Study Questions

Chapter 2. Energy Lessons from the Past and Modeling the Future

Study Question 2.1. Suppose that you have estimated the following time series model for world oil price

$$P_t = 0{:}9P_{t-1} - 0{:}8P_{t-2} + 0{:}0002Y_t + 0{:}0001Y_{t-1}$$

You have the starting values for price per barrel and world income in billions of dollars for 2009, 2010, and 2011 as follows:

	Pt	Pt-1	Pt-2	Yt	Yt-1
2009	61.92			73045	
2010	79.45	61.92		78897	73045
2011	95.04	79.45	61.92	83706	78897
2012	**47.51161**	**95.04**	**79.45**	**85825.03**	**83706**

In Excel create a simple forecasting model to forecast oil price from 2012 to 2013 in the column under Pt. Note I have included the forecasts for 2012 so you can check if you are doing the problem correctly.

2.1a. First assume that income grows by 2.5 % per year with continuous growth rate.

(i.e. $Y_t = Y_{t-1}e^{0.025}$) Fill the column under Y_t using this formula. Create the values in the column for $Y_{t-1.}$ What is income in 2100?

2.1b. What is income in 2100, if you use discrete annual compounding. (i.e. $Y_t = Y_{t-1}(1+0.025)$)?

2.1c. Create your columns for forecasted P_t, P_{t-1}, P_{t-2}. Graph P_{t-1} against time.

Study Question 2.2 A firm owns a coal mine (X1) and an electricity generator (X2) $0.23 of coal is required per dollar of coal, and $0.25 of electricity is required per dollar of coal. $0.30 of electricity is required per dollar of electricity and $0.15 of coal is required per dollar of electricity. End-use demand for coal is $700 and end-use demand for electricity is $2000. How much coal and electricity have to be produced?

Study Question 2.3 You live in an economy with three industries - non-energy basic resources (B), manufacturing (M), and energy (E). The following A matrix represents the input-output coefficients for this economy. The matrix is represented in $input/$output.

	B	M	E
B	0.15	0.07	0.20
M	0.01	0.20	0.06
E	0.09	0.01	0.05

2.3a. Explain the coefficients 0.05 and 0.07.

2.3b. What is value added in each of the three industries?

2.3c. If end use demand for (B, M, E) = (2,3,8), how much total B, M, E must be produced?

2.3d. For the solution in 2.3c what are the direct purchases of energy for the production of B?

2.3e. What is the cradle to grave use of E in the production of **one** unit of B?

2.3f. Suppose that the production of each of these products generates carbon dioxide. The pounds of carbon dioxide per $ of B, M, E are: 0.02, 0.03, 0.04, respectively. Compute the total amount of CO_2 generated by the total output vector you found in part 2.3c.

2.4. The following is an input output coefficient matrix for a five sector economy.

	Food	Housing	Basic materials	Energy	Manufactured	Services
Food	0.10	0.03	0.04	0.01	0.02	0.01
Housing	0.05	0.20	0.06	0.05	0.03	0.20
Basic Materials	0.02	0.07	0.30	0.07	0.04	0.01
Energy	0.01	0.06	0.09	0.22	0.02	0.07
Manufactured	0.02	0.03	0.03	0.13	0.17	0.05
Services	0.04	0.02	0.02	0.05	0.06	0.25

2.4a. In Excel, solve the model for end use demands of Food = 25, Housing = 50, Basic materials = 34, Energy = 10, Manufactured Goods = 20, and Services = 15. 5b. For a summary of matrix computation in excel: http://dahl.mines.edu/530R-matrix-excel.pptx.

2.4b. How much does each sector buys from another?

2.5c. What is the total cradle to grave use of each sector in another.

Chapter 3. Perfect Competition and the Coal Industry Keywords

Study Question 3.1 In the text, we observed that if price was above equilibrium in a competitive market, excess quantity demanded would put pressure down on price. Or equilibrium was stable from above. Is equilibrium stable from below?

Study Question 3.2 Take the following model from the text:

$$Qd = 100 - 2Pc + 3Psb - 4Pcm + 0.10Y \quad (3.6)$$

$$Qs = 6 + Pc - 1Pk - 0.2Pl - 0.8Pnr - 1.5Psm \quad (3.7)$$

where

Pc is the price of coal

Pcm is a complement to coal consumption such as a boiler, set = 10

Pk is the price of capital, set = 2

Pl is the price of labor, set = 3

Pnr is the price of other natural resources used in production of coal, set = 5

Psb is the price of a substitute to coal, such as natural gas, set = 6

Psm is the price of similar products which a coal producer could produce, set = 4

Y is a measure of economic activity, set = 954 Change the ceteris paribus value for the price of a substitute from 6 to 2. Resolve the model for price and quantity.

Study Question 3.3 Graph what happens in the world coal market given the following events. Note what happens to equilibrium price and quantity. Has there been a change in demand or in supply? Has there been a change in quantity demanded or in quantity supplied? Note one is a shift of the curve and the other is a shift along the curve.

3.3a Exxon develops large coal deposits in Colombia.

3.3b Combined cycle gas turbines increase natural gas efficiencies for the generation of electricity.

3.3c A financial crisis causes recession in Asia.

3.3d The end of apartheid removes trade embargoes on South Africa.

3.3e Interest rates increase making it more expensive to borrow money. (note that coal consumption tends to be more capital intensive than the consumption of other fossil fuels and that often such capital is financed by borrowing money at the interest rate. Recent U.S. DOE data suggests that capital costs for cheaper coal plants are near $3000/kwh while for conventional gas they are nearer to $1000/kwh.) http://www.eia.gov/oiaf/beck plantcosts/

Study Question 3.4 What do you predict would happen to price and quantity if both c and d in Study Question 3.3 occurred? Support your answer with diagrams.

Study Question 3.5 For the demand model in Study Question 3.2 after the price of the substitute changed, compute the demand elasticity at equilibrium P & Q with respect to (a) price, (b) income, and (c) price of a substitute. (d) Compute price elasticity of demand at a price of 0, 20, 40, 60 and 80. (e) What happens to the elasticity as we move up the linear demand function? Compute the supply elasticity at equibrium P & Q with respect to (f) price, (g)price of capital, and (h) price of a similar good. (i) Compute price elasticity of supply at a price of 0, 20, 40, 60 and 80. (j) What happens to the elasticity as we move up the linear supply function?

Study Question 3.6 South Africa coal consumption is about 140 million metric tonnes. If coal price goes from $100 a tonne to $120 per tonn and the short run elasticity is -0.25, what would the percentage change in coal consumption be? What would the change in coal consumption be? What would new coal consumption be? You can check your in answers ch03m.xlsx, worksheet HW0305.

Study Question 3.7 Revenues and elasticity:

3.7a Explain what happens to revenues for a price decrease with an elastic demand.

3.7b Explain what happens to revenues if price increases with inelastic demand, ($-1 < \varepsilon p < 0$).

Study Question 3.8 Income elasticities can be used in the same way as price elasticities to show how much product consumption will change when income changes. Suppose that in China, the largest coal consumer, income elasticity of coal demand is 0.8, current coal consumption is 2500 million tonnes, and income will grow at 5% per year.

3.8a What would you forecast next year's coal consumption to be?

3.8b If the price elasticity is -0.7, what price increase would be required to offset the income increase?

Study Question 3.9 Cross-price elasticities:

3.9a What does a negative cross price elasticity of demand imply? Give an energy example of two goods that might have a negative cross price elasticity of demand.

3.9b What does a positive cross price elasticity of demand imply? Give an energy example of two goods that might have a positive cross price elasticity of demand.

3.9c What does a negative cross price elasticity of supply imply? Give an energy example of two goods that might have a negative cross price elasticity of supply.

3.9d What does a positive cross price elasticity of supply imply? Give an energy example of two goods that might have a positive cross price elasticity of supply.

Study Question 3.10 Compute the price elasticities for the following functions:

3.10a $Q = \alpha + \beta \ln P + \delta \ln Y$

3.10b. $\ln Q = \alpha + \beta P + \delta Y$

3.10c $Q = \exp(\alpha - \beta P + \delta Y)$

3.10d $Q = \alpha + \beta P + \delta Y = \gamma P\ Y$

Study Question 3.11 Create a log linear demand for coal demand in India if coal consumption is 350 million tonnes, coal price is $100 per tonne, income is 4 trillion dollars, price of imported LNG is $10/MCF, and price, income, and cross price elasticities are -0.2, 0.75, and +0.3.

Study Question 3.12 Your task is to forecast carbon dioxide emissions coming from the consumption of coal, oil, and natural gas. You have used historical data and econometric techniques to estimate own price, cross price, and income elasticities for coal, oil, and natural gas demand. Which are as follows:

	PriceO	**PriceC**	**PriceNg**	**Y**
Oil	-0.15	0.20	0.10	0.70
Natural Gas	0.14	-0.25	0.17	0.50
Coal	0.07	0.08	-0.30	0.90

You get 161 lbs of CO2 per million Btus of oil, 205 from coal, and 117 from natural gas.

Consumption in million BTU of oil in 2010 is 50, of coal is 25, of natural gas is 25.

Forecast consumption of oil, coal, gas, and CO2 emissions for 100 years, if price of gas increases 1% every year, price of oil increases 1.2% every year and price of coal increases 0.7% every year, and income grows 3% every year.. You can play around with inputs in the model to see what kind of pricing policy the government would need to implement to cut CO2 emissions by 2100.

Chapter 4. Energy Taxes, Subsidies, and Social Welfare Keywords

Study Question 4.1 When considering investment in another country, it is important to investigate the tax regimes. http://www.taxsites.com/ is a good link for tax information and links to large accounting firms. Explore this link and note differences across countries.

Study Question 4.2 Severance taxes are one of a variety of taxes collected by U.S. states. See http://www.census.gov/govs/statetax/ to compare the different ways states collect taxes.

Study Question 4.3 Let Qd=a-bPd and Qs=c+dPd and the unit tax is tx. Mathematically show that a unit energy tax on the consumer in the competitive case is identical to the tax on the producer. Thus, unless the costs of collection are different it doesn't matter where the tax is collected.

Study Question 4.4 The tax could be on the value of the product sold (ad valorem) instead of on each unit sold. Let's say the rate for an ad valorem tax is t_a, which is now a share. Such a tax on the supplier price could be represented as t_a and the market is in equilibrium where $P_d=(1+t_a)P_s$.

4.4a Graph this market with the old and new supply curve.

4.4b If the tax is 10% or $t_a = 0.10$, what are the new equilibrium price and quantity for the following market?

$$Qd=50-2Pd$$

$$Qs= -10 +3Ps$$

4.4c Who pays the tax? What are government revenues?

4.4d. If the tax is on the end demand price it could be represented by t_aP_d and equilibrium would be where $P_d(1-t_a)=P_s$. If the same tax rate were implemented on the supply price the equilibrium condition would be $P_d=P_s((1+t)$ In this case, does it matter whether the tax of t is levied on the consumer or the producer?

