

Full-Cost Pricing:

An approach to internalize the full-cost of a gallon of unleaded gasoline in the U.S. and the feasibility of markets sustaining this result

Joseph Mack

Table of Contents

The Problem	3
Economic Terms	4
Empirical Work	15
Interpreting Results	21
Market Feasibility	23
Conclusion	26
Works Cited	28

The Problem

When the American consumer recognizes the need to refuel their automobile, they often search for the lowest price available. Eventually however, the consumer will need to fuel their tank in order to get to school, work, or wherever their destination may be. If the consumer's decisions concerning fuel consumption are to be consistent with the interests of society as a whole, the price paid should reflect the total cost of using that fuel. Total cost refers to the value of all that is lost or given up as a result of the act of consumption. What if the price that we pay for unleaded fuel reflects half of that total cost? Perhaps if the consumer were more aware that consuming a gallon of unleaded gasoline lowers crop yields, kills aquatic wildlife, increases smog, and increases risks to human health, they would consume less fuel. Then again, perhaps consumers would ignore these negative effects on others. Economists refer to these negative third party effects as external costs and believe that prices send the right signals only when they reflect all of these effects. Developing a "full-cost" price of unleaded gasoline is an

effort to estimate such a socially efficient price. The operations of markets, techniques for estimating the full-cost price of unleaded gasoline, and methods for applying that price in real world markets will all be considered in the following discussion.

Economic Terms

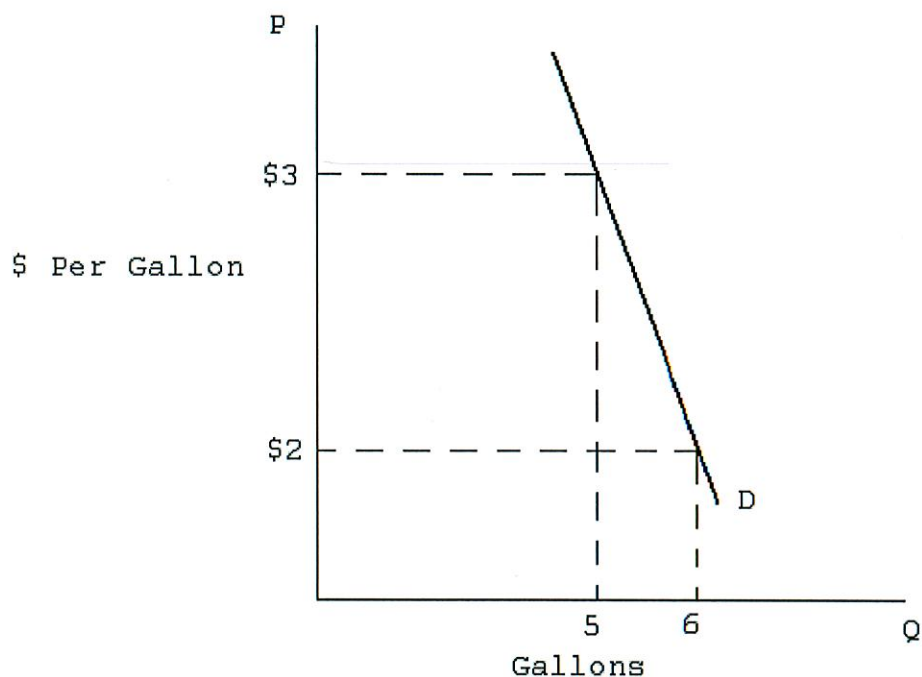
While developing a full-cost price of unleaded gasoline in the United States, several economic terms will need to be employed. Since these concepts may be unfamiliar to readers, we will begin the inquiry by clarifying the necessary context. Economic terms that must be understood to follow a discussion of the full-cost price of unleaded gasoline include: market demand and supply, which comprise a market, the nature of externalities, and Pigouvian Taxes.

- Individual demand refers to the amount of a good that a buyer is willing and able to purchase at alternative prices (Mankiw, 1998). In the case of gasoline, the individual demand of person "A" would be the amount he would want at a certain price. As prices increase, "A" would be unwilling or unable to demand as much as he did at the original price, therefore the quantity demanded by "A" would decrease. Likewise, when prices fall, "A" would want to consume at higher levels; therefore, "A" would have a

higher quantity demand. To further characterize demand, a graphical representation is depicted in Figure 1.

