If OPEC wants to take in more revenues from the sale of oil should they increase the price of oil, decrease the price of oil, or hold steady on the price?[1]

erm: draft Oct 17, 2018.

The Organization of Petroleum Exporting Countries (OPEC) is a group consisting of 12 of the world's major oil-exporting nations. OPEC was founded in 1960 to coordinate the petroleum policies of its members, and to provide member states with technical and economic aid.

OPEC has a lot of market power; it does not have a monopoly over oil but it produces a large proportion of the world's oil, so can (almost) set the world price of oil.

Today, let's pretend it is a monopoloy:[2]

What price should OPEC set?

Whether OPEC should increase or decrease the price to increase revenue depends on the price elasticity of demand for oil, $\frac{\%\triangle O_D}{\%\triangle p_O}$ where O_D is the world demand for oil and p_O is the world price of oil.

Note that for OPEC total revenue is highly related to total profit (the cost of pumping additional barrels is close to zero)

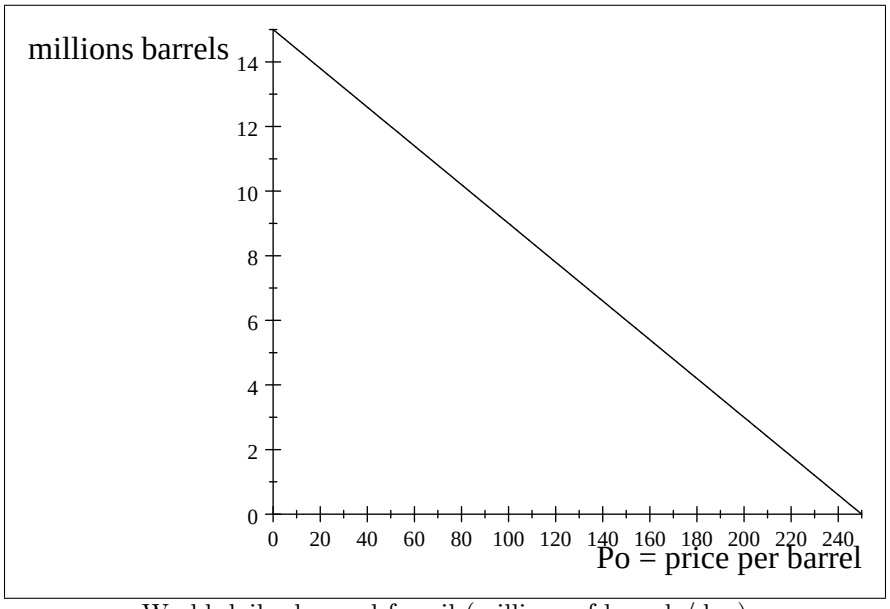
Note that demand function for oil, $O_D = O_D(p_o)$, such that $O_D \downarrow$ when $p_o \uparrow$ Read $O_D = O_D(p_o)$ as the demand for oil is a function of the price of oil. (make sure you understand functional notation.)

[1] Does everyone know what OPEC is? Organization of the Petroleum Exporting Countries.

[2] This is a simplifying statement. OPEC has a lot of control over the price, but not complete control. Here I am simplifying by assuming they have complete control.

1 I will imagine, assume, a linear demand function, specifically $O_D = O_D(p_o) = 15 - .06p_o$, where world demand drops to zero at $\$250$ a barrel (so OPEC does not want to charge $\$250$ a barrel).

p_o is price per barrel measured in dollars and quantity is measured in millions of barrels per day. E.g if price were zero, demand would be 15 million barrels[3]



World daily demand for oil (millions of barrels/day)

(so OPEC does not want to charge $250 a barrel – it would sell nothing, so have zero revenue).

Note that the slope of this curve is $\frac{\triangle O_D}{\triangle p_O} = -.06$, a constant because the demand curve is a straight line, a minus number because the line slopes down. (in the real world it is probably not a straight line.)[4]

[3] In 2011 daily U.S. consumption is approximately 19 million barrels, so demand is too low in my example function.

[4] looking ahead„ the price elasticity of demand is not a constant.