Study Question 4.5 The prices for some of the products in Table ?? are below world prices. This implies that they are subsidized instead of taxed. Think about how a subsidy works in a competitive market. Would the consumer or the producer receive the subsidy?

Study Question 4.6 We can think of the social security tax as a tax on labor. Use the above analysis on incidence of a tax to discuss who pays this tax - the employee or the employer. The price of labor is the wage rate and the quantity is hours worked.

Study Question 4.7 Compute the deadweight loss for the ad valorem tax in Study Question 4.4.

Study Question 4.8 State governments frequently regard severance taxes as a revenue source

with a minimal burden to the State's own residents, especially if the taxed resources are exported to customers in other States. Based on the above discussion, do you agree or disagree?

Study Question 4.9 Suppose that demand and supply of Chinese coal are

$$Q_d = 60 - 0.5P.$$

$$Q_s = -2 + 2P.$$

4.9a What are equilibrium price and quantity in the Chinese coal market?

4.9b What happens to price and quantity if a subsidy of $10 is paid on Chinese coal?

4.9c What are the costs to the government of a subsidy?

4.9d What are the gains in consumer surplus from the subsidy?

4.9e What are the gains in producer surplus from the subsidy?

4.9f What are the dead weight losses of the subsidy (Government cost - gain in producer surplus minus gain in consumer surplus)?

4.9g Show the costs, gains in consumer surplus, gains in producer surplus and deadweight losses from a subsidy on a graph.

Study Question 4.10 Suppose the demand equation for shale gas is $Qd = 10P^{-1.8}$ and the supply equation $Qs = 2P^{0.2}$.

4.10a What is the price elasticity of demand?

4.10b What is the price elasticity of supply?

4.10c What is the incidence of a $2 tax?

Chapter 5. Natural Monopoly and Electricity Generation

Study Question 5.1 Suppose that a 500 megawatt hydro power plant including the dam has upfront or overnight cost of $2500 per kilowatt of capacity.

5.1a What is the total cost of building the plant?

5.1b What is the maximum amount of electricity in kilowatt hours this plant could produce in 40 years if it could operate 24 hours a day, 365 days a year for 40 years?

5.1c If capital is paid for upfront, it takes 2 years to build the plant, it then operates for 40 years at 80% of capacity, and the interest rate is 10%, what is the levelized cost of capital? Assume all capital is paid for up-front at time 0, electricity is all paid for at the end of the year. Thus, payments start at the end of year 3 and commence for 40 years.

5.1d How would your answer to 5.1c change if the half of the cost of the plant was paid at year 0 and the balance was paid at the end of the first year?

Study Question 5.2 Suppose the electricity generation industry in a region has the following demand and cost curves:

$Q = 40 – 0.5P$

$TC = 60Q - 0{:}6Q^2$

Q is measured in megawatt hours, price is measured in dollars per megawatt hour, and total costs are measured in dollars.

5.2a. What is the socially optimal price and quantity in this market? What are profits at this level of price and quantity? (Remember to invert demand curve so you can set P = MC.)

5.2b. What are the economies of scale at the price and quantity in part a? (Check whether $\partial ATC/\partial Q$ ><=0 indicating diseconomies, economies, or constant economies of scale. (Note: Industries with these properties can be called increasing, decreasing of constant cost industries.)

5.2c. Should this market be treated as a natural monopoly? Why or Why not?

5.2d. What would you expect to happen in this industry, if the industry was allowed to develop with no interference? What would price and quantity be? Would there be social losses compared with case a? Why or why not? If there are social losses what would they be?

5.2e. What would happen if a $2 tax were places on electricity? Be sure to be able to do this for a subsidy as well.

Study Question 5.3 Now suppose that this utility is connected to a power grid and people are free to choose any supplier. Power can be wheeled for 17 dollars per megawatt hour. Thus, any buyer would not buy from this utility if they charged a price higher than 17 dollars but would buy off of the grid. This makes this utility's demand curve at 17 dollars and above but they face their downward sloping demand at prices below 17 dollars.

5.3a D the utility's new demand curve?

5.3b What is marginal revenue for the flat area of the demand curve?

5.3c What is the marginal revenue curve for the downward sloping portion of their demand curve?

5.3d What price and quantity would a profit maximizing monopoly choose?

Study Question 5.4 Suppose you are on a state utility commission and you have to make a decision on a rate case for Power Galore Utility (PGU). The legally established rate of return for the utility is s = 10%. PGU sells to two customer classes - residential and business - and is requesting the following prices for each class in dollars per kilowatt hour ($/kWh). They estimate sales in each rate class to be Qi, their rate base is $750,000, they estimate fuel costs in $/kWh to be ci and other operating costs in$/kWh to be oi.

	Pi	Qi	ci	Oi	RB
i=1	0.08	1,966,667	0.02	0.03	750,000
i=2	0.05	799,999	0.02	0.01	

5.4a Based on their request summarized in the table would you approve the rates requested? Why or why not?

5.4b Now suppose you have hired an independent contractor to estimate the demand equations for the two customer classes.

Q1 = 2; 000; 000 - 100; 000P1

Q2 = 900; 000 - 100; 000P2

From this new information, what would you predict to be electricity consumption in each rate class at their requested rates (prices?

5.4b Given all the information in parts a and b, would you approve their rate request?

Why or why not?

Study Question 5.5 Suppose stand alone costs in your market are

Cx = 800 + 20X

Cy = 700 + 40Y

If one utility provides services to both customers, combined costs are:

Cxy = 1200 + 20X + 40Y

5.5a Are costs sub-additive for this example?

5.5b If 75% of fixed costs are allocated to consumer class X and 25% to consumer class

Y, how much of the fixed costs would be charged to X and how much to Y?

5.5c. Suppose you have marginal cost pricing. What is the marginal cost of producing a unit for X? a unit for Y?

5.5d If you marginal cost price for X and Y and allocated costs as in b, what is the total cost curve for X? What is the total cost curve for Y?

5.5e. If you were a customer in group X would you feel the prices were discriminatory, why or why not? If you were a customer in group Y would you feel the prices were discriminatory, why or why not?

5.5f. If demand for group X were Px=92 - 3X and demand for group Y were Py=120-4Y, would the above fixed cost allocation be efficient?

Study Question 5.6 Let off-peak demand be $Q_{opk} = 10-2P_{opk}$, peak demand $Q_{pk} = 20-P_{pk}$, $c_k = 4$ and $c_o = 2$.

5.6a What are the socially optimal prices in this market?

5.6b How much electricity is consumed peak and off-peak?

5.6c How much is consumed in each, market if a price of 5 is charged in each market?

5.6d What are the social losses, if a price of 5 is charged in both peak and offpeak? (To get loss compare the social welfare with optimal situation and remember to check that utility is covering all of its costs)

5.6e Suppose you have been charging 5 and are considering charging optimal peak load prices for peak and offpeak. The costs to implement peak load pricing are 10 would it be a good idea to implement peak load pricing or not? Why or why not?

5.6f Would your answers to a and b change if capital costs were 6 instead of 4.

Study Question 5.7 Suppose a utility owns a coal mine. It sells 100 tons of coal to itself per year at $29 per ton and produces and sells 222,000 kilowatts of electricity at $0.06 per kilowatt hour. Coal mining has a 10% Federal depletion allowance, which allows them to deduct 10% of their revenues for tax purposes. Deductible costs are shown in the example below. Taxable income for the combined mine and utility are $2260 + $2420 = $4680.

Mine	
Sales Revenue = 29*100 =	**$2,900**
Operating Costs	**$300**
Depreciation	**$50**
% depletion allowance (10%)	**$290**
Taxable income	**$2,260**
Utility	
Sales Revenue = 0.06*222000	**$13,320**

fuel cost	**$2,900**
other operating costs	**$5,000**
Depreciation	**$3,000**
Taxable income	**$2,420**

5.7a What happens to taxable income in the above example if the utility pays its mine $40 per ton?

5.7b Explain why taxable income changes ?

Chapter 6. Deregulation-Privatization Electricity Sector

Study Question 6.1 The table at http://dahl.mines.edu/T0604.xlsx contains information for countries electricity sectors. Find one new country or update the information for one country that has or is privatizing its electrical sector and note the following information.

6.1a Indicate when the privatization was initiated.

6.1b Try to determine which of the models from Shuttleworth and Hunt the new model most closely resembles.

6.1c What sort of dispatch is being used or considered?

Study Question 6.2 Many countries are opening up their power sectors to private investment leading to a boom in electricity projects. The table at http://dahl.mines.edu/T0605.xlsx contains information for some such projects. Find another example of one such recent project. Note the location, cost, capacity, construction time, completion/expected completio date, and reference. **Study Question 6.3** What is the maximum possible efficiency of a light water reactor that inputs steam at 1000 degrees F and outputs cooling water at 100 degrees F?

Read the technology box at http://dahl.mines.edu/tech0501.pdf to answer this question.

Input temp		
1000	F1	
Output temp		
100	F2	
T1 in K = 5/9(F1-32) + 273 =		810.7778
T2 in K = 5/9(F2-32) + 273 =		310.7778
Efficiency =		
1-T2/T1=		0.616692

Study Question 6.4 A typical 1000 MW light water reactor creates about 3 cubic meters of waste every three years. Compute what this implies about how much nuclear waste the average American who receives all their electricity from nuclear power would generate in 70 years with

and without reprocessing. Indicate all the assumptions you have to make to do your computation.

Study Question 6.5 A trade organization for the US electric power industry is the Edison Electric Institute at www.eei.org. Go to this address and find out what companies belong to this trade group. Try to find 10 other electricity links.

Study Question 6.6 Suppose that during a peak period forecasted demand is 150 and the bids from the original 5 bidders is

National Power bids $0.06 per kWh for 80 kW

Power Gen bids $0.065 per kWh for 30 kW

Scottish Power bids $0.07 per kWh for 50 kW

EdF bids $0.075 per kWh for 10 kW

National Grid bids $0.08 per kWh for 50 kW

There is the same transmission constraint of 65 kW from National Power to market.

6.6a What is SMP for this set of bids? What are the dispatch orders.

6.6b Suppose for the next hour, there is a 5% probability of a 10 kW short fall and a 1% probability of a 15 kW short fall. The loss of output from a 10 kW shortfall is estimated at $15, and the loss of output from a 15 kW shortfall is estimated at $25. What is CC for this market?

6.6c Assume the power dispatched in 5.6a is the amount taken. If $20 of spinning reserve was dispatched but not taken, what is the uplift charge per kWh dispatched.

6.6d What is the pool selling price?

Study Question 6.7 Regulated utilities that must charge average rather than marginal costs sometimes undertake demand side management programs to reduce peak loads and improve load factors. Such activities include free energy audits to advise customers on how to reduce loads, information on energy saving possibilities, loans, subsidies and rebates for energy efficient lighting, appliances and motors.

6.7a Explain why a utility would encourage customers to consume less electricity under average cost pricing, particularly during peak periods?

6.7b What do you think will happen to demand side management programs if a utility is deregulated and moves to marginal cost pricing?

Study Question 6.8 If the market interest rate on a bond of similar risk is 8% and the bond holders marginal tax rate is 25%, what interest rate would you expect the tax free bond to pay? Why?