Figure 1

Demand of Individual "A" for Unleaded Gasoline

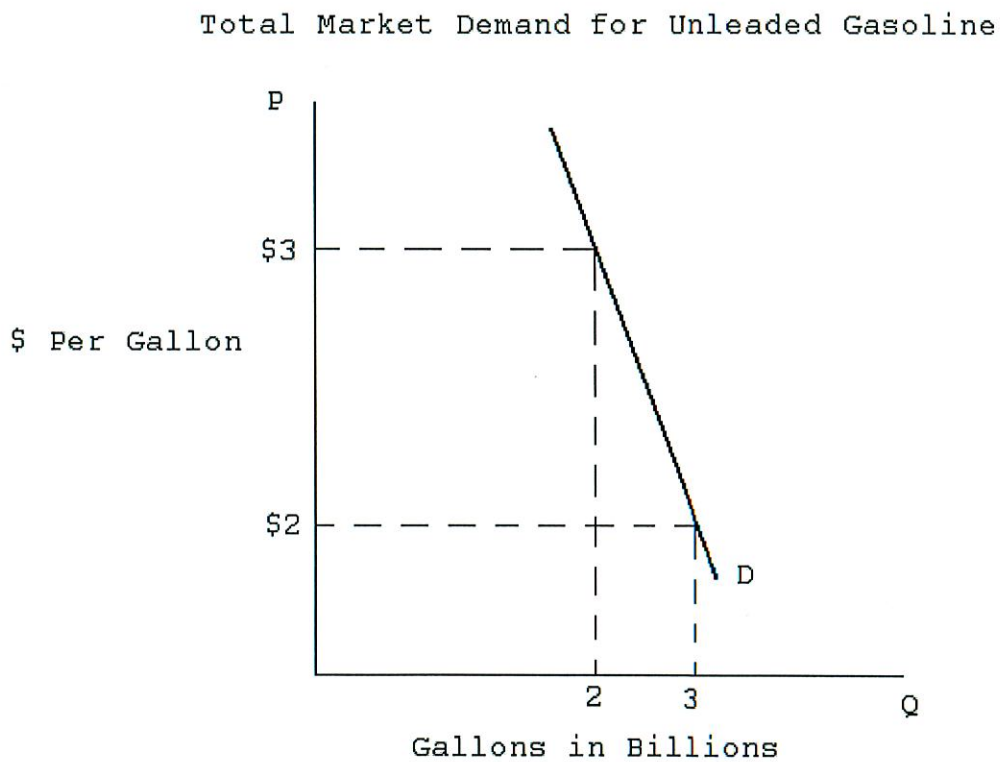


In this example, the amounts "A" demands are shown on the horizontal axis (Q). Price (P) is measured by the vertical axis. From the curve, D, the inverse relationship between higher prices and lower quantity demand is shown.

- In the case of the United States, it would be naïve to assume that the demand for gasoline is determined by only one individual. Rather, to determine the demand for a product by all consumers, a market demand curve must be constructed. To derive the market demand curve, the

individual demand curves of all consumers in the market must be added together (Boyes and Melvin, 1999). A market demand curve thus illustrates the demand for unleaded gasoline for all consumers. As shown in Figure 2, the market demand curve for unleaded gasoline would appear similar to an individual demand curve, although the quantities shown on the horizontal axis are vastly greater.

Figure 2



- The shape of the market demand curve is an important determinate of how consumers would respond to a full-cost price for unleaded gasoline. Whether the demand curve for

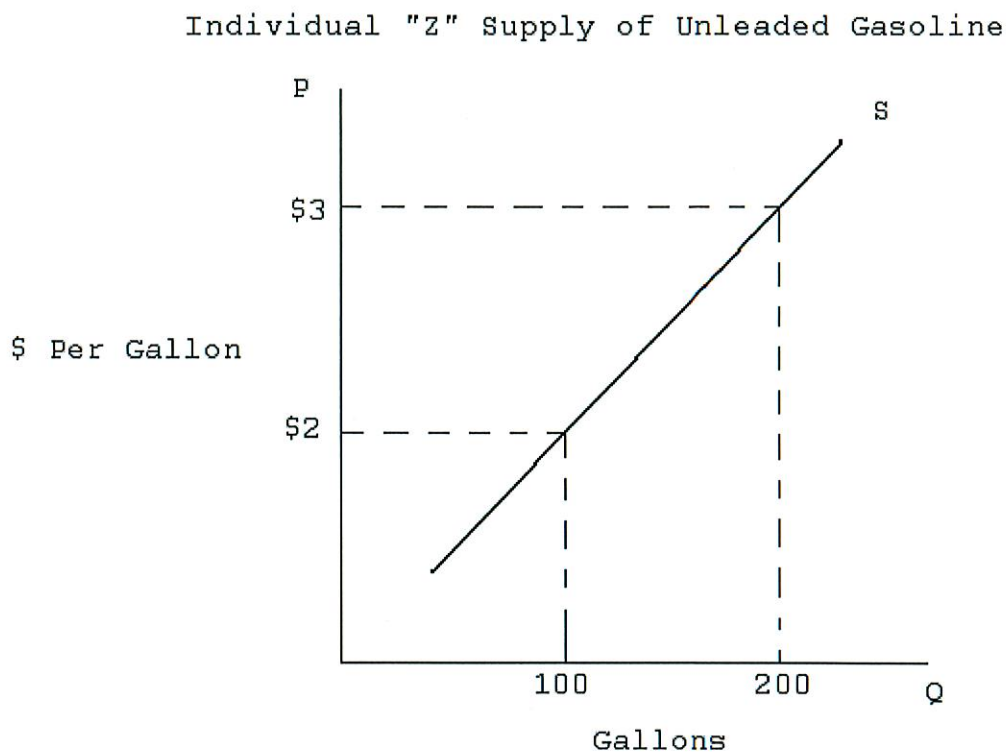
a particular good is more nearly vertical or horizontal depends on the elasticity of the demand curve. Elasticity is the measure of the percentage change in one variable brought about by a one percent change in some other independent variable (Nicholson, 2000). In this case, the two variables involved are the quantity of unleaded gasoline and the price per gallon. Expressing changes in these variables as percentages, the elasticity of demand is seen to decline as one "slides down" a linear demand curve.

