My Two Cents
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Partial Equilibrium Analysis Parts 1 & 2

One of the many tools available to economists and analysts in determining the suitability of fiscal or economic policy is partial equilibrium (PE) analysis. However, many scoff at the notion of using partial equilibrium simply because many of its assumptions are deemed to be too unrealistic. However, for taking a look at the potential benefits (or costs) of a policy such as a tax on a single good, PE is a very valid construct. One of the biggest hot button topics these days in nearly every state is how to raise revenue (rather than cutting costs). One of the traditional cash cows for states is in the form of gasoline taxes. The same goes for the Federal government in this regard. However, as we all know, simply arbitrarily and capriciously taxing a product is not necessarily efficient. In fact it usually isn't.

Proponents of supplemental gasoline taxes have pointed out that the additional revenue gives the taxing authority resources, which it can use to benefit citizens, increase spending, and generate economic activity. This argument is centered on the belief that government can most efficiently allocate economic resources. Opponents claim that the taxes create an unnecessary and unfair drag on those economic agents (people) who tend to create the most in the way of economic activity. Their argument is based on the belief that the economic agents can allocate resources more efficiently than government.

The goal of this exercise is to assess the efficiency of this go-to, knee-jerk taxing mechanism, and also take a look at the equitability of such taxes. It must be noted before we begin that gasoline is not a true final good since it is used in some instances in the production or provisioning of other final goods and/or services.

Scope of PE Analysis and Assumptions

As a general rule, PE analysis works much better for more specific instances. For example, our exercise of a tax on a single product (a gallon of gasoline) lends itself to PE much better than the government's proposal of adding a VAT to all products. In the case of the VAT, general equilibrium analysis would be more appropriate.

The following assumptions are used in PE analysis:

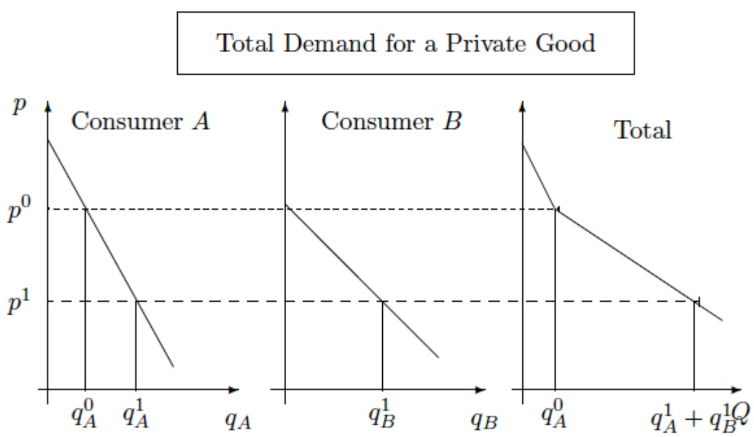
- The market under scrutiny is that of a private good. There are no externalities such as imports and/or exports.

- All product and factor markets are perfectly competitive.

- Production shows non-increasing returns of scale (scale economies)

- There is no government intervention

What these assumptions mean is that we can look at the demand curve for gasoline as being equal to the Marginal Social Benefit (MSB) and the supply curve as being equal to the Marginal Social Cost (MSC). By aggregating the individual curves of all economic agents, we can derive the total demand and total supply curves (shown below).



From this, we can derive the total social benefit (TSB) and total social cost (TSC) for a market by summing the marginal benefits and costs for all units purchase/produced according to the following:

TSB = $\sum MSB(1 \rightarrow Q_{purchased})$
TSC = $\sum MSC(1 \rightarrow Q_{produced})$

Before anyone gets too excited about the government intervention and externalities assumptions, these can be backed out of the analysis or mitigated once a baseline has been established.

Interpretation and Pareto Efficiency

For now, it is important to connect supply and demand for a product to the concept of Net Social Benefit/Cost. Really, when you think about it, the validity of any tax or subsidy is whether its benefits outweigh its costs. If we can answer 'yes' to that question, then from a strictly economic perspective, it is a valid policy.

One of the measuring sticks used to interpret the results of PE analysis is the concept of Pareto efficiency, which states simply that efficiency exists when all factors are such that one party cannot be made better off without making another party worse off. In other words, our gas tax would be Pareto efficient if it were structured so that its net benefits to government and individuals were equal to or greater than its net costs to other individuals.

It is crucial to note that just because something makes sense economically and is Pareto efficient does **NOT** make it equitable. There are many instances of taxes and levies that may pass the Pareto efficiency criteria, but you'll be hard pressed to convince the payers of the tax that it is equitable.