Study Question 6.9 Hunt and Shuttleworth present four different models for the electricity sector. Briefly compare and contrast the four models.

Study Question 6.10 California's electricity restructuring in the late 1990's and early 2000's went radically wrong. Outline what happened in the California's market at that time. Indicate what you think was the biggest policy mistake the regulators made and suggest a better policy.

Study Question 6.11 The text includes deregulation experiences for 4 countries. Compare and contrast these four experiences. Be sure to include which model from Hunt and Shuttleworth each country has as its goal, the type of price regulation if any they are most in favor of, which segments of the industry are allowed to compete and which segments are still regulated and the type of ownership.

Chapter 7. Monopoly, Dominant Firm and OPEC

Study Question 7.1 Many countries have antimonopoly laws as shown at http://dahl.mines.edu/T07??. Check information for 1 country in the Table and see if you can find information for one country not in the Table.

Study Question 7.2 Suppose that MC = 12 and the demand price elasticity equals -1.8.

The monopoly pricing result is $P = MC/(1-1/|\varepsilon_p|)$

7.2a Using the above expression, what price should the monopolist charge?

7.2b If MC goes up what will happen to optimal price?

7.2c If the demand becomes more elastic and changes to -2.5, what happens to optimal price?

7.2d Why does the pricing equation imply that the monopolist must be operating in the elastic region of a linear demand curve? (i.e. Where $\varepsilon_p < -1$ or $|\varepsilon_p| > 1$.)

Study Question 7.3 Let marginal costs for two OPEC countries be:

$MC_1 = 5 + Q_1$

$MC_2 = 5 + 4Q_2$

7.3a What would OPEC price and quantity be, if OPEC inverse demand is P=100-2Q?

7.3b How much would each OPEC country produce (Q_i)?

7.3c What are profits for each OPEC country (p_i)?

7.3d What are total social losses (DWL)?

7.3e What happens if a unit tax of 20 is placed on the supplier to P, Q_o, Q_1, Q_2, p_1, p_2, DWL.

7.3f If the producing country, which adds the tax only sells oil, and the consuming country only buys oil is the producing country better off with or without the tax? (Hint does the producer country get enough tax revenue to more than offset the loss in producer surplus.)

7.3g What if the consuming instead of the producing country puts on a tax? Is the consuming country better off with or without the tax?

7.3h How much would the monopolist produce if a price control of $80 were implemented in case 7.3a (no taxes)?

7.3i Can you find a price control for which the monopolist would produce less than in case 7.3a (no taxes)?

7.3j If OPEC started to squabble and the industry became competitive, what would happen to price and quantity for case 7.3a (no price controls of taxes)?

Study Question 7.4

With an ad valorem tax, profits for the monopoly become:

$$\pi = (1 - t_a)\, p(Q)Q - TC(Q)$$

First order conditions are:

$$(1 - t_a)MR - MC = 0$$

Suppose Q_d= 100 -2Pd

$$TC = 10\text{Q} + \text{Q}^2$$

7.4a Show the monopolists optimal price and quantity on a graph.

7.4b Solve for the optimal P and Q using the above demand and cost functions.

7.4c Does this policy get us to the socially optimal Q?

7.5 Two other taxes are a profit tax, t_π, and a lump sum tax (T). The after tax profit for these taxes are as follows:

$$\pi_{t_\pi} = (1 - t_\pi)(PQ - TC(Q))$$

$$\pi_T = PQ - TC(Q) - T$$

7.5a. What would be the first order conditions ($\frac{d\pi}{dQ}$) for each of these functions? What are second order conditions? For the lump sum tax

$$\frac{\partial \pi_T}{\partial Q} = P - \frac{\partial TC(Q)}{\partial Q} = 0$$

7.5b. Use the implicit function on the first order condition to show that the tax has no effect on output in these two cases.

(e.g. use $\dfrac{dQ}{dt_\pi} = -\dfrac{\partial \pi_{t_\pi} / \partial Q}{\partial \pi_{t_\pi} / \partial Q}$ to show that $\dfrac{dQ}{dt} = 0$

$$\frac{dQ}{dt_\pi} = \frac{-1(P - \frac{\partial TC(Q)}{\partial Q})}{(1 - t_\pi)\frac{\partial^2 TC(Q)}{\partial Q^2}} = \frac{(-1)0}{\text{sign of slope of } MC(\text{usually}+)} = 0$$

For the tax to not kill the industry ($1\text{-}t_\pi$)>0. The numerator $(P - \frac{\partial TC}{\partial Q})$ in the above

expression must be 0**.**

For the lump sum tax T,

$$\frac{dQ}{dT} = \frac{0}{\frac{\partial^2 TC(Q)}{\partial Q^2}} = \frac{0}{\text{sign of slope of } MC(\text{usually+})} = 0$$

7.5c. Explain intuitively why these taxes have no effect on output.

Study Question 7.6 Now OPEC is a dominant firm facing the demand and costs information in 7.3 along with a competitive fringe.

7**.6a** Let fringe supply be Q_f= -17.5 +0.5P. Solve for Q_o, Q_f, Q_1, Q_2, P, π_o, π_f, π_1, π_2.

7.6b Let fringe supply be Q_f= -37.5 +0.5P. Solve for Q_o, Q_f, Q_1, Q_2, P, π_o, π_f, π_1, π_2.

7.**6c** Let fringe supply be Q_f= -50 +0.5P. Solve for Q_o, Q_f, Q_1, Q_2, P, π_o, π_f, π_1, π_2.

7.6d Compare the solution for the dominant firm model in 7.6a to a competitive solution. Remember that in a competitive model MC would be the horizontal sum of OPEC plus the fringe and they would face total world demand. Solve for Q_o, Q_f, Q_1, Q_2, P, π_o, π_f, π_1, π_2.

7.6e For a competitive model for case 7.6a. solve for Q_o, Q_f, Q_1, Q_2, P, π_o, π_f, π_1, π_2.

7.6f Did OPEC or the fringe gain more from OPEC acting as a dominant firm in 7.6a compared to 7.6e?

Study Question 7.7 Suppose at optimal output $\varepsilon_w = -0.8, \varepsilon_f = 0.3, Q_w = 67.5, Q_o = 27.5, Q_f = 40$.

7.7a What is the price elasticity of demand for OPEC's oil?

7.7b What happens to the price elasticity of the demand for OPEC's oil as the world's demand gets more price elastic? Why?

7.**7c** What happens to the price elasticity of demand for OPEC's oil as the fringe supply gets more price elastic? Why?

7.**7d** What happens to the price elasticity of demand for OPEC's oil, if OPEC's production is a higher percent of world production. Why?

7.**7e** If MC = 8, what price should OPEC charge?

Study Question 7.8 Suppose inverse export demand for OPEC is P_x = 53 -4Qx, marginal cost is MC = 5+(Qx+Qd) and inverse domestic demand is $P_d = 20 - 10Q_d$. OPEC wants to maximize the benefits its gets from its oil reserves.

7.8a How much will OPEC sell on the domestic and on the export market?

7.8b What price will is charge in the domestic and export markets.

Study Question 7.9 Daniel Yergin has written a Pullitzer Prize winning book on the history of the oil industry. PBS has a nice eight part series based on the book now on youtube. Watch one episode of The Prize. For your chosen episode make up and answer one question. Your

question and answer should be no more than 1/2 single spaced typed page. Your score will be based on the quality of the question and the answer. Questions that require a bit of thought or analysis will receive more points than questions that would require only memorization. (e.g. Questions requiring more thought include ones that compare, contrast. look for themes, give preferences and justify why, relate material in the episode to current events or other material in the course, etc.)

The Prize by Daniel Yergin. Each episode is approximately one hour long.

1: www.youtube.com/watch?v=Qspu35JG59Q

2: www.youtube.com/watch?v=ioazMpe1SHE

3: www.youtube.com/watch?v=y-yaMTYczMM

4: www.youtube.com/watch?v=PvkT3ByU5yg

5: www.youtube.com/watch?v=IIJxBrHcSUo

6: www.youtube.com/watch?v=BOMIY9yAbZw

7: www.youtube.com/watch?v=vgt1ZLDIy1M

8: www.youtube.com/watch?v=u4FdR3KMOZ8

The descriptions of the programs from the VHS tapes are as follows:

``The Prize recounts the panoramic history of oil -- and the struggle for wealth power that has always surrounded oil. This struggle has shaken the world economy, dictated the outcome of wars, and transformed the destiny of men and nations. The Prize is as much a history of the twentieth century as of the oil industry itself. The canvas of this history is enormous -- from the drilling of the first well in Pennsylvania through two great world wars to the Iraqi invasion of Kuwait and Operation Desert Storm. The cast extends from wildcatters and rogues to oil tycoons, and from Winston Churchill and Ibn Saud to George Bush and Saddam Hussein.

Eight one hour tapes.

Program 1: Our Plan

Trace the turbulent, rapid rise of the world's biggest business, how a visionary but ruthless John D. Rockefeller controlled it - and how reporter Ida Tarbell took him on in one of the most famous muck racking exposés ever. A fascinating look at Rockefeller's controversial legacy, the rise of modern business, and how Tarbell served as the role model for the modern investigative journalist.

Program 2: Empires of Oil

Witness capitalism on a grand scale: how Shell Oil and Royal Dutch merged, then challenged the supremacy of Rockefeller's Standard Oil. A compelling tale of how oil transformed everyday life in the farthest corners of the globe, mad Russia a great oil power, and helped the Allies win World War I.

Program 3: The Black Giant

It's the Roaring Twenties, and the magic of oil touches everyone, from millions of new car owners to hopeful Texan wildcatters. The American oil industry wrestles with shortage and

surplus, as flamboyant entrepreneur Calouste Gulbenkian stakes his claim in Iraq.

Program 4: War and Oil

The untold story of World War II unfolds: how oil dictated strategy to Hitler; how lack of oil slowed Japan's war machine: how oil ultimately determined victory or defeat. Features rare footage on the critical impact of oil on decisively military events.
Program 5: Crude Diplomacy

Post-World War II America awakens to the strategic importance of oil, and witnesses a key moment in history when oil production shifts from the U.S. to the Middle East. An extraordinary cast of characters, including Arabian kings, U.S. presidents, British adventurers, Iranian politicians, and American explorers, paint a global portrait of how oil shaped the world economy and politics.

Program 6: Power to the Producers

It's the heyday of cheap oil, the dawn of the Hydrocarbon Society and the introduction of a prosperous new automobile culture for Americans. Follow the heroes and antiheros, plots and counterplots, as the producing countries and the independent oil companies challenge the ``Seven Sisters'' and open a new era in world oil.

Program 7: The Tinderbox

Relive two decades of upheaval that shook the world and changed our lives as power shifted, and nations and companies jockeyed for position

amidst embargoes, shortages, and surpluses. A unique view of the rise of the OPEC era, beginning with the British withdrawal from the Persian Gulf and ending with the burning oil wells of Kuwait.