According to the Mackinac Center for Public Policy, the short-run elasticity of unleaded gasoline is currently 0.2 in the United States (2004). This suggests that a price change would affect the level of unleaded gasoline consumption. If the price of unleaded gasoline were to rise significantly, consumers would be able to change their consumption levels through participating in car-pools and postponing vacations. If the demand curve was perfectly inelastic, the level of consumption in the short-run would be fixed and price change would not affect levels of consumption.

- Individual supply refers to the amount of a good a seller is willing and able to sell (Mankiw, 1998). In the market for unleaded gasoline, the amount supplier "Z" will provide is the maximum quantity he would supply at a

certain price. As price increased, "Z" would be willing to supply more than at the original price. As the price decreased, producer "Z" would be willing to supply less. A graphical representation of the individual supply curve is shown in Figure 3.

Figure 3

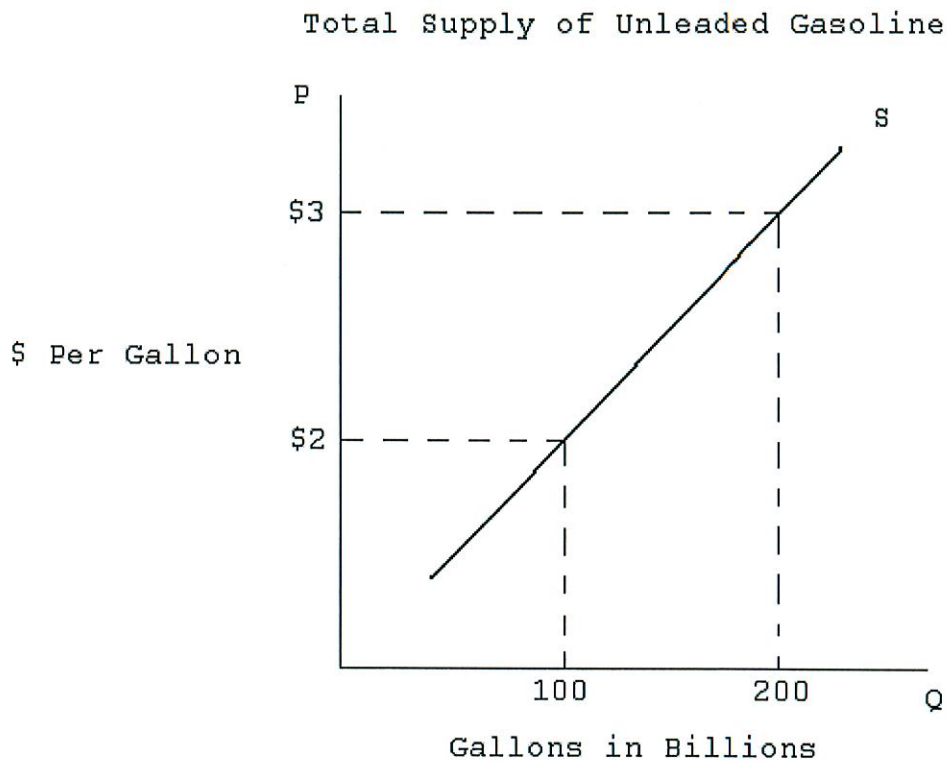


As illustrated, the amounts "Z" supplies are shown on the horizontal (quantity) axis (Q). Price (P) is measured by the vertical axis. The positive slope of the supply curve reflects the positive relationship between quantities supplied and prices, as previously noted.

- As with demand, an individual supply curve cannot illustrate the total market supply. A market supply curve can be constructed by summing the quantities that each producer supplies at each price (Boyes and Melvin, 1999). Therefore, a market supply curve illustrates the supply of unleaded gasoline across all suppliers. As shown in Figure 4, the market supply curve for unleaded gasoline would appear similar to that of the individual supply curve.

- The price elasticity of supply for unleaded gasoline is greater than the price elasticity of demand. This is due to the relationship between supply and the marginal cost of production. Marginal cost is the cost of the extra inputs needed to produce a specific unit. For several reasons, including differences in the quality of inputs, the marginal cost of additional units is expected to rise. If suppliers were faced with a significant increase in price, they could respond immediately by reopening high cost oil wells.

