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A Theoretical Framework for the Analysis of Nigeria's Petrol Subsidy (Part 1)

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Abstract: This study provides a simple theoretical framework with which to analyze the effects of Nigeria's petrol subsidy on welfare. We are able to show how a subsidy can improve societal welfare but minor changes to assumptions can negate the results. In particular, rises in crude oil prices can make the optimal subsidy negative.

Key words: International trade in petroleum products, optimal subsidies, import subsidization, minor changes, crude oil, optimal subsidy

INTRODUCTION

A recurring theme in Nigeria's political economy is conflict over whether the Federal government should subsidize the consumption of petrol by the citizenry. It is a highly emotive issue with successive governments claiming the subsidies are too expensive and workers declaring general strikes whenever they feel their fuel consumption subsidies are threatened. Most OPEC governments subsidize petrol as a result of political pressure premised upon a widely held view that the citizenry is entitled because the oil comes out from the ground.

Most Nigerian economists are against subsidization because of its distortionary effects and negative impact on public finances and public debt. On the other hand, some macroeconomists argue that withdrawal of subsidies would have an impact equivalent to a supply-side shock.

All this is fine but there is no theoretical framework upon which we can get guidance to tackle the issue of subsidization of a refined petroleum product head on. Guidance from the practice in European countries is controversial because they tax petrol. Their taxes are simply following the Ramsey (1927) maxim that to raise revenue you impose high taxes on products with relatively inelastic demand. The economics of exhaustible resources, Dasgupta and Heal (1979) also, proposes policies that constrain output of exhaustible resources as a conservation measure. The implication of this is that the consumption of petroleum and its derivatives should be taxed rather than subsidized.

The purpose of this study is to provide a theoretical framework with which to analyze the issue of whether to subsidize or not. In fact, we are able to show that (under restrictive circumstances), the optimal subsidy is positive. In addition to this though, we show how minor changes to the model can negate the proposition. The discussion focuses mainly on Nigeria but it is relevant and applicable to any oil exporting nation that subsidizes imported petroleum products.

The petrol importation model: Let us start with a populace that has demand for petrol (y) represented by:

$$p(y) \tag{1}$$

with $dp/dy<0$, so that, the demand curve is downward sloping. Further assume that the demand curve is derived from their collective utility function:

$$U(y) \tag{2}$$

with $dU/dy>0$, implying that they are gas guzzlers who just cannot get enough of the stuff.

The Y is crude petroleum sold on the world market for a price, σ/L. The demand for Y is derived from the demand for y, i.e:

$$Y=\gamma y \gamma>1 \tag{3}$$

Petrol is supplied by refineries that are all abroad but exploration and production of crude oil is local. We state $\gamma>1$ because in practice you typically need more than one liter of crude oil to produce 1 L of petrol.

MATERIALS AND METHODS

Petrol refineries: Profit for the petrol refineries is:

$$\pi^{y}=p(y)y-\sigma\gamma y+sy \tag{4}$$

where, s is the subsidy per liter of petrol. They choose their output level by setting:

$$\frac{d\pi^{y}}{dy} p(y)+y\frac{dp}{dy}-\sigma\gamma+s=0 \quad (5)$$

as a first order condition. The second order condition is that:

$$\frac{d^{2}\pi^{y}}{dy^{2}}=y\frac{d^{2}p}{dy^{2}}+2\frac{dp}{dy}=\pi_{yy}<0 \quad (6)$$

which ensures an equilibrium solution of $y^{*}>0$ and $Y^{*} = \gamma y^{*}$. The equilibrium output levels in this model increase with the subsidy and decrease with the price of crude oil. To see this, totally differentiate Eq. 5:

$$\pi_{yy}dy+\pi_{ys}ds+\pi_{y\sigma}d\sigma=0 \quad (7)$$

Note that, $\pi_{yy}<0$ from Eq. 6. The π_{ys} from Eq. 5 and $\pi_{y\sigma} = -\gamma$. Therefore:

$$\frac{dy}{ds}=\frac{-1}{\pi_{yy}}>0 \quad (8)$$

and:

$$\frac{dy}{d\sigma}=\frac{-\pi_{y\sigma}}{\pi_{yy}}=\frac{\gamma}{\pi_{yy}}<0 \quad (9)$$

Using Eq. 3, it is easy to establish that $dY/ds>0$ and $dY/d\sigma<0$. It is also worth noting that the price of petrol falls because:

$$\frac{dp}{ds}=\frac{dp}{dy}\frac{dy}{ds}<0 \quad (10)$$

RESULTS AND DISCUSSION

Crude oil exploration and production firms: Assume the upstream firms have a cost of production per liter of crude oil equal to c. Also, assume $\sigma>c$, so that, oil exploration and production is always profitable (This is consistent with the teachings of Hotelling (1931) that in the case of an exhaustible resource, price should exceed marginal cost (even if the oil market is perfectly competitive). This implies that their profits are:

$$\pi^{Y}=[\sigma-c]Y \quad (11)$$

from which we get:

$$\frac{d\pi^{Y}}{ds}=\frac{d\pi^{Y}}{dY}\frac{dy}{ds}=\frac{d\pi^{Y}}{dY}\frac{dY}{dy}\frac{dy}{ds}>0 \quad (12)$$

Welfare: Welfare in the economy is simply the sum of consumer utility and profits from oil exploration. This, we write as:

$$W=U(y)+\pi^{Y}-sy \quad (13)$$

It should be clear that the subsidy increases welfare because both consumer utility and profits from sales of crude oil increase. Nevertheless, the result is best stated in the following proposition:

Proposition 1: The optimal subsidy with regards to maximizing welfare is positive.