Program 8: The New Order of Oil

The Gulf War marked the beginning of a new era for the Hydrocarbon Society. This program explores the relation of oil and environmental conscience, and the technological race to balance energy, economic, and ecological needs in the Information Age."

Chapter 8. Transaction Costs and U.S. Natural Gas Markets

Study Question 8.1. Go to the U.S. EIA International Energy Database (http://www.eia.gov/countries/data.cfm)

8.1a For the latest year available, find the country with the largest gross natural gas production. Indicate the country, year, and production. How much of its gas was flared?

8.1b Convert the gross production in 8.1a from cubic feet into cubic meters. (Recall that 1 m^3=35.3 ft^3).

8.1c Find the heat content of this countries natural gas in the data base and its energy content from BTU/ft^3 to Kcal/m^3. (Recall that 1 Kcal =3.966 BTU).

8.1d What country flares the most natural gas? How much? What country re-injects the most natural gas? How much?

8.1e Go to their glossary (http://www.eia.gov/tools/glossary/) and find out the difference between gross production, dry production, and marketed production.

8.2 Transaction cost economics suggests that market governance is influenced by the costs of making transactions.

8.2a Give examples of 4 types of transaction costs

8.2b What are the four types of governance discussed in the book.

8.2c What are quasi-rents and do you expect they are high or low in the natural gas transmission industry. Why or why not?

8.2d Suppose the price natural gas is $5 per Mcf, average fixed cost is $2.00 per Mcf, and average variable cost is $0.50. How much is quasi rent and rent.

Study Question 8.3 Economies of scale, economies of scope and transaction costs influence firm behavior. Define each of these concepts and discuss what influence they are likely to have on market behavior. Be sure to include some discussion of market governance and transaction cost economics.

Study Question 8.4 Discuss the evolution of the governance in the U.S. natural gas market. Relate the changes in governance across time to transaction cost economics.

Study Question 8.5 Trace the historical policy changes in the U.S. natural gas market and indicate how they changed governance in the market.

Chapter 9. Monopsony - Japan and the Asia Pacific LNG Market

Study Question 9.1

9.1a What is the temperature of LNG in degrees Fahrenheit? Degrees Celsius? What equation converts degrees Celsius to degrees Fahrenheit?

9.1b How many cubic meters of LNG are there per tonne of LNG? How many cubic meters of natural gas are there per tonne of LNG? I believe the conversions in data_BP12.xlsx for a tonne of LNG into cubic meters and cubic meters of natural gas are incorrect. Check these conversions and see if you agree with me.

9.1c Other cargoes more typically are measured in deadweight tonnes (DWT), which is the number of metric tons a ship can carry including cargo, bunkers, crew, and provisions. DWT tonnes are a bit larger than the cargo space. How many deadweight tons would a 135,000 cubic meter LNG tanker carry? (Ignore non cargo capacity for this computations unless you can find a value for it.)

9.1d How many miles in a nautical mile? How many kilometers?

9.1e Suppose you have a 4 million metric tonne per year project that will deliver LNG 3000 nautical miles away. If you have ships that carry 135,000 cubic meters and travel at 20 knots, loading and unloading each takes 12 hours, how many ships would you require for your project? You may assume that ships do not have any downtime. (This would be roughly the distance from Australia to Japan. The distance from the Middle East to Japan would be about 7000 nautical miles.)

9.1f If LNG cost $4.31/MMBTUs, what would be the per barrel oil price on an energy equivalent basis for a barrel of oil that has 5,800,000 BTUs/barrel and an Mcf of gas that has 1,026,000 BTUs?

Study Question 9.2 Since Japan has some of the most efficient power plants in the world, redo the example in the text beginning at equation 9.1 assuming the efficiency of a combined cycle power plant using LNG is 50%.

9.2a. How much LNG would Japan import, if it were a monopsonist? What would be the price paid? What would be the total cost of imports?

9.2b How much would Japan gain by being a monopsonist instead of a competitor?

9.2c Explain how combined cycle gas turbines work. Why are they more efficient?

Study Question 9.3 Now suppose we have a downward sloping marginal revenue product curve as in Figure 9.2 in the text. Let $MRP_L = 103.8 - 0.215L$.

9.3a Now how much LNG would Japan consume and what price would they pay?

9.3b What is producer and consumer surplus and social losses?

Study Question 9.4 Suppose that Japan lost its monopsony power in the Study Question 9.4.

a. Graphically show the new solution.

b. How much LNG would Japan import? What would be the price paid? What would be the total cost of imports?

c. Is monopsony power stronger or weaker (stronger would indicate it could push price lower) when supply is more elastic? Justify your answer with a diagram.

Study Question 9.5 Redo the example in Study Question 9.4 assuming that Japan is a perfectly price discriminating monopsonist.

Study Question 9.6. Diagrammatically compare the case in study question 9.3 to the case where Japan is a monopsonist on the input and a monopolist on the output market. Does Japan buy more or less LNG in this case? Is the price of LNG higher or lower?

Study Question 9.7. Suppose we have a bilateral monopoly. The monopolist has a cost curve $MC = 2 + 4Q$, and the monopsonist has an inverse demand curve $P = 50 - 4Q$. They are negotiating the price for 4 units of the product.

a. What is the monopolist's reservation price for 4 units?

b. What is the monopsonist's reservation price for 4 units?

Study Question 9.8 You are an integrated oil company that produces and refines crude oil. You produce a 1000 b/d, your annual depreciation is 200, you pay royalties on your lease of 12% of price, your operating cost is $5.10 per barrel, you pay corporate taxes of 40%, and you sell your product to your refinery at $60 per barrel.

- **a. What are your annual after tax accounting profits for crude oil production?**

- **b. Your refinery processes the crude oil. The product gains 5% in volume with refinery and sells for an average of $30 per barrel. Your depreciation for the refinery is 500, operating costs per barrel are $4. You pay a corporate tax rate of 40%. What are your after tax accounting profits for your refinery? What are your total profits.**

- **c. Now suppose that Congress passes a depletion allowance of 20%. This means that you will be able to deduct 20% of your gross profits after royalties from your profits before computing your corporate tax. What are after tax production profits now?**

- **d. What happens to your after tax profits, if you charge the refinery $20 for the crude oil instead of $15?**

Chapter 10 Game Theory in W. European Natural Gas Market

Study Question 10.1 Go to www.eia. gov/countries (geography, international, fuel) and see if you can find data to explain why the UK is a net importer of natural gas in 1993.

Study Question 10.1 Go to www.eia.doe.gov (geography, international, fuel) and see if you can find data to explain why the UK is a net importer in 1993.

Study Question 10.2 Using Table 11.2, write a brief summary of how energy production changed in W. Europe from 1983 to 1998. Include some country detail to show how patterns changed in different countries.

Study Question 10.3 Suppose two Cournot duopolists face the following demand and cost functions.

$$\boldsymbol{P = 100 - 0.5(q_1 + q_2)}. \tag{435}$$

$$\boldsymbol{C_1 = 6 + 1.5q_1^2}. \tag{436}$$

$$\boldsymbol{C_2 = 4 + 2q_2}. \tag{437}$$

At the equilibrium level, what would $q_1, q_2, P, MC_1, MC_2, \pi_1$ and π_2 be? This model can easily be extended to more suppliers. Then each player would have a reaction function that depended on the production of the other players. For example, the Norwegian Central Bureau of Statistics has modeled the European gas market with Norway, Russia, and Algeria as the major players in order to work out optimal gas development plans. (Bjerkholt et al. (1990))

Study Question 10.5 Redo Study Question 10.4 assuming the two producers agree to monopolize the gas market.

Study Question 10.6

1. **a. In the monopoly case, if you were negotiating for q_1, how would you argue that the profits should be distributed?**

2. **b. What would be the profits for q_1 and q_2, if you won the negotiation?**

3. **c. If you were negotiating for q_2, how would you argue that the profits should be distributed?**

4. **d. What would be the profits for q_1 and q_2 if you won the negotiation?**

Study Question 10.7

- **a. An interesting result is that in this example, firm 1 does better in the**

Cournot and Stackleberg case than in the monopoly case. Why do you think this happens?

- **b. What would have to happen for firm 2 to agree to join the monopoly?**

Study Question 10.8 How does the price leader model differ from the dominant firm model we discussed in chapter 6. If firm 1 is the dominant firm and firm 2 is the competitive fringe, what are $q_1, q_2, P, MC_1, MC_2, \pi_1$ and π_2?

Study Question 10.9 a. Work out an example with 2 buyers (duopsony) and 1 seller (monopoly) using the same logic as above. The buyers reservation prices are b_1 and b_2 and the sellers reservation price is c with $b_1 > b_2 > c$. What does this example imply about Algerian rents if they can sell not only to Italy but also to Spain.

Study Question 10.10 Pick a renewable energy resource that could be a potential backstop and describe a technology that can be used to convert it to useable energy.

Study Question 10.11 Suppose the average cost function for a backstop technology is 20/x for x less than 20 and is 1 for x $\geq>$ 20. Demand is $Q = 100 - 2P$. A monopolist has a marginal cost curve $MC = 0.1Q$. What would be P and Q for a monopoly following the limit pricing model?

Chapter 11. Externalities and Energy Pollution

Study Question 9.3 Suppose that instead of energy production causing pollution, energy consumption causes the pollution. Therefore demand is the private demand or private benefits. Private benefits subtract the external costs to arrive at the social benefits of energy consumption. As an example take the demand for gasoline. Let supply equal $Q_s = -10 + 16P$ and demand equal $Q_d = 12 - 4P$. Suppose that external costs are 0.25 per gallon.

- **a. What would the market price and quantity be? What are the social losses at this price?**

- **b. What are the optimal price and quantity?**

- **c. What would a tax have to be to make the private and the social cost the same?**

Study Question 9.4 The link http://www.gksoft.com/govt/en/ has links to governments around the world. See if you can find a governmental organization with good environmental information. Write a brief description in English of the information in the link. Indicate the language or languages of the link.

Study Question 9.5 The third incentive would be to subsidize the polluter not to pollute. Suppose the subsidy was *AE* or we paid a firm *AE* for each level of pollution that they abated.

- **a. Explain why this policy would get us the optimal level of pollution.**

- **b. What would this policy cost the government?**

- **c. Although all policies, if properly enforced, could get us to the optimal level *AC*, they have different income distribution effects. Compare the costs to the firm of all four policies - a standard, a tax, a marketable permit, and a subsidy.**

Study Question 9.6 Let marginal cost of pollution in Manhattan be 0 for Q $<$ 5 and -10 + 2Q for Q $>$ 5. Let marginal cost of pollution in Wyoming be 0 for Q $<$ 10 and -10 + Q for $>$ 10. Suppose the marginal benefits of pollution are the same in both places = 20 - 0.5Q.

- **a. What is the optimal pollution in Wyoming and in Manhattan?**
- **b. What are the social losses if the environmental protection agency, U.S. EPA, sets the standard at 15 in both places?**
- **c. If U.S. EPA could only set one standard, would they be better off setting the standard at the optimal Wyoming rate or the optimal Manhattan rate?**

Study Question 9.8 Goodstein (1995) suggests that evaluating hazardous waste legislation is difficult. What evidence can you find to decide whether you think such legislation has been successful or not? You may limit yourself to one country or do comparisons across countries.