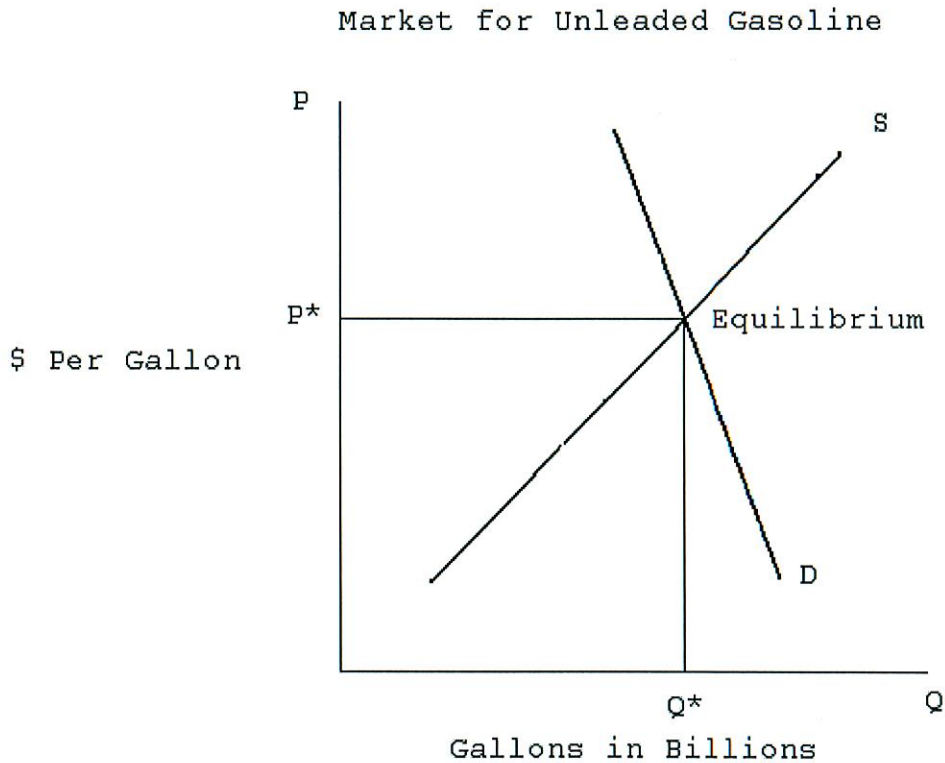
Figure 4



- Now that market demand and supply curves are established, market equilibrium can be defined. In Figure 5, where both the market demand and market supply curves are placed in the same quadrant, they intersect at one point. This point is called the market's equilibrium and the associated price and quantity are referred to as the equilibrium price and equilibrium quantity respectively. At equilibrium, the amount sellers wish to sell equals the amount buyers wish to buy. Thus, competitive equilibrium represents an efficient solution.

The following analysis assumes that the market for unleaded gasoline is tolerably competitive. The framework employed would not pertain to all market structures.

Figure 5



- Unfortunately, there are cases where the market price does not lead to an efficient outcome. This occurs when externalities are present. An externality is an effect that production or consumption has on third parties (not the buyer or seller), the value of which is not included in the market price (Boardman, Greenberg, Vining, and Weimer 2001). It should be noted that externalities

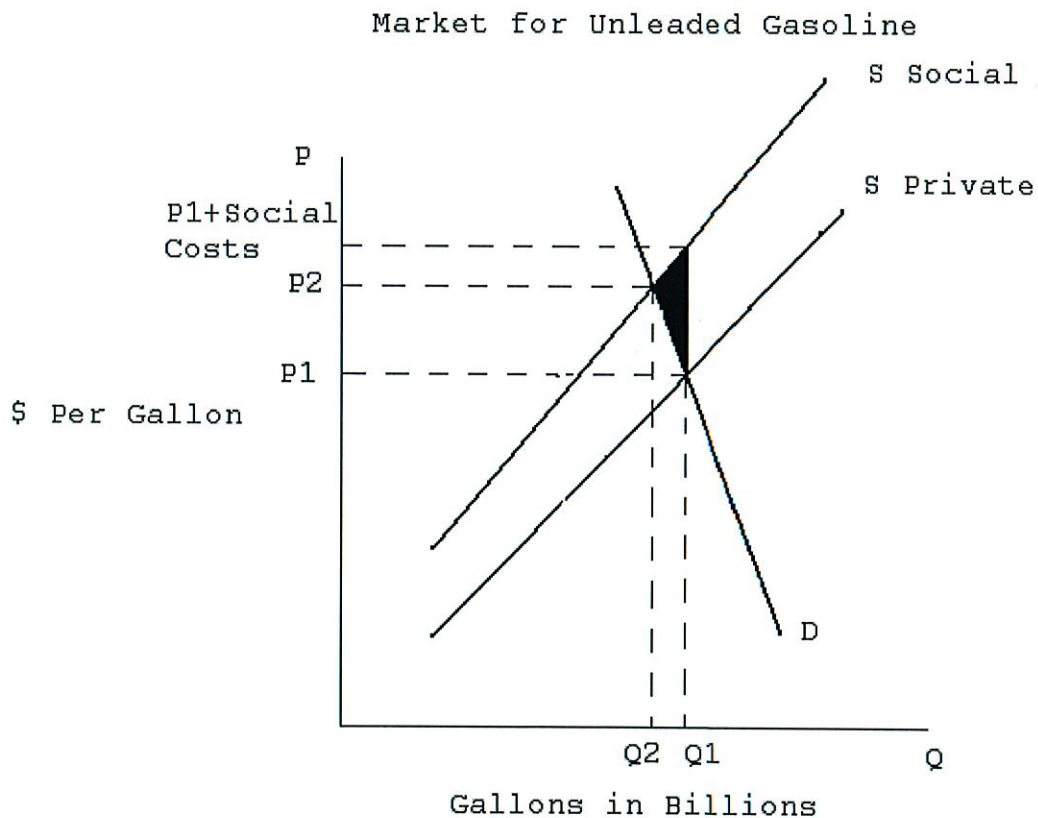
can be positive or negative. However, for the purpose of this paper, negative externalities are relevant.