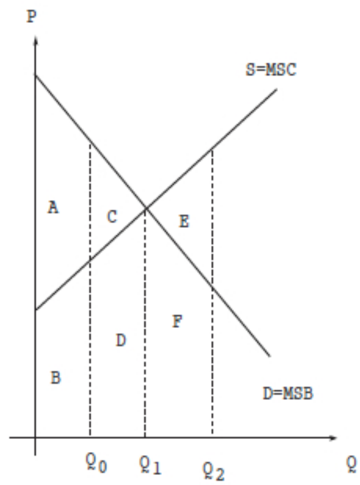
Supply, Demand and Total Net Social Benefits

With the earlier assumptions in place, it is now possible to take a look at the demand function for a particular product, in this case, gasoline, and interpret it as a social benefit. This is important since one of the goals of PE analysis is to create a cost-benefit scenario then make judgments from there. That said if we know each individual's demand function, it is simple to derive the total demand for that particular good, or in our case, the total social benefit. We can aggregate the supply curves in similar fashion, and derive total social cost. Once we have these two, finding net social benefit is done by:

$$\mathbf{TNSB = TSB - TSC}$$

Where TNSB is total net social benefit, TSB is total social benefit, and TSC is total social cost.

Below, we take a look at a chart with three quantity levels, Q_0, Q_1, and Q_2. Using PE, we will then analyze TNSB at each point.



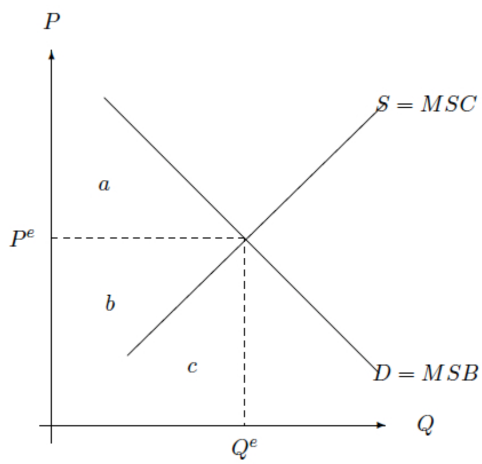
In traditional general equilibrium analysis, Q_1 represents what we would consider equilibrium at P_1 (unlabelled). However, using PE, we're going to take a look at TNSB at each level of Q.

Q	TSB	TSC	TNSB
Q_0	A+B	B	A
Q_1	A+B+C+D	B+D	A+C
Q_2	A+B+C+D+F	B+D+E+F	A+C-E

Let's take a look at Q0. The area under the Demand Curve (MSB) is A+B. This represents the TSB for gasoline. The area under the supply curve (MSC) is B. Subtracting TSC from TSB leaves us with a TNSB of A. Following the methodology for Q_1, we get a TNSB of A+C, which is obviously more optimal than that of Q_0. In this case, the highest TNSB occurs at the market equilibrium Q_1.

Another Look at Market Efficiency

For comparative purposes, let's take a look at another example and examine the various surpluses that arise and what that means for equilibrium:



It is also relatively easy to see how we can look at the surpluses generated at the different levels of Q and assign these surpluses to either producers or consumers. Looking at the above market equilibrium chart, we can see that the consumer’s surplus in this case is the value of purchases to consumers (total benefits) minus the cost paid. Consumers received value of ABC, and paid BC, leaving the consumer surplus of A. The producer surplus equals total payments received (B+C) minus the opportunity cost of the production of the goods (C), leaving the producer surplus at B. The TNSB of this situation is the sum of the producer and consumer surpluses (A+B). It is important to note that:

- Market equilibrium requires MSB=MSC,
- Supply equals Demand, and
- Assuming no externalities, market equilibrium represents a Pareto optimum (as illustrated above).

In the next installment we’ll apply the concept of PE analysis to the notion of an additional tax on each gallon of gasoline sold and determine if in fact this would represent market efficiency.

09/24/2010 – Part Two

In the first part of this series, we took at a look at Partial Equilibrium (PE) analysis in terms of analyzing a particular good or service rather than macroeconomic aggregates. What PE allows us to do as well is to both qualitatively and quantitatively assess the true effects of taxes and subsidies. We can also answer whether or not taxes and subsidies represent Pareto efficiencies. For our example we chose to look at the area of gasoline taxes.

Many state governments are considering increasing gasoline taxes in the face of collapsing tax receipts. Intuitively, it would seem that such measures would be penny-wise and dollar foolish, but let's use PE and see if that bears out conventional wisdom.

