Application Oil Drilling in the Arctic National Wildlife Refuge

We can use information about demand and supply elasticities to answer an important public policy question: Would selling oil from the Arctic National Wildlife Refuge (ANWR) substantially affect the price of oil? ANWR, established in 1980, covers 20 million acres, is the largest of Alaska's 16 national wildlife refuges, and is believed to contain massive deposits of petroleum. For decades, a debate has raged whether the owners of ANWR, the citizens of the United States, should keep it in its undeveloped state or permit oil drilling.[1]

Though the debate is complex, in its simplest form, environmentalists argue that drilling would harm the wildlife refuge and pollute the environment, while President Bush and other drilling proponents argue that extracting this oil would substantially reduce the price of petroleum (as well as decrease U.S. dependence on foreign oil and bring in large royalties). Recent large increases in the price of gasoline and the war in Iraq have heightened this intense debate.

The effect of selling ANWR on the world price of oil is a key element of this debate. We can combine oil production information with supply and demand elasticities to make a "back of the envelope" estimate of the price effects.

A number of studies estimate that the long-run elasticity of demand, E_P, for oil is about -0.4 and the long-run supply elasticity, E_S, is about 0.3. There is less agreement about how much ANWR oil will be produced. The Department of Energy's Energy Information Service (EIS) predicts that production from ANWR will average about 800,000 barrels per day, or about 1% of the worldwide oil production, which averaged about 82 million barrels per day in 2004. (World output was slightly higher in 2005 and is likely to continue to rise. The EIS estimates that ANWR's oil will increase the volume of production by about 0.7% in 2020.)

A report of the U.S. Department of Energy predicted that ANWR could lower the price of oil by about 50¢ a barrel. Given that the price of a barrel of oil was around $50 (and sometimes much higher) in 2005, that is about a 1% change in the price. Severin Borenstein, an economist who is the director of the U.C. Energy Institute, concludes ANWR might reduce oil prices by up to a few percentage points so that "Drilling in ANWR will never noticeably affect gasoline prices." We can make our own calculations of the price effect of drilling in ANWR.

What is the effect of ANWR production on the world price of oil given that E_P = -0.4, E_S = 0.3, the pre-ANWR daily world production of oil is Q_1 = 82 million barrels per day, the pre-ANWR world price is p_1 = $50 per barrel, and daily ANWR production will be 0.8 million barrels per day? For simplicity, assume that the supply and demand curves

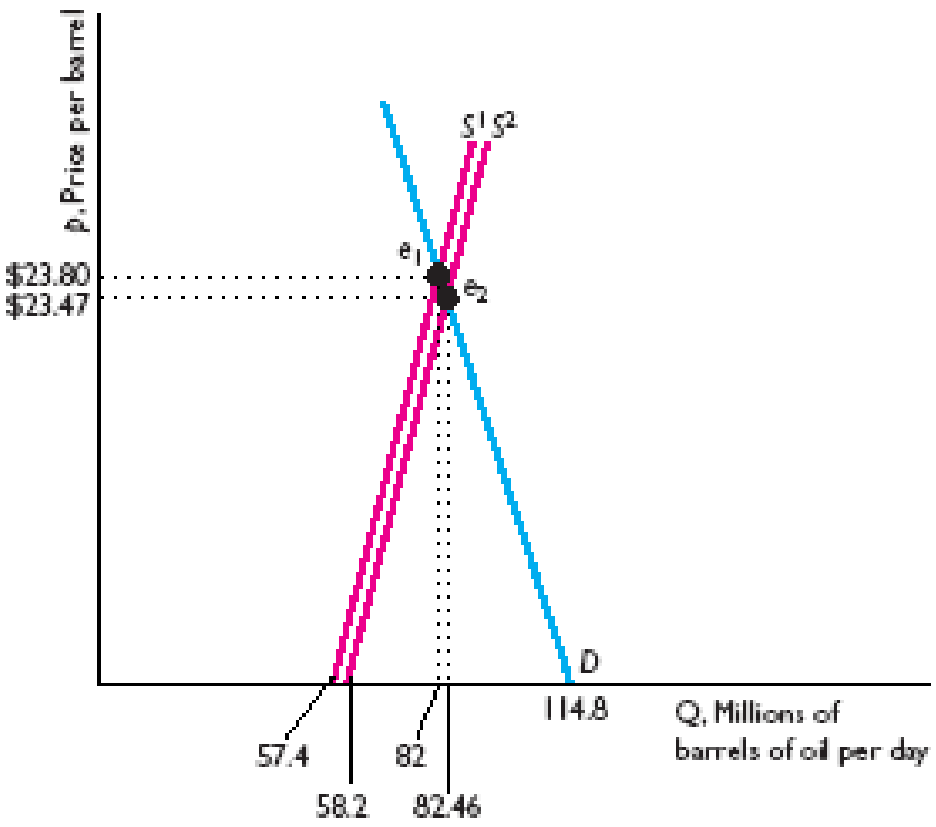
[1] I am grateful to Robert Whaples who wrote an earlier version of this analysis. In the following discussion, we assume that the oil market is competitive for simplicity and use current values of price and quantities even though drilling in ANWR could not take place for at least a decade.