Chapter 12 Public Goods and Global Climate Change

Study Question 9.1 Now suppose we have a third consumer. Marginal benefits for the three consumers are as follows

$$MB_1 = 150 - A \tag{313}$$

$$MB_2 = 100 - 0.5A \tag{314}$$

$$MB_3 = 120 - A \tag{315}$$

- **a. If MC = 70, what would be the individual optimal amounts of abatement?**
- **b. What would the total marginal benefit curve be?**
- **c. Where would the kinks be?**
- **d. What would be the social optimum?**
- **e. Now suppose the cost of CO $_2$ abatement is $\boldsymbol{TC = 50 + 0.5A^2}$. What would be the social optimum?**

Study Question 9.2 Suppose that region 3 in Study Question 9.1 is a region that benefits from global warming and they would lose from abatement. Let their benefit curve above be the costs they suffer from abatement of CO2. Thus, the relevant curves for the three regions are:

$$MB_1 = 150 - A \tag{316}$$

$$MB_2 = 100 - 0.5A \tag{317}$$

$$MC_3 = 120 - A \tag{318}$$

or the marginal benefits MB_3 are $-MC_3 = -120 + A$. What is the new social optimum

under this scenario if CO_2 abatement costs are $70 per ton?

Study Question 9.3 Both costs and benefits of CO_2 abatement are uncertain. Suppose that you have the above two benefit scenarios but you also have three possible abatement cost scenarios. The first has probability 0.4 and the second has probability0.10 and the third has the remaining probability.

$$MC_1 = 10 + 0.1A \tag{326}$$

$$MC_2 = 20 + 0.15A \tag{327}$$

$$MC_3 = 30 + 0.2A \tag{328}$$

- **a. What is the probability of cost scenario 3?**
- **b. What is the expected cost?**
- **c. If you maximize expected net benefits, what is the optimal level of abatement for this case?**

Study Question 9.4 Suppose we put some credence on Porter's hypothesis and that scenario 2 actually represents decreasing production costs resulting from abatement. We represent them as negative marginal costs of abatement. Thus, we write the three scenarios as

$$MC_1 = 10 + 0.1A \tag{329}$$

$$MC_2 = -20 - 0.15A \tag{330}$$

$$MC_3 = 30 + 0.2A. \tag{331}$$

- **a. Using the same probabilities for the scenarios as in 9.3, what is the new expected marginal cost curve?**
- **b. If you maximize expected net benefits, what is the optimal level of abatement for this case?**

Study Question 9.5 Verify the above statement by two separate experiments.

- **a. Recompute the costs when only the interest rate is changed to 20 %.**
- **b. Recompute the costs when only the price of electricity is changed to $0.05 per kilowatt hour.**
- **c. At what interest rate is the incandescent light cheaper?**

Study Question 9.6 Let the following represent the losses for our option choice that now includes adaptation

GW NGW

Do Nothing	1000	0
Mitigate	400	200
Adapt	150	200

Which choice is the one that minimaxs regrets?

Study Question 9.7 What would you expect the following events to do to the value of the Euro. Support your answer with a diagram.

- **a. Oil prices increase and Europe needs more foreign currency to import oil.**
- **b. As the European Economies strengthen, European interest rates increase.**
- **c. Increasing productivity in the U.S. lowers U.S. inflation.**
- **d. What do you expect increasing oil prices will do to the exchange rates for OPEC countries? Remember that oil is paid for using dollars?**

Study Question 9.8 There is a tendency for the prices of tradeable goods to converge towards each other differing only by transport cost.

- **a. Why do you think this would be?**
- **b. Non-tradeable goods prices, however, may not converge. Thus, exchange rates may not truly represent the purchasing power of the two currencies within a given country. Exchange rates that represent the relative purchasing power of currencies are also computed and could be an alternative way of converting the GDP's from one currency to another. Such indexes are called purchasing power parity indexes. For one country find their exchange rate, their purchasing power parity index, their GDP, and their population. Which index suggests that they have a higher dollar GDP per capita? You can find most of these statistics in the CIA Factbook http://www.cia.gov/cia/publications/factbook/. Another good source of International Financial Statistics is the International Monetary Funds publication International Financial Statistics.**
- **c. What are some of the other statistics you might find useful if you are considering a large energy investment in a foreign country?**

Study Question 9.9 The Economist Magazine is an excellent source of economic news. Reading this magazine as you are taking economics classes will give you practice in applying the analytical skills you are learning and help you better understand economics of the world around you and to make better economic decisions in your personal and professional life. Look through recent issues of the Economist and find one story relating to the economy and one relating to energy issues. Turn in copies of the articles along with a brief summary of each.

Study Question 9.10 Coal emits 27.9 tons of carbon/billion BTU, gas emits 14.4 tons of

carbon/billion BTU, and oil emits 23.9 tons of carbon/billion BTU.

- **a. If a carbon tax (T) were passed of $0.50 per billion BTU on coal, what would be the carbon equivalent tax on oil and on gas? (Note Tcoal/Toil = Carbon coal/Carbon oil.)**

- **b. If all of the tax is passed on to consumers, what would be the percentage change in carbon emissions from the tax? To answer this question, find the most recent prices and consumption for oil, gas and coal at http://www.eia.doe.gov and use own price elasticities for coal, oil, and gas of -1.14, -0.81, and -1.32 that were found in the literature. You may assume that cross price elasticities are zero to make the problem easier. If you need to convert from physical units to BTUs you may use 1 barrel of oil = 5,800,000 BTUs, 1 short ton of coal = 22,500,000 BTUs and one thousand cubic feet of natural gas (typically abbreviated 1 mcf) = 1,000,000 BTUs.**

- **c. If income growth in the U.S. averages 2.5% a year between the year of your last data (n) and 2012, income elasticities are 0.7, 0.8, and 1.1 for coal, oil, and natural gas, respectively, what BTU taxes would insure that the U.S. meetits target of a 7% reduction below 1990 carbon emissions levels by 2012?**

- **d. I suspect that the elasticities that I found and gave you in b are too elastic. If my suspicions are correct, would the above taxes cause more or less emissions reductions than you computed? Why or why not?**

Chapter 13. Energy Accidents

Chapter 14. Allocating Fossil Fuel Production over Time and Oil Leasing

Study Question 14.1 Pick another country and trace its oil R/P for 5 year intervals since 1970. Reserves and production can be found in the Oil and Gas Journal, Worldwide Production Issue in Mid December.

Study Question 14.2 Use a graph to show that if the allocation were between f and g in Figure 12.6, instead of at d, you would have lower social welfare than at the competitive optimum.

Study Question 14.3. What are Q_o, Q_1, P_o, P_1, PV of π and PV of consumer surplus for model 2 with income growth.

Study Question 14.5 Make marginal costs a function of production (Model 5b - cost a function of production) instead of a constant as in 4a (constant marginal costs) or

$$\boldsymbol{MC}_o = 20 + 0.2Q_o. \tag{555}$$

$$\boldsymbol{MC}_1 = 10 + 0.2Q_1. \tag{556}$$

Costs are lower in the future period because of technical progress. Show the optimum for this problem in a diagram and mathematically solve for Q_o, Q_1, P_o, P_1, $\boldsymbol{PV}_r$, and $\boldsymbol{PV}_{cs}$ of social welfare.

Study Question 14.6 Although technology reduces costs, depletion raises them. We can represent depletion by making costs a function of cumulative production in Model 5c or

$$MC_o = 20 + 0.2Q_o. \quad (557)$$

$$MC_1 = 20 + 0.2Q_o. \quad (558)$$

Note cumulative production at the beginning of the future period is how much has been produced in the current period Q_o.

- **a. Explain why MC_1 is a function of Q_o when costs are a function of cumulative production.**
- **b. Show the optimum for this problem in a diagram.**
- **c. Mathematically solve for Q_o, Q_1, P_o, P_1, PV of π, and PV of social welfare.**
- **d. How could we change the marginal cost function to also represent economies of scale?**

Study Question 14.7 Suppose the backstop price were $27 in the above example.

- **a. What would current price be?**
- **b. What would price in the future period be?**
- **c. How much of the resource is consumed in the current period? The future period?**
- **d. How much of the backstop is consumed in the future period?**

Study Question 14.9 Complete a Table similar to Table 12.4 for the case where MC is constant at 20. Do reserves last a shorter or long period when costs are included in the model?

Study Question 14.10 Redo Table 12.4 for a monopoly producer.

Study Question 14.11 a. What would a unit tax of 1 do to the production profile of model 5a above?

b. What would an ad valorem tax on price of 8%, do to the production profile of model 5a above?

Study Question 14.12 Suppose a 50% rent tax is imposed in model 5a. Economic costs including opportunity cost are $20.

a. Suppose opportunity costs of $5.00 are not allowed to be deducted before paying the tax. How would the tax distort the production profile from the optimal profile?

b. Suppose the company is able to inflate accounting costs to $22 for tax purposes. How would this distort the production profile from the optimal profile?

Study Question 14.13 For Model 5a, what would you expect competitive bonus bidding to yield in revenue? If the government gave the bid to the company that promised the most production in the current period, what would the price and production profile look like?

Chapter 15. Supply and Costs

Study Question 13.1 Convert the above formula to H measured in feet and F measured in cubic feet per second.

Study Question 13.2

- **a. Set up an excel program to compute unit costs for the above base case scenario. Now compute costs for the following scenarios.**
- **b. Interest rate is 15%.**
- **c. Base case scenario with interest rate 10% but you install your generator at a windier location, where you run at 35% of capacity.**
- **d. Base case scenario except you buy a more durable generator that lasts 25 instead of 20 years.**
- **e. Base case scenario but you have to do some repairs to your turbine which cost $50,000 at year 10.**

Study Question 13.3 In a bit more realistic example, the wind patterns might follow some probability distribution over time at varying wind speeds. Suppose that the generated amount of electricity is proportional to the wind speed and that at 20 mph it generates at 600 kw, at 15 mph it generates at 450 kw, at 10 mph is generates at 300 kw, at 5 mph it generates at 150 kw, and with no wind it generates no power. Assuming only five possible wind speeds, let the probability distribution of wind speed be:

x = wind speed (mph)	P(x) = percent of time
0	0.35
5	0.25
10	0.15
15	0.15
20	0.10

- **a. What is the expected or average value of wind speed per year? Remember the expected value of a discrete random variable is E(x) =** $\Sigma_{i=1}^{n} x_i \boldsymbol{P}(x_i)$**.**
- **b. What is the expected amount of power generated each year, if power is generated according to the function g(x), which is electricity generated as a function of wind speed, with g(x) = 30x. Remember the expected value of a function of a discrete random variable is** $\boldsymbol{E}(\boldsymbol{g}(\boldsymbol{x})) = \Sigma_{0}^{n} \boldsymbol{g}(x_i) * \boldsymbol{P}(x_i)$.