2 Simply put, total revenue is price multiplied by quantity, in this case $TR(p_o) = p_o * (O_D(p_o))$

(make sure you understand this notation)

It says that total revenue is price multiplied by quantity demanded, where quantity demanded is a function of price.

If OPEC raises the price of oil, demand will go down, $O_D \downarrow$. The question is whether $p_o * O_D$ increases or decreases when price increases or decreases.

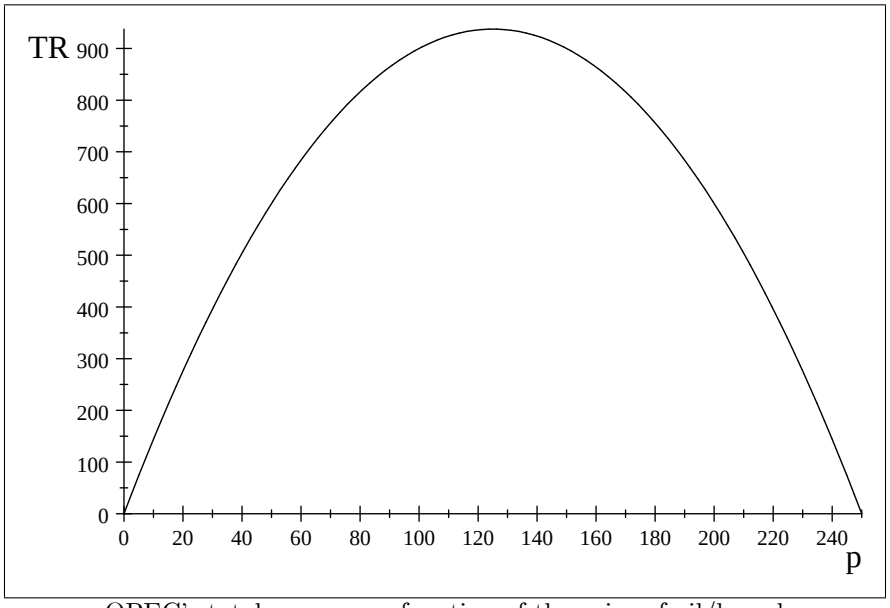
Let's calculate total revenue at a few prices.
$TR(p_o) = p_o * (O_D(p_o)) = p_o * (15 - .06p_o) = 15p_o = .06p_o^2$

When $p_o = \$25$ a barrel, total revenue is $25(15 - .06(25)) = 337.5$ million
When $p_o = \$50$ a barrel, total revenue is $50(15 - .06(50)) = 600.0$ million, so OPEC has almost twice the revenue at \$50 compared to \$25
When $p_o = \$100$ a barrel, total revenue is $100(15 - .06(100)) = 900.0$million
When $p_o = \$150$ a barrel, total revenue is $150(15 - .06(150)) = 900.0$ million
When $p_o = \$200$ a barrel, total revenue is $200(15 - .06(200)) = 600.0$ million

When $p_o = \$250$ a barrel, total revenue is $250(15 - .06(250)) = 0$

Total revenue, $TR(p_o)$ first increases in price and then decreases in price.

$TR(p_o) = p_o(15 - .06(p_o)) = 15p_o - .06(p_o)^2$
Graphing this



OPEC's total revenue as function of the price of oil/barrel

Can you guess the price elasticity of demand for oil at $p = 120$?

3 Whether $TR(p_o)$ increases, stays the same, or decreases when p_o increases depends on the $\frac{\%\triangle O_D}{\%\triangle p_O}$ at the current price/quantity.

If at the current price, $\frac{\%\triangle O_D}{\%\triangle p_O}$ is between zero and -1 (price inelastic),marginally raising the price will increae OPECs total revenue from the sale of oil.

If at the current price, $\frac{\%\triangle O_D}{\%\triangle p_O}$is less than -1 (price elastic), marginally raising the price will decrease OPECs total revenue from the sale of oil.[5]

In words (and hopefully some intutition), if at the current price the demand for oil is elastic (price senitive in % terms) and OPEC raises the price by 1% ,demand for oil will fall by more than 1% and total revenue will fall.

