Midterm Exam 2: Answer Sheet

1. (6 points each) True, False, Uncertain, and Explain. Explain whether the statement is true, false, or uncertain.

(a) "If shocks to oil demand and supply are permanent then storage behavior is more likely to smooth prices than if shocks are transitory. Transitory shocks lead to much more volatile swings in prices."

**brief answer** False. If shocks are transitory then traders will expect price to revert back to the mean. So to take advantage of temporary fluctuations they will trade into the wind. For example, if demand is temporarily high then traders will reduce inventories to take advantage of temporarily high prices. This will reduce the upward pressure on prices. But if shocks are permanent then traders will not expect reversion, so they will not reduce inventories to take advantage of temporarily high prices, since prices may be permanently high.

(b) "Because OPEC controls a large share of world oil supply, oil price volatility is much lower in the period since 1973 than it was before then."

**brief Answer** False. First, we know that prices are more volatile since 1973 than before. Second, OPEC has contributed to this by reducing spare capacity in their aim to push up prices. With supply less elastic in the medium run, there is little incentive for traders to reduce inventories in the face of supply shocks. With more elastic supply the effect of shocks on price would be less. But OPEC constrains investment in capacity in its part of the world, reducing supply elasticity.

(c) "Because the most productive (low cost) oil fields in the world are in OPEC countries, as the cartel gains power world oil production becomes more efficient."

**brief answer** False. While it is true that most of the really low-cost deposits in the world are in OPEC, this has not led to more efficient production. The reason is that OPEC’s supply restrictions have led to more production outside of OPEC where prices are higher. OPEC has caused a shift in the distribution of world production towards higher costs producers, which is not efficient. Instead of producing from low cost-deposits first, as a social planner would choose, since 1973 we have seen growth in production in high-cost deposits.

(d) "Between 1950 and 1990 the ratio of petroleum reserves to annual consumption fell by two-thirds, and that is why oil prices are so high today."

**brief answer** False. In 1950 the ratio of petroleum reserves to annual consumption was approximately 22 years. By 1990 this ratio was 45 years. So it practically doubled.

(e) "If supply and demand are very elastic then small shocks to oil availability will produce large effects on the price of oil."

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**brief answer** False. The more elastic are supply and demand the smaller the impact on price from a small shock. We know that the change in price is equal to $\frac{1}{\varepsilon_s - \varepsilon_d}$ so higher elasticity makes the denominator smaller, not larger.

2. (25 points) Suppose that total oil production in each period is given at the level $x_t$, and that the demand for oil is given by $d(p_t)$, where $p_t$ is the spot price of oil. Draw the diagram for the current market of oil. Label the market clearing price, $p^*$.

**brief answer** Consider figure 1 where we have demand and supply. The market-clearing price is $p^* M$.

![Figure 1: Market for Current Crude Oil](image)

(a) For simplicity, let storage costs and the interest rate both equal zero, and suppose that investors are risk neutral. What is the expected spot price next period, $E_t(p_{t+1})$, equal to? What should the the future price, $F_{t+1}$ be equal to? Explain.

**brief answer** Since $\beta = 1$ and $C = 0$, we have $E_t(p_{t+1}) = p_t$. It is costless to store and there is no opportunity cost of time so the expected price of oil cannot differ from the current price. Similarly then, $F_{t+1} = E_t(p_{t+1}) = p_t$. Why would anyone pay more for future delivery next period if they can costlessly store it and buy if for less this period.

(b) Suppose that "financialization" causes increased demand for oil futures, as investment houses offer energy-related financial assets for their customers. These traders increase the demand for oil futures, driving up the price of oil delivered next period, $F_{t+1}$. If this rise in $F$ is to cause the current spot price to rise above $p^*$ what would we have to observe in the spot market? Use your diagram, if possible, and explain.

**brief answer** Futures trading causes $p_t$ to increase to $p_b > p^*$ in figure 1. Since demand at that price, $d(p_b)$ is less than production, inventories must be rising: $\Delta I_t = x_t - d(p_b) > 0$. We must be observing rising inventories if the spot price is rising.