- To demonstrate the inefficiency created by external costs, a second supply curve needs to be constructed. From the earlier discussion of the market supply curve, it was shown that that curve represents the prices at which suppliers are willing and able to sell alternative quantities. As noted, the amount suppliers are willing to sell at some price depends on the marginal cost of particular units. As illustrated in Figure 5, the marginal cost of the last unit sold equals the equilibrium price. However, in the case of goods where external costs are created, the social cost of each unit offered will exceed the marginal cost faced by the producer.

- Social costs include producers' private costs as well as the extra costs borne by third parties adversely affected by the production and/or consumption of the unit (Mankiw, 1998). A social cost curve is graphically represented in Figure 6. Notice this social supply curve lies above the private supply curve. The social supply curve thus "internalizes" the external costs and reflects the full marginal cost to society of producing each unit of the good.

This new supply curve can be used to determine a socially optimum level of consumption. The darkened triangle in the figure represents the welfare gain to society through the reduction in output from the private equilibrium quantity to the socially optimal level. At "P2" the price people are willing to pay for the last unit is equal to marginal social cost rather than marginal private cost.

Figure 6



- To conceptually quantify the dollar values of external costs, the concept of "willingness to pay" by the

consumer is often applied. In this case, willingness to pay is the maximum amount an individual would be willing to pay to avoid undesirable impacts from unleaded gasoline consumption such as negative health affects associated with a particular unit of the product (Boardman, Greenberg, Vining, and Weimer, 2001).

- In recognition of the inefficiencies created by negative externalities, what can be done to achieve a socially optimal output? A conventional response is to institute taxes on the product so that the marginal cost faced by the producer (including the tax) is equal to social cost. These taxes, which correct the effects of negative externalities on price and output are referred to as Pigouvian Taxes, named after A. C. Pigou who first proposed them in 1920 (Pigou). Therefore, if external costs can be measured and added to the producer's marginal cost, a social supply curve like that in Figure 6 can be determined. Such a tax would raise producers' cost to make it equal social cost and would then achieve the socially optimal output.

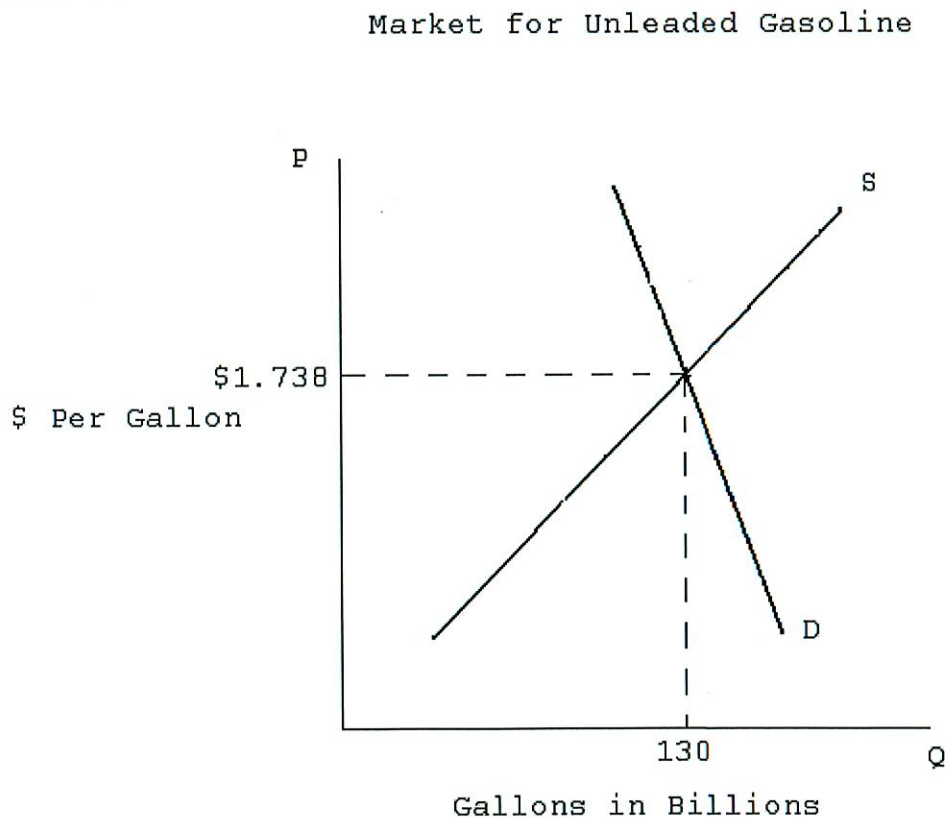
This review of economic principles is intended to enable the reader to more easily follow the analysis presented below. The next section surveys empirical studies of the full-cost of a gallon of unleaded gasoline

in the United States. As such, they estimate the external costs of unleaded gasoline consumption. With this information in hand, the feasibility of using taxes to improve the social efficiency of the unleaded gasoline market will be considered.