If at the current price the demand for oil is inelastic (price insenitive in % terms) and OPEC raises the price by 1% ,demand for oil will fall by less than 1% and total revenue will rise.

[5] Remember that less than -1 are number like -2, $-.5$, for example, is not less than -1.

So OPEC want to raise the price as long as the price elasticity of demand is inelastic.

3.1 For our imagined demand curve for oil, let's calculate the price elasticity of demand curve at two different prices (one low, one high)

3.1.1 When $p_o = \$50$ and it increases to $\$55$

$$\begin{aligned}\frac{\%\triangle O_D}{\%\triangle p_O} &= \frac{\frac{\triangle O_D}{(O_D(p_o^1)+O_D(p_o^0))/2}}{\frac{\triangle p_O}{(p_o^1+p_o^0)/2}} \\ &= \frac{\frac{\triangle O_D}{(O_D(55)+O_D(50))/2}}{\frac{5}{(55+50)/2}}\end{aligned}$$

But how much does demand change?

$O_D = O_D(p_o) = 15 - .06p_o$

So, $O_D(50) = 15 - .06(50) = 12.0$ million barrels and
$O_D(55) = 15 - .06(55) = 11.\,7$, million barrels

Plugging these into the elasticity formula above

$$\begin{aligned}\frac{\%\triangle O_D}{\%\triangle p_O} &= \frac{\frac{\triangle O_D}{(O_D(p_o^1)+O_D(p_o^0))/2}}{\frac{\triangle p_O}{(p_o^1+p_o^0)/2}} \\ &= \frac{\frac{\triangle O_D}{(O_D(55)+O_D(50))/2}}{\frac{5}{(55+50)/2}} \\ &= \frac{\frac{-.3}{(11.7+12)/2}}{\frac{5}{(55+50)/2}} \\ &= -.266\end{aligned}$$

In this price range a 1% increase in price leads to a .27% drop in demand, so in this range world demand for oil is inelatic. OPEC would raise the price of oil if its intent was to maximize its total revenues.

3.1.2 Alternatively, When $p_o = \$200$ and it increases to $\$205$

$$\begin{aligned}\frac{\%\triangle O_D}{\%\triangle p_O} &= \frac{\frac{\triangle O_D}{(O_D(p_o^1)+O_D(p_o^0))/2}}{\frac{\triangle p_O}{(p_o^1+p_o^0)/2}} \\ &= \frac{\frac{\triangle O_D}{(O_D(205)+O_D(200))/2}}{\frac{5}{(205+200)/2}}\end{aligned}$$

But how much does demand change?
$O_D = O_D(p_o) = 15 - .06p_o$

So, $O_D(200) = 15 - .06(200) = 3.0$ million barrels and
$O_D(205) = 15 - .06(205) = 2.7$ million barrels

Plugging these into the elasticity formula above

$$\begin{aligned}\frac{\%\triangle O_D}{\%\triangle p_O} &= \frac{\frac{\triangle O_D}{(O_D(p_o^1)+O_D(p_o^0))/2}}{\frac{\triangle p_O}{(p_o^1+p_o^0)/2}} \\ &= \frac{\frac{\triangle O_D}{(O_D(55)+O_D(50))/2}}{\frac{5}{(205+200)/2}} \\ &= \frac{\frac{-.3}{(2.7+3)/2}}{\frac{5}{(205+200)/2}} \\ &= -4.263\end{aligned}$$

