Final Exam
Energy Economics with Geography Focus 567A
Winter 2022
Professor: Geoffrey Barrows

Your Name:_____

Program:_____

If you need more space than is provided underneath the question, please continue on the reverse side of the page, and then the blank pages at the end of the document (and refer to it in the space provided for the answer). Ask for additional paper, if needed. Tell me to staple any additional sheets to the exam when handing in.

You have 3 hours for this exam and can reach a maximum of 100 points

Do not turn this page before you are asked to start.

Good Luck!

Part I (30 points)

Suppose the market demand for a good is given by $Q = 84 - \frac{1}{5}P$, where Q is the quantity demanded and P is the price per unit. The total cost of producing Q units of the good is $\frac{5}{2}Q^2$, so that the marginal private cost of supplying the good is $5Q$. Suppose that the total environmental costs of producing Q units are given by Q^2, so that the marginal environmental cost of supplying the good is $2Q$

1. What are the marginal social costs of producing the good? (5 points)

2. Calculate and illustrate graphically (15 points)
   (a) The socially optimal output level Q^* and associated price P^*
   (b) The unregulated competitive equilibrium output level Q_c and associated price P_c
   (c) The resulting inefficiency (i.e. deadweight) loss DWL

3. Determine the optimal production tax per unit of output. What is the amount of tax revenue collected by the government? (5 points)

4. Could a quota be used to achieve the same result? Which policy instrument would be preferred by producers? (5 points)

Part II (40 points)

In a (fairly) recent paper, Frankel and Rose (2005)[1] study the relationship between "trade openness" and environmental quality at the country level. "Trade openness" can roughly be measured as the share of imports and exports in national output (gross domestic product (GDP)). If countries trade a lot, this ratio will be higher. Many people worry that openness to trade endangers the environment, while others argue that openness to trade may encourage stricter environmental regulations, or cleaner production practices. Frankel and Rose (2005) propose to estimate the relationship using cross country data on trade openness and air pollution concentrations.

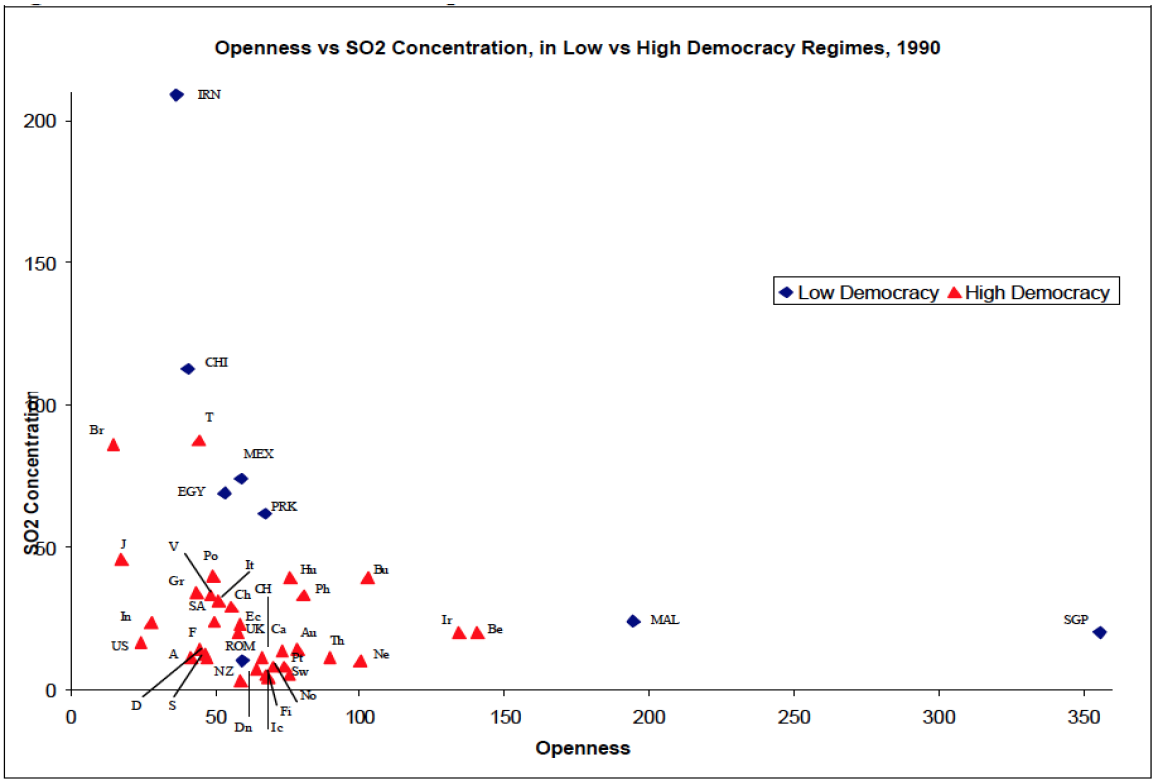
1. Frankel and Rose (2005) begin with some simple graphical analysis. Frankel and Rose (2005) collect data on trade openness and various pollutant concentrations at the national level for the year 1990. In Figure 1, Frankel and Rose (2005) plot trade openness on the x-axis and SO_2 concentrations on the y-axis (measured in micro grams per meter cubed). From Figure 1, it appears that SO_2 concentrations fall with trade openness.