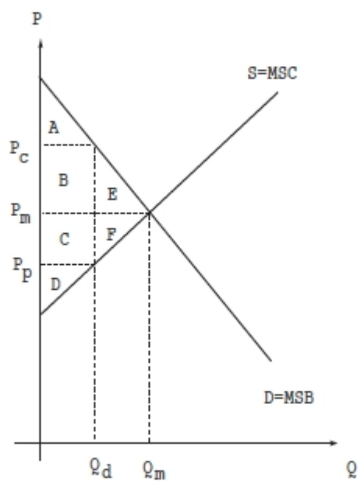
We're going to also take it a step further and add an externality to our analysis: reserves depletion. Peak oil has been talked about in many forums, including military think tanks, World Bank whitepapers, and countless other places. We'll take a look at efficiency and how it is affected by the lack of internalization by energy producers and consumers.

The first conclusion that we were able to arrive at last time is the fact that non-intervention (zero taxes / subsidies) market equilibrium are Pareto efficient, that is to say that Total Net Social Benefit (TNSB) is maximized. This fits the criteria for being Pareto efficient since any other combination would result in certain parties being made better off at the expense of other parties.

In the non-intervention equilibrium, there are only two types of surpluses – consumer and producer. There were no other parties involved. Certain economic agents produced the goods, while others consumed them. However, in the situation where there is a tax or subsidy (in this case a proposed tax), the government is now put into the mix and its impact on equilibrium must be studied. When the government collects a tax, it now has a surplus, which otherwise would have accrued to either producers or consumers. We'll call the government's new windfall GS.

The bottom line in any tax situation is that consumers are now short GS. In the most simplistic terms, GS could be returned to the consumers and a return to Pareto efficiency would be observed. Obviously GS has not disappeared; it is still available to society. This is where the rhetorical question of who spends your money better comes from.

In the following chart, note that equilibrium is present at P_m and Q_m. When the government imposes a tax (let's insert our proposed gasoline taxes in here), the price of gasoline is shifted to P_c, with producers collecting P_p. The new quantity produced/traded is Q_d. This new reality reflects consumers' lack of willingness to consume at the equilibrium quantity since they're facing higher prices. It must be noted that elasticity of demand will determine ***exactly how much less they're willing to consume***, but for the purposes of this discussion, let's assume that demand and supply are both linear functions.

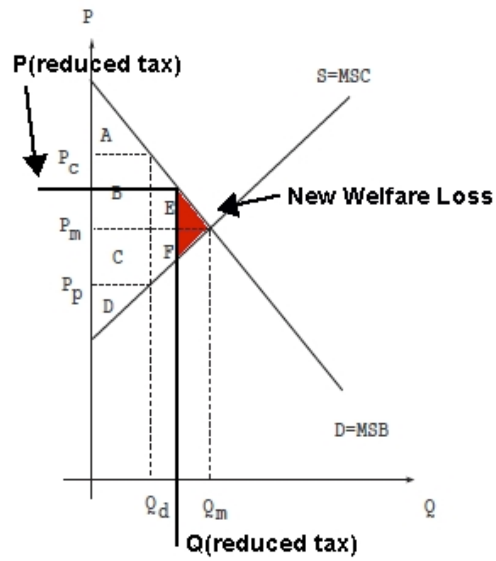


In the situation where the tax is collected, consumers will lose surplus because they are paying more for what is consumed. Producers are losing surplus because they receive less for what they sell. The government generates a surplus because it collected the tax. Let's take a look at the welfare calculations:

	Market	Tax	Change
Consumer Surplus	A+B+E	A	-(B+E)
Producer Surplus	C+F+D	D	-(C+F)
Government 'Surplus'	(Nil)	B+C	+(B+C)
Total	A+B+E+C+F+D	A+D+B+C	-(E+F)

It is obvious from the welfare analysis that the equilibrium was economically efficient while the new tax equilibrium is not because the total welfare is lower under the tax equilibrium than the market equilibrium. Put another way, the change in total welfare from the new tax is negative, indicating that the tax is not economically efficient. –(E+F) is often referred to as a welfare loss in general economics classes.

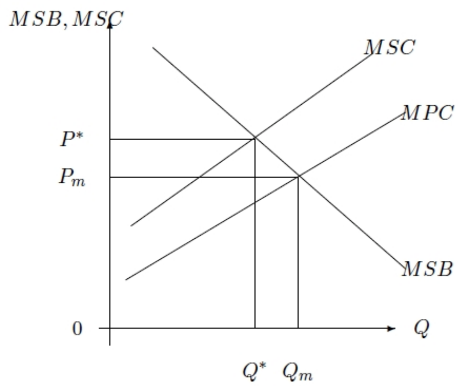
Conversely, let's think about the affect of reducing a tax. Let's say we reduced the tax by 40%. We'd now see equilibrium re-appear at new price level $P_{(reduced\ tax)}$ and the new quantity at $Q_{(reduced\ tax)}$. The new –(E+F) or welfare loss would be considerably smaller than at the original tax level. In this case, the total welfare would have increased from the level of the original tax levy, but would still not be Pareto efficient since it would still be less than market equilibrium.