Empirical Work

The national average price for a gallon of unleaded gasoline in the United States was \$1.738 as of March 8, 2004 ("U.S. Retail Gasoline Prices," 2004). This price can be seen as the equilibrium for unleaded gasoline in the market as shown in Figure 7.

Figure 7



The elements of the marginal cost in this market price are the costs of crude oil, federal and state taxes, refining costs, and distribution and marketing costs ("A Primer on Gasoline Prices," 2004). An algebraic expression of the supply function illustrating these determinants of marginal costs is shown below:

$$P = f(O_P + T_{F+S} + R_C + D_C + M_C)$$

Where:

P : Price of a Gallon of Unleaded Gasoline

O_P : Price of Crude Oil

T_{F+S} : Federal and State Taxes

R_C : Refining Costs

D_C : Distribution Costs

M_C : Marketing Costs

This reflects private costs and, as such, does not include externalities such as the health costs from vehicle emissions, lower crop yields due to global warming, or damage from fuel runoff which kills aquatic life. Simply stated, the current pricing mechanism does not reflect a full-cost of consuming a gallon of unleaded gasoline. By quantifying these externalities and adding them to the market price, it should be possible to estimate the social cost of unleaded gasoline consumption. Given the financial and time constraints of this paper, only external costs associated with human health will be examined. The inclusion of this new variable yields the expression below:

$$P = f(O_P + T_{F+S} + R_C + D_C + M_C) + (H_C)$$

Where:

H_C : Health Costs

There are numerous pollutants associated with gasoline. Even before the fuel is combusted in the car's engine, harmful chemicals evaporate into the atmosphere during fueling. Among the chemicals associated with fueling and operating automobiles are four major groups of pollutants. These are hydrocarbons, nitrogen oxides, carbon monoxide, and particulates. According to WebMD.com, these pollutants cause a wide range of adverse health affects including: various cancers, Parkinson's disease, pulmonary oedema, asphyxia, and increased risk of respiratory and cardiovascular illness (2004). These ailments can and do lead to death.

A recent study conducted by the International Center for Technology Assessment found that the external health costs associated with the consumption of unleaded gasoline in the United States totals from \$231.7 to \$942.9 billion every year (2000). The ICTA arrived at this conclusion by estimating the amounts consumers pay indirectly through increased taxes and insurance costs to deal with these health affects. However, this study did not quantify each

component of these costs explicitly. The wide range of these estimates demonstrates the difficulties involved in trying to quantify such costs. If the lower end range is used and divided by annual unleaded gasoline consumption in the United States, a conservative estimate of the external cost can be derived. In 2000, the U.S. consumed 130 billion gallons of unleaded gasoline which implies that the external health cost of each gallon was \$1.78 per gallon (Gasoline and the American People, 2000). This cost, added to the average current price of gasoline mentioned above (\$1.738 per gallon) equals \$3.518 per gallon. Using the higher end of the ICTA estimates yields a full-cost for unleaded gasoline of \$8.99 per gallon. Therefore, given the study of the International Center for Technology Assessment, the full-cost of a gallon of unleaded gasoline in the United States would equal between \$3.518 to \$8.99 per gallon.

Another approach to determine the health costs could be through determining the consumer's willingness to pay to avoid these health risks. Unfortunately, no current study of a U.S. citizen's willingness to pay to avoid these risks is available. However, a study conducted in France, Austria, and Switzerland has determined the willingness to pay of these foreign consumers to avoid certain health

risks associated with the consumption of unleaded gasoline (Sommer, 2003). Table 1 below illustrates these specific health risks and the willingness to pay of each individual to avoid them, converted to U.S. dollars:

Table 1

Health Indicator	Willingness to Pay (Dollar)
Respiratory Hospital Admission	\$9,253.55 per admission
Chronic Bronchitis	\$245,742.00 per case
Asthma Attacks	\$36.45 per attack

(Source: Economic Evaluation, Sommer)

It is important to note the significant value of the willingness to pay for these health effects. For example, the typical European consumer would undoubtedly not be able to pay nearly one quarter of a million dollars to avoid chronic bronchitis. Yet, if the occurrence of death is highly frequent with chronic bronchitis (and the individuals described in the study were aware of this) then perhaps this amount is not inflated.

In order to apply this data to the U.S., the annual incidences of each health indicator (shown in Table 2) were multiplied by the willingness to pay.

Table 2

Health Indicator	Incidence per Year
Respiratory Hospital Admission	4,300,000
Chronic Bronchitis	11,200,000
Asthma Attacks	14,000,000

(Source: National Center of Health Statistics)

This study illustrates the absolute upper bound estimates for a full-cost price for unleaded gasoline. Not all the cases of these health problems that occur in the United States are specifically due to the pollution created by unleaded gasoline consumption. However, this quantified relationship is currently unavailable. Therefore, when each individual's willingness to pay to avoid chronic bronchitis is applied in the U.S., the cost would equal \$21.17 per gallon ($\$245,742 * 11,200,000 / 130 \text{ billion} = \21.17). Adding this to the current price of \$1.738 a gallon provides a price of \$22.90 per gallon. According to this study therefore, the full-cost price of gasoline would be vastly higher than the price in the U.S. market today.