are linear and that the introduction of ANWR oil will cause a parallel shift in the world supply curve to the right by 0.8 million barrels per day.

Answer

1. *Determine the long-run linear demand function that is consistent with pre-ANWR world output and price*: At the original equilibrium, e_1, in the figure, $p_1 = \$50$ and $Q_1 = 82$. There, the elasticity of demand is $E_P = (\Delta Q/\Delta p)(p_1/Q_1) = (\Delta Q/\Delta p)(50/82) = -0.4$. Using algebra, we find that $\Delta Q/\Delta p$ equals $-0.4(82/50) = -0.656$, which is the inverse of the slope of the demand curve, D, in the figure. Knowing this slope and that demand equals 82 at \$50 per barrel, we can solve for the intercept, because the quantity demanded rises by 0.656 for each dollar by which the price falls. The demand when price is zero is $82 + (0.656 \times 50) = 114.8$. Thus, the equation for the demand curve is $Q = 114.8 - 0.656p$.
2. *Determine the long-run linear supply function that is consistent with pre-ANWR world output and price*: Where S^1 intercepts D at the original equilibrium, e_1, the elasticity of supply is $E_S = (\Delta Q/\Delta p)(p_1/Q_1) = (\Delta Q/\Delta p)(50/82) = 0.3$. Solving, we find that $\Delta Q/\Delta p = 0.3(82/50) = 0.492$. Because the quantity supplied falls by 0.492 for each dollar by which the price drops, the quantity supplied when price is zero is $82 - (0.492 \times 50) = 57.4$. Thus, the equation for the pre-ANWR supply curve, S^1 in the figure, is $Q = 57.4 + 0.492p$.
3. *Determine the post-ANWR long-run linear supply function*: The oil pumped from ANWR causes a parallel shift in the supply curve, moving S^1 to the right by 0.8 to S^2. That is, the slope remains the same but the intercept on the quantity axis increases by 0.8. Thus, the supply function for S^2 is $\underline{Q} = 58.2 + 0.492p$.
4. *Use the demand curve and the post-ANWR supply function to calculate the new equilibrium price and quantity*: The new equilibrium, e_2, occurs where S^2 intersects D. Setting the right-hand-sides of the demand function and the post-ANWR supply function equal, we obtain an expression in the new price, p_2:
$$58.2 + 0.492p_2 = 114.8 - 0.656p_2.$$
We can solve this expression for the new equilibrium price: $p_2 \approx \$49.30$. That is, the price drops about 70¢, about 1.4%. If we substitute this new price into either the demand curve or the post-ANWR supply curve, we find that the new equilibrium quantity is 82.46 million barrels per day. That is, equilibrium output rises by 0.46 million barrels per day (0.56%), which is only a little more than half of the daily ANWR supply, because other suppliers will decrease their output slightly in response to the lower price.

Comment: Our estimate of a small drop in the world oil price if ANWR oil is sold would not change substantially if our estimates of the elasticities of supply and demand were moderately larger or smaller. The main reason for this result is that the ANWR output is a very small portion of worldwide supply—the new supply curve is only slightly to the right of the initial supply curve. Thus, drilling in ANWR cannot insulate the American market from international events which roil the oil market. A new war in the Persian Gulf could shift the worldwide supply curve to the left by three million barrels a day or more (nearly four times the ANWR production). Such a shock would cause the price of oil to soar whether or not we drill in ANWR.


P, Price per barrel
$23.80
$23.47
e1
e2
S1
S2
D
114.8
Q, Millions of barrels of oil per day
57.4
58.2
82
82.46