In the case of a linear function, where $\boldsymbol{g}(\boldsymbol{x}) = \boldsymbol{a} + \boldsymbol{bx}$,

$$E(g(x)) = \Sigma_{i=1}^{n}(a + bx_i)P(x_i) \quad (589)$$

$$= \Sigma_{i=1}^{n} aP(x_i) + bx_iP(x_i) \quad (590)$$

$$= a\Sigma_{i=1}^{n}P(x_i) + b\Sigma_{i=1}^{n}x_iP(x_i) \quad (591)$$

$$= a + bx = a + bE(x). \quad (592)$$

c. What is the expected cost of power per kilowatt hour?

Study Question 13.4 Suppose the wind follows a continuous probability function f(x) from 0 to 20 miles per hour. You have found a probability density function for wind speed of f(x) = 0.005*(20 - x).

- **a. Is this a bonafide density function? (i.e. Does $\int_0^{20} f(x)dx = 1$?). If it is not, fix it to integrate to 1.**
- **b. What is the expected wind speed in this case? Remember that expected value in the continuous case is $\int_0^{20} x\, f(x)dx$.**
- **c. Assume that power generated = (wind speed)/(20*600) for z between 0 and 20. What is the expected electricity generated per year?**
- **d. What is the expected capital cost per kilowatt hour?**

Study Question 13.5 The Nuclear Energy Agency computed the costs in Table13.7. Does a discount rate of 5% seem high or low to you? For a comparison find a bond rate for an electrical utility, preferably one with nuclear power plants. Would costs be higher or lower if the bond rate you found were used instead? Why?

Study Question 13.6 Show that the formula for $ $_o$ and $ $_t$ for the discrete case can be written as

$$\$_o = \frac{K}{Q}/\Sigma_{t=1}^{n}\frac{(1-\alpha)^t}{(1+r)^t} \text{ and } \$_t = \frac{K}{Q}/\Sigma_0^{n}\frac{1}{(1+r)^t}. \quad (621)$$

Study Question 13.7 a. What are unit costs for a pipeline that will be used to transport 300 million barrels of oil a year for 25 years? Its initial cost is $500 million and your discount rate is 11%. b. Now suppose that you don't know the cost ofthe pipeline. You know it will be 1000 miles long and you know how much crude you will have to transport from part a. Cookenboo has calculated the throughput of a pipeline as:

$$T^{2.735} = H * (D)^{4.735/0.01046}$$

Where T = throughput in thousands of a barrels per day. D = inside diameter, which is 1/2 inch less than the outside diameter of the pipe. H is the pumping station horsepower in thousands. The *Oil and Gas Journal* reports pipeline costs for the U.S. in the Annual Pipeline Economics Report, which is published in September every year. You have chosen a pipeline with a 20" outside diameter. What size pumping station wouldyou need to pump 300 million barrels a year. (Round to the nearest horsepower). Find the per mile

cost of a 20" pipeline from the latest Pipeline Economics report. Add 15% to this cost to account for pumping station costs. What is your best unit transport cost estimates for your pipeline?

Study Question 13.8 Values for the denominator of our continuous and discrete case are

$$\text{Continuous: } \int_0^n e^{(-\alpha-r)t}\,dt, \text{Discrete: } \Sigma_{i=0}^{n}\frac{(1-\alpha)^t}{(1+r)^t}. \tag{622}$$

These are computed in Table 13.8 for various interest rates, decline rates, and project lives. Fill in the missing values and verify the values in Table 13.8. Give an intuitive explanation of what happens to costs as interest rates increase and asproject life lengthens for both the continuous and discrete case.

38. Denominators for Computing Capital Costs in the Continuous and Discrete Cases for Various Interest Rates

Decline Rate = →	**0%**	**5%**	**10%**	**15%**
Discrete Discounting at IIR(r) =5%				
Project life ⇓				
20 years	13.46	9.22	6.73	5.19
25 years	15.09	9.72	6.87	5.23
30 years	16.37	10.03	6.94	5.24
infinity				
Discrete Discounting at IIR(r) = 10%				
20 years	9.51	7.00	5.42	4.38
25 years	10.08	7.17	5.47	4.39
30 years	10.43	7.26	5.49	4.40
Infinity				

Continuous Discounting at IIR(r) = 5%				
20 years	12.64	8.65	6.33	4.91
25 years	14.27	9.18	6.51	4.97
30 years	15.54	9.50	6.59	4.99
infinity	20.00	10.00	6.67	5.00
Continuous Discounting at IIR(r) = 10%				
20 years	12.64	8.65	6.33	4.91
25 years	14.27	9.18	6.51	4.97
30 years	15.54	9.50	6.59	4.99
Infinity (∞)	10.00	6.67	5.00	4.00

Study Question 13.9 Go to energy trade journals and find a project for which capital costs are reported. Compute unit costs for this project. For example if you choose an electricity generation plant compute cost per kilowatt hour, if you chose a refinery compute cost per barrel, if it's an LNG tanker compute costs of transporting a metric ton, it it's the cost of developing a gas field compute costs per cf. Use an interest rate of 15%. State any assumptions you are making about the life of the project. Reference your cost source and note if it's a journal that we should add to the following list. Examples of Trade Journals include

- **American Gas Association Monthly**
- **American Gas**
- **Coal**
- **Coal Age**
- **Coal Outlook**
- **Electrical World**
- **Energy Daily**
- **Energy Developments**

- **Energy World**
- **Independent Energy**
- **Independent Power**
- **Marathon World Review**
- **Mining Magazine**
- **National Coal Voice**
- **Offshore**
- **Offshore Incorporating the Oil Man**
- **Oil and Energy Trends**
- **Oil and Gas Investor**
- **Oil and Gas Journal**
- **Oil Investors Journal**
- **Oil Week**
- **Pacific World Oil**
- **Petroleum Economist**
- **Petroleum Independent**
- **Petroleum Intelligence Weekly**
- **Petroleum News**
- **Petroleum Review**
- **Petroleum Times**
- **Southwest Oil World**
- **Western Energy Update**
- **Western Oil World**
- **World Coal**
- **World Oil**

Chapter 16. Modeling Energy Demand

Chapter 17. Refining, Transportation, and Linear Programming

Study Question 14.1 The *Oil and Gas Journal* has a worldwide refining issue, usually the third week in December. This issue gives information on process units for refineries around the world. Go to the last issue.

- **a. What are the top 5 countries for refining capacity?**
- **b. What % of total world capacity do they represent?**
- **c. Which of these seems to have the most complicated refineries? (Refineries that only distill oil are the simplest. The more oil is processed beyond distillation, the more complicated the refinery. Crude processed, sometimes called crude runs to stills, is a measure of the total distillation capacity of a refinery. It is the first column in the Oil and Gas Journal Tables labeled crude. Thermal distillation, where crude is simply heated, is the simplest type of distillation. Vacuum distillation, where crude is heated in a vacuum, is slightly more complicated. Other processes are even more complicated. A crude measure of refinery capacity is to divide crude capacity by all other non-distillation capacity.**

Study Question 14.2 Pick a refinery and try to determine its complexity factor using the above formal procedure. Possible sources of information include the following firms that supply turnkey construction of refineries: Bechtel, Fluor, Lurgi Group, andFoster Wheeler. The Oil and Gas Journal also has an annual issue on Construction Projects usually around mid-April.

Study Question 14.3 How much butane would you need to blend in for a *RVP* of 11 in the above problem?

Study Question 14.4 Octane blending requirement s can be computed in the same way as vapor pressure. Compute the motor octane number of the blend in Study Question 14.3. Suppose you need to raise the motor octane to 80 by blending in alkylate with an octane of 95.9. How much alkylate would you need?

Study Question 14.5 (More challenging) You will note that the blended gasoline in Study Question 14.4 no longer meets the *RVP* specification. Use a two equation model to compute both the amount of alkylate and butane to add to meet both *RVP* and octane requirements. Your alkylate has an *RVP* of 3.

Study Question 14.6 Astron International has software to help you compute stream blending and other refinery and petroleum related characteristics. Download a sample program and see what you think of it. http://www.astroninc.com/astron/derlinepctkdetl.htm

Study Question 14.7 Draw two isoquants for grade two gasoline. One for a quantity of 1.75 gallons and the other for a quantity of 3.50 gallons.

Study Question 14.8 Develop the constraint for u_2, $0.8X_1 + 0.57X_2 \leq$ 140,000.

Study Question 14.9

- **a. Use Excel Solver to solve for optimal profits in the above example as described above.**
- **b. Change the amount of crude D available to 200 and resolve. What happens to profits, crude runs and product production?**

Study Question 14.10 A simple example illustrates the magnitude of the economies of scale in tankers. Suppose you have a box 10 x 10 x 10.

- **a. What is the area of the surface of the box? What is its volume?**

- **b. Now double the dimensions of the box to 20 x 20 x 20. What is the area of the surface? What is the volume of the box?**

- **c. Would these same economies of scale hold for a pipeline? Explain. Remember the circumference of a circle is πd and its area is πr^2, where r is the radius of the circle and d is the diameter of the circle.**

Study Question 14.11

- **a. If you have a tanker that sails 15.8 knots (1 nautical mile per hour = 1.151 land miles per hour) fully loaded, how long will it take you to bring a cargo from the Arabian Gulf to Rotterdam via the Cape?**

- **b. How about via Suez with 15 hours for traversing the canal?**

- **c. Shell has a 374,000 barrel per day refinery at Rotterdam, the world's largest oil port. Suppose that Shell is running the refinery at 84% of capacity and is using Saudi Intermediate. How many 200,000 dwt tankers would Shell require to supply their refinery for a year. Assume that each ship carries 1.5 million barrels of oil. Berthing, offloading/loading ballast, loading/unloading crude, and deberthing average 18 hrs at each end of the voyage. Your tankers come around the Cape of Good Hope with oil and go back through the Suez in ballast.**

Study Question 14.12 Find one other tanker port that can handle VLCCs and one other tanker port that can handle ULCCs.

Study Question 14.13 You have five supply points for crude oil A, B, C, D, E. The amounts available at each point are 10, 20, 30, 80, 100. You have three refineries X, Y, Z with crude oil requirements of 40, 80, and 120, respectively. Transportation costs from each supply point to each refinery are

	A	B	C	D	E
X	7	10	5	4	12
Y	3	2	0	9	1
Z	8	13	11	6	14

a. Set up the objective function and constraints for a transport cost minimization problem.

b. Solve the problem using Excel Solver.

Chapter 18. Energy Futures Markets for Managing Risk

Study Question 15.1

- **a. Find energy prices for two of the following energy products in the *Monthly Energy Review* from the U.S. DOE. (Propane, heating oil, natural gas, electricity, crude oil, gasoline). Graph them in an Excel file to illustrate the price volatility of the two products. Discuss whether the patterns of volatility are**

similar or not.