Due to the high degree of difficulty in estimating a full-cost price of unleaded gasoline, the number of available studies is limited. The studies that do exist agree that the current price falls short of encompassing the external costs of consuming unleaded gasoline. We may conclude that the current market price of \$1.738 is too low

and should be adjusted to enhance economic efficiency. Using available studies and averaging their different results to determine what the price increase should be is too simplistic and would consequently be politically unviable. The variability of the estimates does not, however, make it appropriate to simply ignore the external costs of a gallon of unleaded gasoline. As shown above, the full-cost of a gallon of unleaded gasoline in the U.S. could range anywhere from \$3.518 to \$22.90 a gallon. Therefore, whichever estimate of external costs is finally chosen, the resulting health cost variable, H_C , could be added to the price function for a gallon of unleaded gasoline in the U.S.

Interpreting Results

The empirical data reported above needs to be examined critically in order to determine the most appropriate estimate of the health costs from unleaded gasoline consumption in the U.S. The study performed by the International Center for Technology Assessment would seem most relevant. The principle reason for this is that the ICTA study looks at health costs in the United States. For that reason, it is more relevant than estimates based on data from France, Austria, and Switzerland, since it is inappropriate to assume that the willingness to pay of

European consumers is identical to that of Americans. Differences in tastes and preferences, and attitudes toward risk are expected to vary across countries. Similarly the health affects of unleaded gasoline use would vary with settlement patterns, population density, and pollution control technologies. Nevertheless, it may be worth noting that the California Energy Commission reports that French consumers pay \$4.191 per gallon for unleaded gasoline (2004). One may conclude that French voters/consumers are willing to pay far more for a gallon of unleaded gasoline than U.S. consumers currently pay.

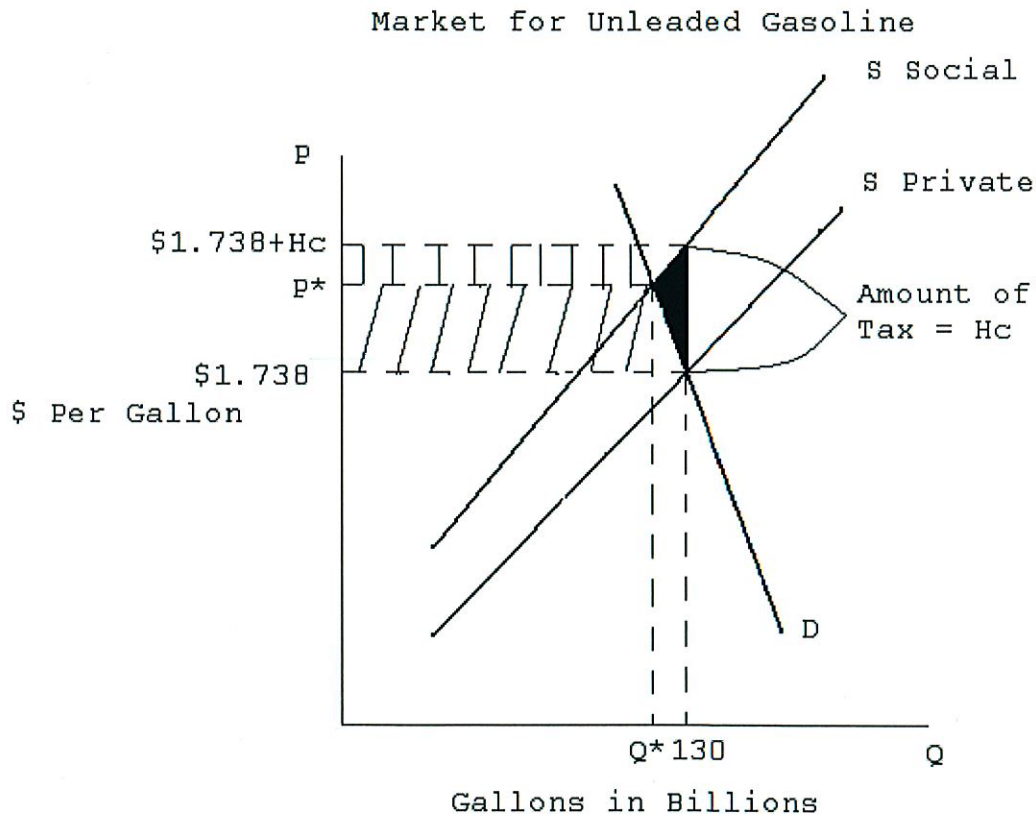
Though the figures in this paper can be criticized, there remains one underlying fact: the price for an unleaded gallon of gasoline in the U.S. is not a full-cost price and as such, is inefficient. Further, the several health costs associated with the combustion of unleaded gasoline are external costs, which should be added to the market price to achieve a more efficient level of consumption. To quantify the term H_C precisely is not possible with the available data. Recognizing that the current price is too low is nevertheless important.

Assuming that the political process in the U.S. recognizes this market failure, what policy should be used to make the market more efficient?

Market Feasibility

After determining the health costs associated with the consumption of unleaded gasoline to be H_C , this amount can be reflected through the price in the U.S. market by introducing a Pigouvian Tax. Using the earlier representation of the unleaded gasoline market in the United States, a second supply curve based on marginal cost including the tax is shown in Figure 8.

