Trading of pollution permits allows for least cost of abatement if polluters are heterogeneous, as is the case of the Kyoto Protocol. If we have a case in no regulation, then the two polluters will be polluting at points X_2^0 and X_1^0 in Figure 1, taken from David's notes. The Kyoto Protocol aims to limit the amount of pollution to X*, however since X* is not known in reality the Intergovernmental Panel on Climate Change (the set up institution for the Kyoto Protocol) just takes as a guide the 1989 level of pollution (I believe). If each polluter needs to meet exactly half of this quota, then they are both at X*/2 and to polluter 1 this is worth $K and to polluter 2 $L. If trade is allowed then they will move to MB of $? (which is the eq'm price for permits) and each one benefits from trade: 1 is a buyer who is allowed to pollute more for less than what the country is getting out of the pollution (MB_1 > ?), 2 is a seller and they are paid more than it is worth to them to be abating (MB_2< ?).

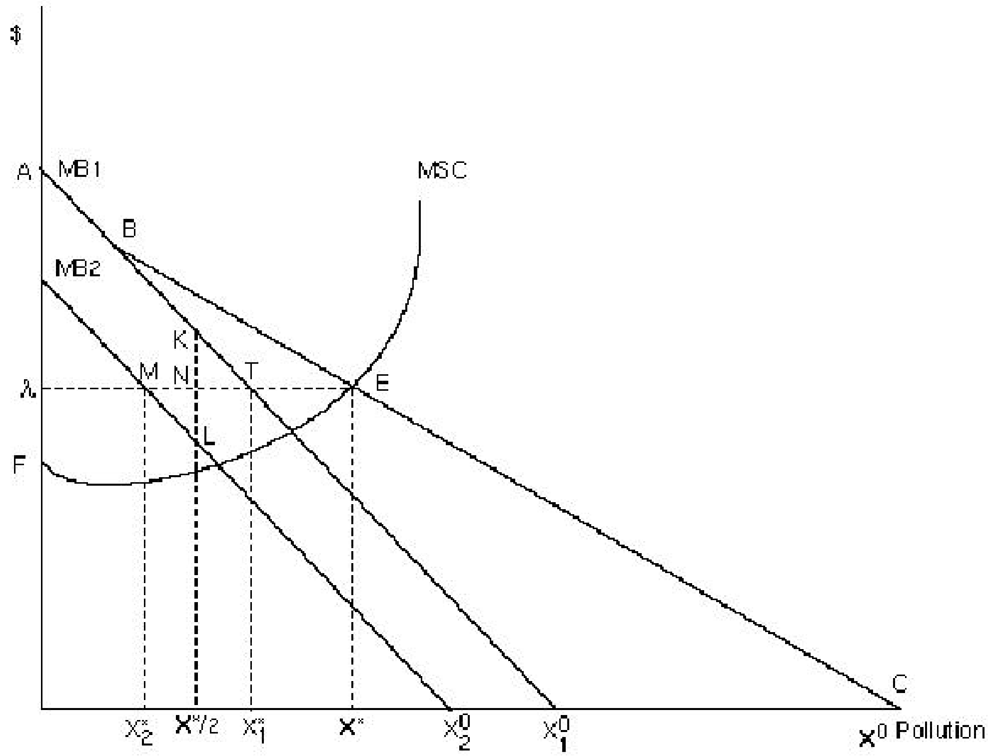


Figure 1. Benefits of pollution trading if heterogeneous polluters.

(2) **16 pts**. Thm – 7 pts, Conditions – 7 pts, Relevance to Kyoto – 2 pts. The theoretical underpinning of pollution trading is the Coase Thm. It says that the final pollution level and distribution does not depend on the initial allocation of pollution permits. For the Coase thm to hold the following conditions should be true: no income effect (the demand for permits is not affected by the initial distribution of permits), full information, no transaction costs, no externalities. These are obviously not all met under the Kyoto Protocol, and especially the first one – developing countries will be limited in their ability to purchase permits.

(3) 18 **pts – 4 table 4 discussion 6 graph 4 discussion** Next we look at current emissions and the potential demand and supply of permits.