- **b. What is the sample variance of each price, often designated s^2? Remember the sample variance is measured as**

$$s^2 = \frac{\Sigma_{i=1}^{n}(x_i - \overline{x})^2}{n-1}. \tag{708}$$

- **Where $\overline{x}$ is the sample mean or $x = \frac{\Sigma_{i=1}^{n}(x_i - \overline{x})^2}{n}$.**

- **c. What is the standard deviation of each price? Remember that standard deviation is the square root of the variance or**

$$\sqrt{\frac{\Sigma_{i=1}^{n}(x_i - \overline{x}^2)}{n-1}}.$$

- **Note you can compute means in Excel using the function =average(addresses of the variable). Thus, if your sample values are in an Excel file from A1 to A50, the Excel command for the mean of the sample values is =average(A1.A50). You can compute the sample variance of the sample using the function =var(addresses of the variables). You can compute the standard deviation of a sample using the function =stdev(addresses of the variables).**

- **d. What is the sample correlation coefficient between your two prices? Remember the correlation coefficient between two variables x and y is the sample covariance (σ_{xy}) = $\frac{\Sigma_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{n-1}$ divided by the standard deviations of each variable, which can be computed as follows**

$$\sigma_{xy} = \frac{\Sigma_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{x})}{\sqrt{\Sigma_{i=1}^{n}(x_i - \overline{x})^2}\sqrt{\Sigma_{i=1}^{n}(y_i - \overline{y})^2}} \tag{709}$$

- **Excel can be used to compute the correlation between two variables using the function =correl(addresses of variable x, addresses of variable y). The correlation, often designated by the Greek letter ρ or ρ_{xy}, is a measure of the linear relationship between two variables. $-1 < \rho < 1$. If ρ is positive, when x increases, y increases. If ρ = 1 then there is a perfect positive linear relationship between x and y. For example, if $y = 10 + 2x$, then ρ would be equalto 1. When ρ is negative, when x increases, y decreases. If ρ = -1 there is a perfect negative linear relationship between x and y. If $y = a + bx$, where $b < 0$, then ρ is less than 1. The closer ρ is to one in absolute value the more tight is the relationship. If $|\rho| > 0.9$, then the variables are often considered highly correlated or they tend to move together fairly closely. Even variables with correlations of $|\rho| > 0.8$are considered to have significant correlation between themselves. Menus for these and other statistical functions can be found in Excel by going to Insert, Function, Statistical.**

Study Question 15.2 (Group Project)

- **a. Check the data in the above Table.**

- **b. Which of the above contracts are traded by open outcry (oo) and which**

are traded electronically (et)?

- **c. Find contract volumes for the above contracts.**

Study Question 15.3 Suppose the spot price for natural gas is $2.50 per Mcf, the futures price is also $2.50. You own 1 Mcf of gas and you sold one Mcf on the futures market.

- **a. Using a Table similar to that above, show how the losses and gains in the spot market are offset by the losses and gains in the futures market at time T for S_T = $1.50, $2, $2.50, $3.00, $3.50. What is your mean return for the combined markets? What is the variance of your mean return for the combined market?**

- **b. Now suppose the spot is $2.50, but the futures price is $3.00. Do the same analysis. What are the losses and gains in each market and the combined market? What is your mean return for the combined markets? What is the variance of your mean return for the combined market?**

Study Question 15.4 Suppose that gas spot prices (G_t) on Agricentauri are perfectly correlated with spot turnip prices (T_t) with $G_t = 0.25(T_t)$. Currently gas and turnip spot prices are 2.5 per Mcf and $10 per turnip, respectively. The turnip futures price is $T_t^T = \$11$. You are long 4 Mcf of gas and you short 1 turnip contract at T_t^T.

- **a. Using a Table similar to above and the same prices at S_T, what are the losses and gains in each market and the combined market?**

- **b. What is your mean return for the combined markets?**

- **c. What is the variance of your mean return for the combined market?**

Study Question 15.5 If $F_t^t > 958.3$ in the above example, what should you do to make money? Explain exactly how you make money on your transactions as in the above example.

Study Question 15.6 Suppose you are holding a futures contract on a T-bill that matures in 3 months at a price of $9442. The 3 month risk free rate is 5% per year. The current spot price for the T-bill is $9300. Is this market in equilibrium or could you make money by arbitrage? If so what would you buy and/or sell to make money?

Study Question 15.7 Consider a 10 month forward contract on a Duke Power Stock with a current price $S_t = \$500$. The risk free rate is 8% and the term structure over a two year period is flat. (e.g. shorter term borrowing has the same risk free rate as longer term borrowing up to 2 years). Dividend payments of $75 are paid after 3, 6, and 9 months.

- **a. What is the equilibrium forward price for this bond?**

- **b. If the price were greater than this forward price, how could you make money by arbitrage?**

- **c. If the price were less than this forward price, how could you make money by arbitrage?**

Study Question 15.8 Explain how arbitrage would make the above equation hold.

Study Question 15.9 Show that F_t^t for further out contracts decreases in a backward market where $r = 1\%$, $\mu = 1\%$, $\delta = 3\%$, $S_t = 20$.

Study Question 15.10 Suppose that United Airlines will buy 500,000 gallons of jet fuel in three months. The standard deviation of the price for jet fuel is 0.028 per gallon. The company uses heating oil contracts for hedging since there is no futures market for jet fuel. The standard deviation of the futures price for heating oil is 0.05. The correlation coefficient between the changes in the jet fuel price and the changes in the heating fuel future price = 0.9.

- **a. To hedge should United buy or sell futures contracts?**
- **b. What is the optimal hedge ratio (h)?**
- **c. How many 42,000 gallon heating oil contracts should United Airline buy or sell?**

Study Question 15.11

- **a. Compute a (3-2-1) crack spread using spot prices and refinery runs from the most recent *Oil and Gas Journal*. Use Gulf Coast Prices.**
- **b. Compute a 3-2-1 crack spread using Nymex 3 month futures.**
- **c. Compute a 5-3-2 crack spread using Nymex 3 month futures. The *Wall Street Journal* is one popular source of the price data you will need. Indicate the trading day and data source. Also you should be able to get the appropriate data from www.nymex.com.**
- **d. Suppose you are a refinery and you hedged 3 months ago with a 3-2-1 spread. Using actual spot and futures values from 3 months ago, show your gains or losses in the spot and future market and how they offset each other.**

Study Question 15.12 A third example is that by a subsidiary MG Refining and Marketing (MGRM) of Metallgesellschaft A.G, which was Germany's 14 th largest industrial firm in 1993. In this more complicated trading strategy, MGRM contracted to supply gasoline and heating oil at fixed prices for 10 years. It then hedged these forward contracts with futures and other over the counter assets. So far, so good. Where the problem arose was that the hedging was in short term assets, whereas the forward contracts were long term. Thus, the short term assets had to be continuously rolled over. Such a strategy can work when markets are in backwardation but not when they are in contango as they were through 1993 and the beginning of 1994. Explain why their strategy could make money in an inverted market but not in a normal market?

Chapter 19. Energy Options Markets for Managing Risk

Study Question 16.1 Give another energy example where you might want to lock in a maximum price? A minimum price?

Study Question 16.2 The above formulas can be used to graph the net payoffs. Use Excel to graph a short call with strike price of \$2.30 and $C_t = \$0.10$ for S_T from 0 to \$6. Note the Excel command for maximum is max. The increment for S_T is set up in a deparate cell D2. \$D\$2 locks the formula onto D2. Copy A6 down the column and B5 down the column. See the spreadsheet below for guidance.

	A	B	C	D
1	K=	2.5	Ct =	0.2
2	Start	0	Increment	0.25
3		Value		
4	St	Short Call		
5	0	+MAX(A5-B1-D1,-D1)		
6	=A5+D2			
7				
8				
9				
10				
11				
12				
13				

Study Question 16.3

- **a. At what spot prices S_T would you be in and out of the money, using the above table, if you owned a June natural gas put for $6.15?**
- **b. Puts and calls effectively put a maximum or a minimum price on a commodity. Which puts a maximum price and which puts a minimum price.**

Study Question 16.4 Why do you think it costs more to buy a call at $6.15 than a put at $6.15?

Study Question 16.5

- **a. Revalue the above call if n is 0.12 instead of 0.10.**
- **b. For the above example, what would p_u (value of the put when the stock prices goes up) and p_d (the value of the put when the stock prices goes down) be for a put option with strike price $100?**
- **c. Value the put by plugging in p $_u$ for c_u and p_d for c_d into equations 16.2 and 16.3.**

Study Question 16.6 Assume a stock price is $110 and next year it will either rise by 20% or fall by 10%. The risk free rate is 5%.

- **a. Find the value of a call option with an exercise price of $120 which expires in a year by using a replicating portfolio?**
- **b. What are the equivalent risk free probabilities associated with these**

market price changes? What do they imply about the price of the portfolio?

- **c. Find the value of a put option for this stock with the same exercise price using the same replicating formula?**
- **d. Value the same portfolio using the probabilities from part b.**

Study Question 16.7

- **a. For the above example, value a European Put with strike price of 102.**

1. **b. For the above example, value a European call with strike price of 102.**

Study Question 16.8.

- **a. In the above problem, what is the probability that you get to D, E, and F?**
- **b. Value an American put for the above problem with strike price of 102.**
- **c. Value an American call for the above problem with strike price of 102.**

Study Question 16.9

- **a. Value the put in Study Question 16.8 if the expiration date were 3 periods out.**
- **b. Value the call in Study Question 16.8 if the expiration date were 3 periods out.**

Study Question 16.10. You have daily data for a week for oil prices. Monday = $24.75, Tuesday = $25, Wednesday = $25, Thursday = $24.90, Friday = $24.80. Compute the daily rate of return using the discrete formula above.

Study Question 16.11.

- **a. Let $S_t = e^{\mu_t} S_{t-1}$. $S_{t-1} = 10$, $\mu_t = 0.07$. Compute S_t?**
- **b. Let $S_t = e^{\mu_t} S_{t-1}$. $S_{t-1} = 10$, $\mu_t = -0.1$. Compute S_t?**
- **b. Let $S_t = e^{\mu_t} S_{t-1}$. $S_{t-1} = 10$, $\mu_t = 0$. Compute S_t?**

Study Question 16.12

Suppose daily data for oil prices is Monday = $24.75, Tuesday = $25, Wednesday = $25, Thursday = $24.90, Friday = $24.80. Compute the daily rate of return, its mean, and its variance using the continuous formula for rate of return $\mu t = lnS_{t+1} - lnS_t$.

Study Question 16.13 Compute U, D, and p for the call above example assuming that the daily interest rate is 0.0002.

Study Question 16.14 Compute U, D, R and p for a monthly lattice using the above example.

Study Question 16.15 If the bond you would purchase had continuous compounding, the risk free probability would be computed from the equation

$$S_t * U * p + S_t * D * (1 - p) = B_t * e^r \quad (774)$$

- **a. What would the solution to p be in this case for the values from 16.14?**
- **b. Note you can always convert continuous compounding to discrete and vice versa by changing the interest rate. For example if the rate = 0.05 percent using annual compounding the continuous rate would be solved from $(1 + 0.05)^{-1} = exp^r => r = ln(1.05) = 0.049$. If the continuous rate is 0.10, what is the equivalent rate for annual compounding.**

Study Question 16.16 If the monthly variance of an asset was 0.051, what would be its weekly variance? What would be its daily variance?