Figure 8



Notice that the space between the private supply curve and social supply curve at the original equilibrium represents the external health costs associated with the marginal

gallon of unleaded gasoline. Also by tracing a horizontal line over from the point on the social supply curve associated with the new equilibrium quantity (Q^*) to the vertical axis, the new price can be determined (P^*). As mentioned earlier, the inelastic nature of the demand curve for unleaded gasoline in the United States means that the tax would lead to a modest drop in consumption in the short-run.

Note that the equilibrium price has not increased by the full amount of the tax. The incidence of this Pigouvian Tax would not fall exclusively on the consumer. The area denoted with vertical lines indicates the amount of the tax that would be borne by producers while the diagonal lines indicate the tax burden on consumers. The increased price does lower consumption to the optimal level of Q^* . In terms of economic efficiency, when Q^* is produced, there would be a welfare gain to society equal to the amount of the darkened triangle.

If H_C was a lower end amount mentioned previously of \$3.158, the market would most likely adjust accordingly. Note that as drawn, the short-run effect of the price change is relatively small given the change in the amount demanded. This is due to several factors. For example, in the case of unleaded gasoline, there are no close

substitutes. Thus, if the price of unleaded gasoline rose high in the short-run, there would be limited opportunities to switch to other fuels immediately. People would still need to drive their automobiles to some extent and they could not simply fill their automobile's fuel tank with another good such as water if the price of unleaded gasoline rises.

The long-run reduction in consumption would be greater. The United States is a democracy and, as such, an increase in the price of an important product like unleaded gasoline would lead to a political outcry in favor of the development of alternative, less expensive fuels. These new demands could result in substitutes for unleaded gasoline being developed over time. If this were accomplished, it would be a major success of the full-cost price of unleaded gasoline in the U.S. Health costs associated with unleaded gasoline would diminish sharply as a result of consumption declines and the outcome would be a healthier environment. Despite the short-run distortions created by a major price increase, the long-term outcome would be very welcomed.

In addition, because of the U.S. political process, a significant increase in the total tax bill of the U.S. citizen, through a Pigouvian Tax on unleaded gasoline,

would not be acceptable. Rather, the increase in gas prices would be tolerated only if the net change in the tax bill was equal to zero. For example, if the government recognized the health costs and determined a full-cost price by adding a \$0.50 Pigouvian Tax to each gallon of unleaded gasoline in the United States, this amount would generate \$65 billion in additional tax revenues. In order to maintain a zero net change in the tax bill to the American consumers, a decrease of \$65 billion in taxes from other sources would need to occur. While lower health care costs would help pay for the tax in time, accompanying the Pigouvian Tax with something politically popular, such as an increase in the personal income tax exemptions, might be essential to it's success.

Conclusion

Using a full-cost pricing technique for a gallon of unleaded gasoline in the United States is possible. However, due to the U.S. political process, a significant increase in unleaded gasoline prices is very unlikely unless the American consumer can be enlightened to the external costs of health problems that are associated with the consumption of unleaded gasoline. Even if this is achieved, a concomitant cut in other government taxes to maintain a zero net increase of the American consumer's tax

bill would be necessary if the gas tax were to be politically viable. With the data that currently exists, this full-cost price cannot be precisely determined. However, recognizing that the current price is not socially efficient would be an important first step towards improving the health of Americans, providing a cleaner environment to future generations, and establishing a full-cost price of unleaded gasoline in the United States.

Works Cited

- Boardman, Anthony E, David H. Greenberg, Aidan R. Vining, and David L. Weimer. Cost Benefit Analysis. 2nd ed. Prentice Hall. Upper Saddle River, NJ: 2001.
- Boyes, William and Michael Melvin. Macroeconomics. 4th ed. Houghton Mifflin Company. Boston: 1999.
- California Energy Commission. Online. <<http://www.energy.ca.gov>>. March 25, 2004.
- Energy Information Administration. "A Primer on Gasoline Prices." Online. <<http://www.eia.doe.gov>>. January 27, 2004.
- Gasoline and the American People. Online. <<http://www.mindbranch.com>>. March 10, 2004.
- International Center for Technology Assessment. "The Real Price of Gas." Online. <<http://www.icta.org>>. January 27, 2004.
- Mackinac Center for Public Policy. "Price Elasticity of Demand." Online. <<http://www.mackinac.org>>. April 20, 2004.
- Mankiw, Gregory N. Principles of Microeconomics. The Dryden Press. Fort Worth, Texas: 1998.
- National Center for Health Statistics. Online. <<http://www.cdc.gov/nchs>>. April 20, 2004.
- Nicholson, Walter. Intermediate Microeconomics. 8th ed. Dryden Press. Fort Worth, Texas: 2000.
- Pigou, A.C. "The Economics of Welfare." Transaction Publishers. New York: 1920.
- Sommer, Heini. "Economic Evaluation in the Project Health Costs Due to Road Traffic-Related Air Pollution." Online. <<http://www.fhi.se/pdf/sommer.pdf>>. February 20, 2004.

WebMD. Online. <<http://www.webmd.com>>. March 10, 2004.

U.S. Retail Gasoline Prices. Personal Communication. Bin Zhang from <<http://www.eia.doe.gov>>. March 8, 2004.

Joseph Mack
Bemidji State University
2004