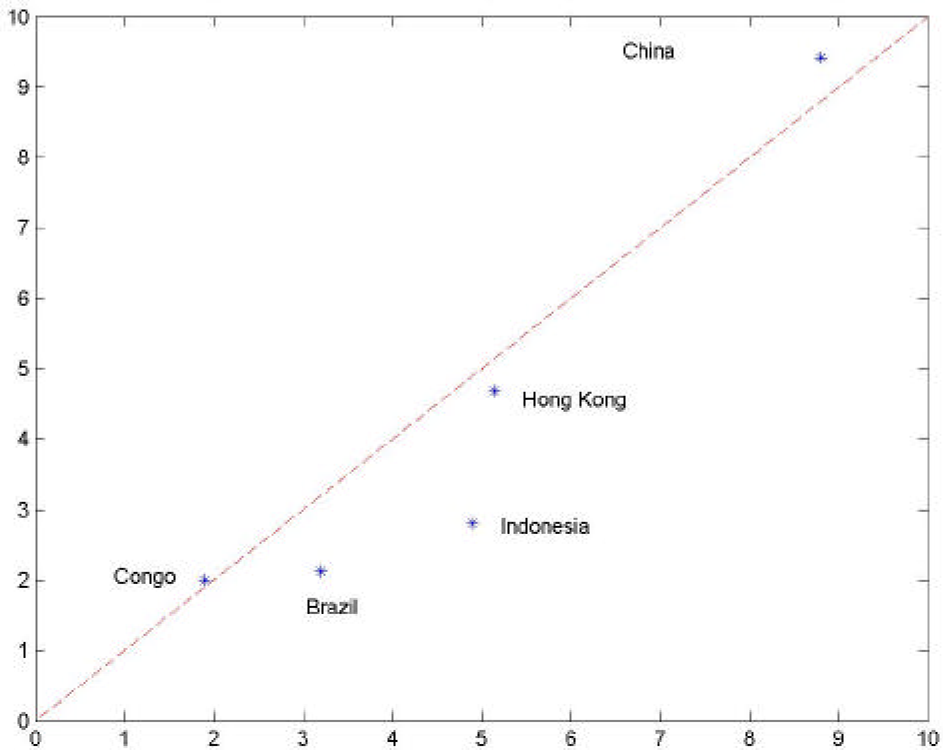
Country	CO_2/GDPPPP '89	CO_2/GDPPPP '97
Hong Kong	.39	.28
China	1.2	.74
Brazil	.29	.33
Indonesia	.32	.33
Congo	.24	.17

Table 1. Pollution Intensity

In table 1, we have the pollution intensities for 5 random countries that cover a different level of economic activity.

We notice that for countries with high economic activity, pollution intensity has decreased whereas for Brazil and Indonesia it has increased and for the very-low-GDP country Congo it has actually decreased. Brazil and Indonesia will definitely be buyers on the market of permits whereas Hong Kong and China, if they continue a more clean development, will possibly be sellers. Congo's data does not seem to be very intuitive, especially that we should observe an energy intensive development there. Without more data we are not able to explain this – we need to know for instance biomass consumption, was 1989 a particularly different year, etc.

We want to know if CO_2 emissions will necessarily continue to grow if GDP of the world continues to grow as well as whether developing countries can claim certain exception from Kyoto so that their growth is not hampered.



Graph 7. Growth in GDPPPP (on horizontal axis) vs Growth in Pollution Intensity.

For the countries that we tabled above, we calculate GDPPPP growth and pollution intensity growth and obtain graph 7. Each point on the graph tells us the GDP growth and the corresponding pollution intensity growth. The red, dashed line is the 45 degree line. (Note: Growth rate is calculated as: (GDP979 – GDP96)/GDP96. Same for pollution intensity.)

For the countries and the period we are looking at, we see an almost linear relationship between GDP growth and growth in pollution intensities. This graph supports the view that GDP growth will necessitate increase in pollution for the countries and period we investigate. This calls for exceptions in the Kyoto protocol for developing countries so that they can increase their GDP.