Proof:

$$\frac{dW}{ds}=\frac{dU}{dy}\frac{dy}{ds}+\frac{d\pi^{Y}}{dy}\frac{dY}{dy}\frac{dy}{ds}-s \quad (14)$$

Set $dW/ds = 0$ to get:

$$s^{*}=\frac{dU}{dy}\frac{dy}{ds}+\frac{d\pi^{Y}}{dY}\frac{dy}{dy}\frac{dy}{ds}>0 \quad (15)$$

$s^{*}>0$ given Eq. 1 and 12. Since, $d^{2}W/ds^{2} = -1<0$, the subsidy that maximizes welfare is positive. This is therefore a simple justification for subsidizing refined petroleum products. The joy that pro-subsidy activists derive from the above result is easily killed by:

Proposition 2: If the price of crude oil is endogenous and responds positively to increases in demand, the optimal subsidy is no longer unambiguously positive.

Proof: Let $\sigma = \sigma(Y)$, so that, the price of crude oil rises as demand increases, i.e., $d\sigma/dY>0$. The effect of the subsidy on petrol is then:

$$\frac{dy}{ds}=\frac{\delta y}{\delta s}+\frac{\delta y}{\delta\sigma}\frac{\delta\sigma}{\delta s}=\underbrace{\frac{\delta y}{\delta s}}_{<0}\underbrace{\frac{\delta\sigma}{\delta y}}_{>0}\underbrace{\frac{\delta y}{\delta s}}_{>0}\gtrless 0 \quad (16)$$

Since, dy/ds can no longer be said to be always positive s^{*}, the optimal subsidy in Eq. 15 can also be either positive or negative. We are no longer certain that consumer welfare or profits from crude oil exports increase. The optimal subsidy might be a tax.

The result in proposition 1 of a positive optimal subsidy is the common man's manner of seeing things. It is somewhat simplistic although difficult to fault on the surface. The subsidy lowers price and makes more petrol

available. Consumer utility (or alternatively consumer surplus) and profits from the exports of crude oil increase, therefore, the subsidy must be a good thing. Right?

Maybe not; Proposition 2 is the answer given by the wet blanket. If the crude oil price rises there is a competing tendency that reduces the subsidy's positive influence on petrol sales and hence, welfare. From Eq. 16, the likelihood that the optimal subsidy becomes negative depends very much on the magnitude of $\delta y/\delta\sigma$. This can be very large as crude petroleum is the main input in the process of "manufacturing" petrol. In this model, the absolute value of $\delta y/\delta\sigma$ increases in value with γ. The other item of importance is $\delta\sigma/\delta y$, the extent to which crude oil prices respond to changes in the demand for refined products. Some studies have shown that the elasticity of demand for crude oil is very low such that improvements in the conditions of demand are immediately observable in price, for instance, Cooper (2003) and Hamilton (2009). All in all, the possibility that increases in the price of crude could destroy the benefits of a subsidy is real.

In sum, direct effects in Eq. 16 could exceed indirect effects and a positive subsidy could still improve welfare but a government would no longer be certain. This fits in well with the case of Nigeria where as crude oil prices have risen, the government has become more convinced that the subsidy is not accomplishing what it is supposed to. The government may be right to feel that way. As this model shows, even if the optimal subsidy remains positive, its absolute value will fall as crude oil prices rise.

CONCLUSION

We have in this study used a simple model to show how subsidization of petrol can be optimal. On the other hand, we have also shown that it is only unambiguously welfare enhancing under the restrictive assumption that increased demand does not affect crude oil prices.

There are other possible criticisms of our analysis. First, it is totally partial equilibrium. Secondly, we have assumed that the oil producing country can capture all the profits from, crude oil exports. This is unlikely. As Johnson (1994) shows the proportion of profits captured by the exporting country depends on a myriad of factors defined in exploration contracts agreed with oil majors who are mostly foreign. It is possible under certain oil concessionary systems that the all the profit from unanticipated increases in crude oil sales to go the oil majors and none to the host government. Thirdly, we have assumed a utility function that does not recognize that the consumption of petrol might have an impact on the utility from consuming other items. Simply put, our analysis has not taken possible complementarities in consumption into consideration, hence, the reason why the study is written in two parts.

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