PE with Externalities

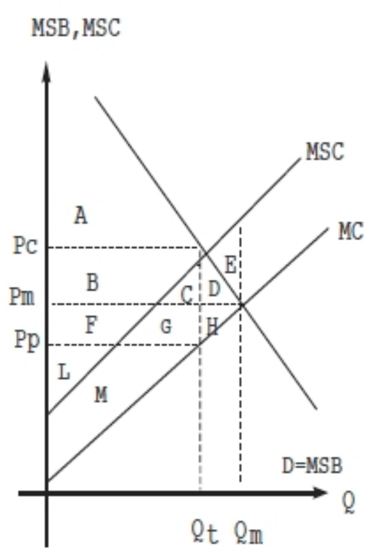
Obviously with peak oil on the mind of most people, it pays to take a look at partial equilibrium with a negative externality, namely overproduction, in this instance. In our prior example, we had several classes of surpluses: consumer, producer, and government. Now, we'll add a fourth economic agent, albeit a non-acting agent, in the form of petroleum reserves. It is important to note up front that we are not in any way trying to estimate the degradation of any specific resources, but merely to show how efficiency towards reserves will be affected by other intransigent policy.

In our example, we'll label our variables CS, PS, GS, and ES for consumer surplus, producer surplus, government surplus, and externality surplus. The total welfare or TNSB will be the sum of these four surpluses. We can then further deduce that the change in TNSB (ΔTNSB) will be the sum of the changes of the four surpluses. ΔG will merely be (R-S) revenue minus subsidy or spending. ΔE will be the change of petroleum reserves.



In the above chart MSC represents the marginal social cost, and MPC represents the marginal private cost. The difference here between the MSC and MPC represents the ΔES or depletion of reserves in this case. The case where MSC intersects MSB is the efficient outcome from the standpoint of the depletion externality, and the intersection of MPC and MSB is the market equilibrium. It is fairly obvious in this case that consuming at the market equilibrium entails inefficiency in terms of reserves depletion. Again, any consumption is obviously going to diminish reserves, however, we're searching for the most efficient mix of production and consumption.

Let's take a look at total welfare and see what we get in terms of adding this very important externality to the equation.



In the case of petroleum, taxes can actually serve to bring MSC and MPC (MC) into line, meaning that in effect, taxes

can make actual production equal the optimal from both a cost and depletion perspective. However, ***too high*** of a tax will obviously be inefficient as well. In our case, graphically, the tax would need to be precisely the difference between MSC and MPC (MC) in the above chart. This would serve to reduce production and consumption to the point where utilization was optimal.
Let's look at the total welfare analysis:

Surpluses in the presence of the tax:

$$\begin{aligned}
\text{CS} &= A \\
\text{PS} &= L + M \\
\text{GS} &= B + C + F + G \\
\text{ES} &= -(C + G + M) \\
\text{TS} &= A + B + F + L
\end{aligned}$$

Surpluses at market equilibrium:

$$\begin{aligned}
\text{CS} &= A + B + C + D \\
\text{PS} &= F + G + H + L + M \\
\text{GS} &= (Zero) \\
\text{ES} &= -(C + G + E + M + D + H) \\
\text{TS} &= A + B + F + L - E
\end{aligned}$$

Welfare analysis (Sum of changes in all surpluses):

$$\begin{aligned}
\triangle\text{CS} &= -(B + C + D) \\
\triangle\text{PS} &= -(F + G + H) \\
\triangle\text{GS} &= +(B + C + F + G) \\
\triangle\text{ES} &= +(E + D + H) \\
\triangle\text{TS} &= +E
\end{aligned}$$

With the externality in place, less oil is produced, less damage is done to reserves, and TNSB is maximized with a tax equal to the different between MSC and MPC in place.

Summary and Conclusions

Consumers and producers both generally prefer the market equilibrium and, minus externalities, the market equilibrium is the most efficient as measure in Pareto terms. Taxes in such a situation will cause immediate dislocations and will not be efficient. However, in cases where there are externalities, taxes can be useful for bringing the monetary costs and the net social costs into line. We can easily conclude that imposing a gasoline tax merely for the purposes of increasing revenue is inefficient because the intent is not to bring monetary and social costs in line, but rather is arbitrary and capricious in nature. Further analysis could easily glean whether or not the actual taxes collected were efficient or not. The example of using depletion of petroleum reserves is key since taxes can actually help to make our use of this wasting asset more efficient. However, simply applying additional revenue-generating taxes on the purchase, consumption, or the byproducts of oil are not economically efficient, and while they may prolong reserves a bit further, there will be other economic costs that will be greater than the benefits accrued.

References: ***Primer on PE***: R. Wigle, ***Microeconomics***: J. Perloff, ***Economics and Public Policy***: J. Kearl.