   (a) Under what condition on trade openness does this graphical analysis identify the causal impact of trade openness on pollution? (5 points)

   (b) Is this condition likely to hold? Why or why not? (be specific for this context) (5 points)

[1] Frankel, Jeffrey A., and Andrew K. Rose. "Is trade good or bad for the environment? Sorting out the causality." Review of economics and statistics 87.1 (2005): 85-91.

Figure 1:


Openness vs SO2 Concentration, in Low vs High Democracy Regimes, 1990
Low Democracy
High Democracy
SO2 Concentration
Openness
0
50
100
150
200
250
300
350
0
50
100
150
200
IRN
CHI
T
Br
MEX
EGY
PRK
J
V
Po
It
Hu
Bu
Gr
Ch
CH
Ph
SA
In
Ec
UK
Ca
Au
Th
Ne
F
US
ROM
A
Pt
NZ
Sw
No
D
S
Dn
Ic
Fi
Ir
Be
MAL
SGP

2. Frankel and Rose (2005) formally estimate the causal relationship with the model

$$EnvDam_i = \phi_0 + \beta\left[(X+M)/Y\right]_i + \phi_1 \ln(Y/pop)_i + \phi_2 \ln(Y/pop)_i^2 + \phi_3 Polity_i + \phi_4 \ln(LandArea/pop)_i + \epsilon_i \quad (1)$$

where $EnvDam_i$ is pollution concentration in country i in 1990, $\left[(X+M)/Y\right]_i$ is the trade openness of country i in 1990 (Exports (X) plus Imports (M) divided by real output (Y)), $\ln(Y/pop)_i$ is the natural log of real per capita output in country i in 1990, $Polity_i$ is an index of democratic policies in country i in 1990, and $\ln(LandArea/pop)_i$ is the natural lof of land area per capita in country i in 1990. The parameter of interest is β. Frankel and Rose (2005) estimate equation 1 by OLS and report coefficient estimates in Figure 2. The independent variables are reported in the left-most column. Then each successive column represents a different regressions. Columns 1-3 estimate equation (1) by OLS taking NO_2, SO_2, and PM, respectively as the dependent variable. Point estimates are reported in the various cells with standard errors below in parentheses. (Note that there are no stars reported with these estimates. This does not mean that none of the estimates are statistically significant. Frankel and Rose (2005) just didn't report any stars.)

(a) Why do Frankel and Rose (2005) include $\ln(Y/pop)_i$, $Polity_i$, $\ln(LandArea/pop)_i$ in the regression? (5 points)

(b) Can we interpret the point estimates in columns 1-3 as causal? (5 points)

Figure 2: Model Estimates.

	OLS (1)	OLS (2)	OLS (3)	IV (4)	IV (5)	IV (6)
	NO_2	SO_2	PM	NO_2	SO_2	PM
Trade / GDP	-.29 (.17)	-.31 (.08)	-.37 (.34)	-.33 (.19)	-.23 (.10)	-.31 (.41)
Log real GDP per capita	409 (122)	287 (119)	567 (336)	461 (199)	296 (140)	681 (412)
Log real GDP p/c squared	-22.8 (6.9)	-16.6 (6.8)	-35.6 (19.1)	-25.6 (10.9)	-17.1 (7.7)	-42.0 (23.2)
Polity	-3.20 (1.47)	-6.58 (2.05)	-6.70 (3.42)	-3.77 (1.37)	-6.41 (2.27)	-7.78 (4.07)
Log of Area per capita	-5.94 (5.93)	-2.92 (1.39)	-13.0 (6.29)	-6.14 (6.43)	-1.54 (1.96)	-12.6 (6.84)
Observations	36	41	38	35	40	37
R^2	.16	.68	.62	.18	.67	.63
Income Peak	$7665	$5770	$2882	$8015	$5637	$3353

3. To address potential endogeneity, Frankel and Rose (2005) propose to "instrument" trade openness using plausibly exogenous determinants of trade. It is well known in the Trade literature that trade flows decline with distance between two trading partners. Frankel and Rose (2005) use this insight to build a prediction of trade flows between two partners based solely on the distance between them (and a few other variables which you don't need to worry about). Frankel and Rose (2005) then aggregate up these predicted trade flows across all trading partners and generate predicted trade openness. Does this procedure generate a valid instrument? Why or why not? (10 points)

4. Frankel and Rose (2005) re-estimate equation 1 using the instrument for trade openness and present results in columns 4-6 in Figure 2. Again, each column reports point estimates and standard errors from a separate regression, taking a different pollutant as the dependent variable.

   (a) Interpret the point estimate on "Trade/GDP" in column 5 (5 points)

   (b) Compute a rough 95% confidence interval for the OLS estimate on "Trade/GDP" in column 5. Can Frankel and Rose (2005) reject the hypothesis that $\beta = 0$ at the 5% level? based on this regression (5 points)

Part III (30 points)

Answer the following questions with a brief explanation.

1. Why is it difficult to measure the willingness to pay for environmental goods as opposed to traded commodities? (5 points)

2. Summarize some evidence we saw in the course with respect to how consumers respond to energy prices? (10 points)

3. According to the economic theory we saw in class, is trade good or bad for pollution? According to the empirical evidence we saw, is trade good or bad for pollution? (5 points)

4. If you wanted to estimate the effect of electricity infrastructure on economic development, would you expect an OLS regression of economic development on electricity infrastructure with time and region fixed effects to deliver an unbiased estimate of the causal effect? If not, in which way would you expect the OLS to be biased? Why? (10 points)