Study Question 16.17 (Group Project)

- **a. Using daily data, compute the variance of the rate of return of a one month futures contract for W. Texas Intermediate (WTI).**
- **b. Compute U, D and p from your answer to part a for a monthly lattice.**
- **c. Use U, D, and p to value an American call option purchased this month for 3 months from now at strike price 25.**

Study Question 16.18

- **a. Create the Excel worksheet and graph to create the above straddle.**
- **b. A long strangle is another strategy, where you buy a put and call. In this case, the call strike price is above the market price and the put strike price is below the market price. In this case the market price was $31. Change your worksheet to create the following strangle**

	Strike Price	
Call	$32.00	$0.53
Put	$30.00	$1.83

Note all you have to do is change the values in cells D1, D2, F1, F2 of your spreadsheet. You can also change B1 and B2 if you want to change the range of S_T over which you want to evaluate your trading strategy.

You can also sell puts and calls. To represent them you would take minus the formulas for buying them from above.

Study Question 16.19 Below are other spreads that involve 2 option contracts. Graph them in the program you have created. Use the following costs for puts and calls. Note when you might want to use each spread. The spot price was approximately $26.15 at the time these options were valued. Note the =strike prices are in cents per barrel whereas the cost of the puts and calls are in dollars per barrel.

20-Mar-01

Crude Oil	Call	Put
Strike Price	June	June
2550	2.16	1.07
2600	1.89	1.29
2650	1.62	1.52
2700	1.32	1.72
2750	1.11	2.01
2800	0.93	2.32

WSJ 3/20/01, C14

Spread	Call or Put	Strike Price	Cost
Short Straddle = Sell Put and Call at same strike price	Call	-26.5	1.62
	Put	-26.5	1.52
Short Strangle = Sell call above, put below market price	Call	-27.5	1.11
	Put	-25.5	1.07
Bull Spread	Call	25.5	2.16

Call = buy call below market, sell call above market	Call	-27.5	1.11
Bear Spread Call = buy call above market, sell call below market	Call	27.5	1.11
	Call	-25.5	2.16
Bull Spread Put = buy put below market, sell put above market	Put	25.5	1.07
	Put	-27.5	2.01
Bear Spread Put = buy put above market, sell put below market	Put	27.5	2.01
	Put	-25.5	1.07

The above trading strategies can also be modeled using the file optionstrading.xls at http://dahl.mines.edu/courses/dahl/530/optiontrading.xls. To graph one option at a time change the values in cells A3 to D3. In A3 enter whether you are graphinga put or a call. Be sure to use singular for the put or call (i.e put not puts, call not calls). Otherwise the program may not work correctly. In cell C3 enter the strike price. Use a positive strike price if you are buying the option, but a negative strike price if you are selling the option. In D3 enter the cost of the option as a negative number.

The model for two contracts at a time is in cells A18.H37. The cells you will have to fill in from A20 to C22 are highlighted in yellow. In A20 enter the name of the spread, which

will print on the graph. Again enter whether the option is a put or a call in column A, the strike price in column B (a positive strike price means you are buying a negative strike price indicates you are selling the option, and the cost of the option in C.

Study Question 16.20 Below are spreads that involve 3 option contracts. You can modify your file to include a 3^{rd} contract or you can use the file optionstrading.xls at http://dahl.mines.edu/courses/dahl/530/optionstrading.xls to graph the payoffs at different spot prices. The model for three contracts at a time is in cells A38.I59. The cells you will have to fill in are highlighted in yellow in A40.C43. Model the following spreads.

Spread	Call or Put	Strike Price	Cost
Put Ratio Vertical = Short more puts than long. Buy	Put	27.5	2.01
the higher strike price and sell the lower strike price. Same	Put	-26.5	1.52
expiration.	Put	-26.5	1.52
Call Ratio Vertical = Short more calls than long call. Buy	Call	25.5	2.16
the lower strike price and sell the higher strike price. Same	Call	-26.5	1.62
expiration.	Call	-26.5	1.62

Put Back Spread =Long more puts than shorts. Buy	Put	26.5	1.52
the lower strike price and sell the higher strike price. Same.	Put	26.5	1.52
expiration.	Put	-27.5	2.01
Call Back Spread = Long more calls than shorts. Buy	Call	26.5	1.62
the higher strike price and sell the lower strike price. Same	Call	26.5	1.62
expiration.	Call	-25.5	2.16

Study Question 16.21

Below are spreads that involve 4 option contracts. These can all be modeled using the file optionstrading.xls. The model for three contracts at a time is in cells A61.J81. The cells you will have to fill in are highlighted in yellow in A64.c68. Model the following spreads.

	Call or Put	**Strike Price**	**Cost**
Butterfly	Call	27.5	1.11

Spread Calls = buy one call high price, sell two			
calls at intermediate price, and buy one call low price	Call	-26.5	1.62
	Call	-26.5	1.62
	Call	25.5	2.16
Butterfly Spread Puts = buy one put with low price, sell	Put	25.5	1.07
two puts at intermediate price, and buy one put at a high	Put	-26.5	1.52
price	Put	-26.5	1.52
	Put	27.5	2.01
Condor with Calls = buy one call at a low and one at a high	Call	27.5	1.11
price and sell two calls at two intermediate prices.	Call	-27.0	1.32
	Call	-26.0	1.89
	Call	25.5	2.16
Condor with Puts = buy one put at a low and one at a high	Put	25.5	1.07

price and sell two puts at two intermediate prices.	Put	-26.0	1.29
	Put	-27.0	1.72
	Put	27.5	2.01

Study Question 17.3 (Group) Check the links in the above Table, add any missing information that you can find. If the company still exists try to find annual revenues. If it does not exist try to find out when they went out of business. If you find other large non-energy companies that are providing information services add them to the Table.

Chapter 20. Climbing the Energy/Development Ladder to a Sustainable Energy Future

Chapter 21. Sustainable Wealth in Fossil Fuel Rich Developing Countries

Chapter 22. Managing in the Multicultural World of Energy

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Study Question 17.4

- **a. Complete the rest of Table 7.6.**
- **b. What will your final allocation of the 20 hours be?**
- **c. Do you have diminishing marginal profit in the problem?**
- **d. Are your second order conditions fulfilled?**

Study Question 17.5 Suppose O represents a consumer's utility function and the H_i's represent the amount of three products the consumer can buy. Let B be the amount of money a consumer has to spend on the three products and P_i be the price of the ith product.

- **a. Explain why your budget constraint is $B = P_1H_1 + P_2H_2 + P_3H_3$.**
- **b. In this case the optimizing function is $L = O(H_1, H_2, H_3) + \lambda(B - P_1H_1 - P_2H_2 - P_3H_3$. What are the first order conditions for this problem?**
- **c. Interprete your first order conditions for this problem.**

Study Question 17.6 Firms also want to pick inputs in an optimal fashion in order to minimize costs. In the age of "bricks and mortor," the focus was on picking optimal amounts of energy, capital, and labor to produce goods. In the age of "clicks and mortor" much more attention is being paid to the proper use of information. Constrained optimization can also give us some insights into the choice between information and our other inputs. Suppose we use three factors of production to produce an output (Q)- information and information technologies (I), energy (E), and other goods (O). We represent the production process by the production function Q = f(I,E,O) The unit cost of each of the inputs is P_i, P_E, and P_0,respectively. We want to minimize the

cost of producing any given amount of output, say Q_o. We can set up the minimization problem as a constrained optimization, where we chooose inputs - I, E, O to minimize cost of output subject to the output constraint. Our Lagrangean in this case becomes

$$\boldsymbol{L = P_E E + P_I I + P_O O + \lambda(Q_o - f(E, I, O))} \quad (819)$$

- **a. What are the first order conditions for this problem?**
- **b. What do they tell you about how you should go about choosing your three inputs?**
- **c. Diminishing marginal product for each factor is represented by $\frac{\partial^2 f}{\partial E^2} < 0$, $\frac{\partial^2 f}{\partial I^2} < 0$, and $\frac{\partial f^2}{\partial O^2} < 0$. Try to explain why this helps insure the solutionto the first order conditions are a minimum and not a maximum.**

Study Question 19.1 Suppose that you have estimated the following time series model for world energy consumption $X_t = 0.9X_{t-1} - 0.4X_{t-2}$. In an Excel spreadsheet, use this model to forecast energy consumption for 100 years. Actual consumption for 1998 and 1999 are 379.77 and 388.88.

Study Question 19.2 Suppose that you have estimated the following time series model for world oil price $P_t = 0.9P_{t-1} - 0.3P_{t-2} + 0.0002Y_t + 0.0001Y_{t-1}$. In an Excel spreadsheet, use this model to forecast world oil price for 100 years. Actual prices for 1998 and 1999 are 14.33 and 10.16 and estimated world income converted to billions of U.S. dollars using currency exchange rates in 1998 is $26,825.5. Assume that world income grows at 2.5% per year.

Study Question 8.2 Group project. Create a table giving information on N. American Gas market hubs. Include the name of the hub, its location, its company or parent company, services offered, and homepage.

Study Question 8.3 (Group Project)

The National Petroleum Council (NPC) (http://www.npc.org/) completed a report on Natural Gas Prospects for the U.S.

- **a. What is the National Petroleum Council?**
- **b. Go over the two volume report downloadable from their homepage 1. Natural Gas Report: Volume I- Summary of Findings and Recommendations (Final) 2. Natural Gas Report: Volume II- Integrated Report (Final)**
- **c. NPC also did a report on gas prospects in the U.S. in 1999. *Meeting the Challenges of the Nation's Growing Natural Gas Demand* (1999). It is downloadable from their site as well. Click on natural gas on the side panels and find the report and go over it. What are the major conclusions from this report? What are the similarities in conclusion to the 2004 report? What are the basic differences and why?**

Study Question 9.1 You are the manager of the Emergency Response Department of a large shipping company. It's January, and you are loafing around on the last day of your New Year

holiday, when the phone rings. Your worst nightmare has come true - one of your company's oil tankers has run aground off the Shetland Islands and is spilling crude oil. You have to clean it up. The crew has already been airlifted off the ship, but since then the weather has gotten much worse. Gale force winds are blowing and whipping up large waves. Develop a response strategy plan. Things you should include are

- **What kinds of damage is the spill likely to cause?**
- **What technologies are available to clean up the spill?**
- **How are you going to handle the press?**
- **What information would you collect to try and prevent this from happening again?**

These principles are called the Valdez principles or CERES after the Coalition for Environmentally Responsible Economies (CERES). Corporations endorsing these principles CERES members. For information on how a corporation may join visit (http://www.ceres.org/Page.aspx?pid=426). Go to the bottom of the page to download or view the form.

Study Question 9.2 Browse this site. Note the companies who are participating. After taking a look at the form, if you were CEO of a large energy corporation would you be inclined to endorse these principles and prepare an annual self-evaluation? Why orwhy not? Your grade does not depend on whether you endorse these principles but upon your justification.