(c) If the traders continued keeping $F_{t+1}$ high, and if $x_t$ remains unchanged, what must happen to inventories?
brief answer If the futures price remains high and production is unchanged then inventories must be rising every period. So inventories would be getting very large.

(d) Suppose that we do not observe inventories increasing, what would be the relationship between the current spot price and $F_{t+1}$ each period? What would be the relationship between $E_t(p_{t+1})$ and $F_{t+1}$. Could this persist in a market with arbitrage? Explain.

brief answer If inventories are not increasing then $p_t = p^*$ each period. But this means that $F_{t+1} > p_{t+1}$ each period. So the future price is always above the actual spot price. But people will expect $E_t(p_{t+1}) = p_t$ since there is no expected shortage. So contrary to part (a) we would have $F_{t+1} > E_t(p_{t+1})$ which is not consistent with arbitrage. That is why we have to see rising inventories for the "financialization" theory to have a chance to make sense [we know there are other issues with it]

3. (20 points) Suppose the interest rate unexpectedly, and suddenly, decreases. What happens to oil production and the price of oil in the current period in the Hotelling model? What happens to oil production and the price of oil in the Adelman model? What explains the differences, if any in the predictions of the two models?

brief answer In the Hotelling model we know that a lower interest rate means slower depletion. The time profile of production flattens. Since next period’s net price is now worth more in present value it would be better to delay production. But this must raise the current price. So the current price rises. In the Adelman model the change in the rate of interest has two offsetting effects. A lower interest rate raises the present value of future production which would reduce the incentive to produce more today. But a lower interest rate reduces the opportunity cost of development investment and this would tend to increase current production. So, to a first approximation, the two effects offset, so production and the current price ought not to change.

4. (25 points) Suppose that shocks to world income are transitory and that supply is relatively elastic in the medium term. What impact will storage behavior have on price volatility in this environment? Explain.

brief answer It will be stabilizing. Since the income elasticity of energy is positive growth in income leads to growth in the demand for energy. If shocks are transitory then demand shocks will be transitory as well. With elastic supply, traders know that supplies will respond to price so time is short to take advantage of demand shocks. They will reduce inventories in the face of positive shocks and reduce it when there are negative shocks. This behavior is smoothing.

(a) Why is it important that shocks to world income are transitory and that supply is relatively elastic? What if supply was inelastic?

brief answer If shocks to income were permanent then demand shocks would be permanent. This would make traders less like to buy or sell out of inventories in the face of demand shocks. If supply were less elastic, then in the face of demand shocks the price impact would be larger and last longer. Hence, there would be less advantage to replying quickly to demand shocks, again implying less smoothing. When supply is
elastic traders know that the profit opportunities will not last long as more supply will come to the market.

(b) During the long period from 1880 to 1970 were oil price shocks transitory or persistent? Was the price of oil relatively high or relatively low by historical standards during this period?

brief answer Oil prices were relatively low and less volatile during this period. Oil shocks were less persistent, price was mean reverting during this period.

(c) Now suppose that shocks to world income are permanent? How does this alter storage behavior? Explain. What if supply is more constrained in the medium term?

brief answer If shocks to income are permanent – say growth in China for example – then traders who observe a positive shock today expect prices will rise further in the future. So there is no incentive to draw down inventories today. So storage behavior is "leans less against the wind." If supply is more constrained the same impact on storage. Less supply elasticity means that in the face of increased demand supply will not rise to cause prices to revert, hence, traders will be reluctant to draw down inventories since high prices look likely to prevail for a while. Hence, less smoothing.

(d) What are the key factors that can be pointed to so that we can explain what caused the shift in the behavior of the oil price?

brief answer If we focus only on the last change the two key factors are the rise in incomes in emerging market economies, China and India especially, which seem like permanent shocks. And the rise of OPEC limits spare capacity which makes supply less elastic in the medium run. Especially as OPEC limits investment in its countries. If we considered previous epoch changes we could point to the opening of new pipelines that broke the Standard Oil rail monopoly, encouraging more production in 1880, along with the rise in Russian production.