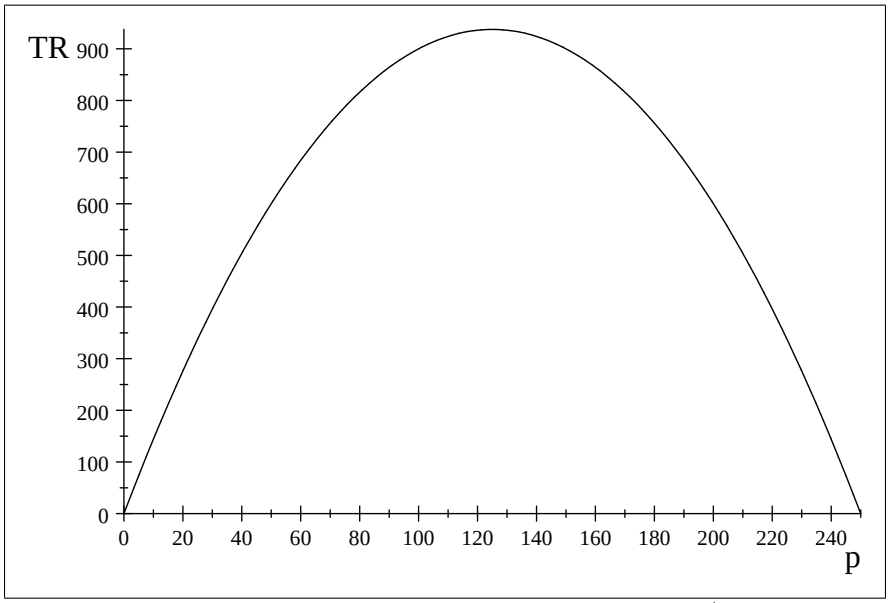
In this price range a 1%, increase in price leads to a 4.26% drop in demand, so in this range world demand for oil is very elastic, so OPEC would not raise the price from here. In fact, they would want to lower the price if the their intent was to maximize their total revenue.

So, OPEC, even though they can set the price as high as they want, they do not want to set it too high.

If their intent is to set price so as to maximize revenues,[6] they will set price at the level where the price elasticity of demand for oil is -1.

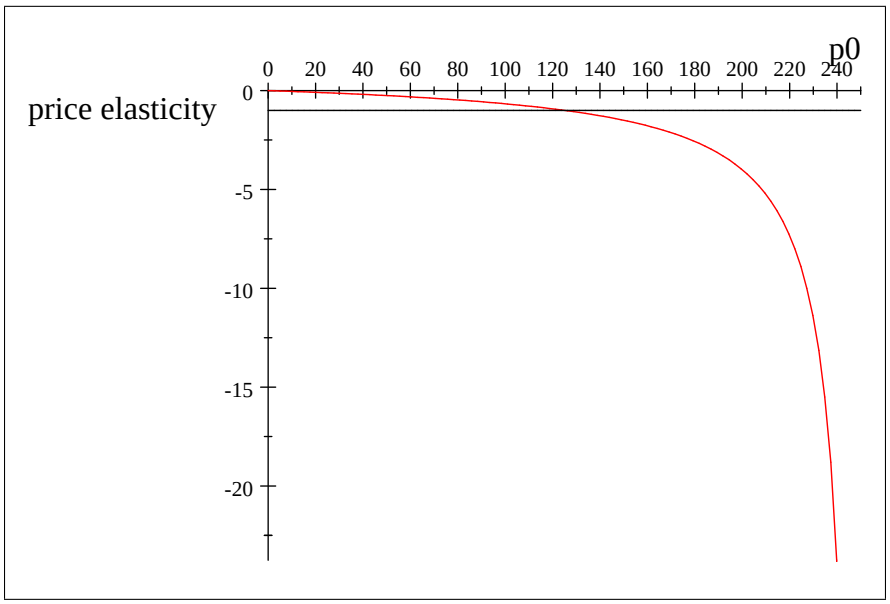
One could use derivatives to calculate the price elasticity of demand for oil.

$\frac{\%\triangle O_D}{\%\triangle p_O} = \frac{\partial O_D}{\partial p_O}\frac{p_0}{(O_D(p_o))} = -.06(\frac{p_0}{15-.06p_0}) = \frac{p_0}{p_0-250.0} = \frac{p_0}{p_0-250.0}$
If one solves this for -1, one gets $\frac{p_0}{p_0-250.0} = -1$, Solution is: 125.0



OPEC's total revenue as function of the price of oil/barrel

[6] Firms want to maximize profits not revenue, but in this case profits pretty much are equal to revenue.



Price elasticy of demand for oil

Note that TR is maximized when the price is set at the level where it price elasticity of demand is -1.