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Estimating the supply and demand of gasoline using tax data

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ABSTRACT

We estimate supply and demand functions for the U.S. gasoline market using information from excise tax returns provided by the IRS for the period 1990–2009. We find price and income elasticities of demand similar to those found using EIA data. We find a price elasticity of supply of 0.29, which differs from the common assumption of a perfectly inelastic short-run supply curve. By using a novel data source, the analysis provides a robustness check of aggregate studies of gasoline demand and a consistent, econometric estimate of the price elasticity of gasoline supply. The results are useful in guiding tax and regulatory policies regarding gasoline consumption.

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1. Introduction

Facing large and growing deficits for both the Highway Trust Fund and the overall federal budget, as well as increasing concern over curbing carbon emissions, there is a renewed interest in the taxation of gasoline and other fossil fuels. Indeed, taxes on fossil fuels have not kept pace with either government expenditures on transportation infrastructure or inflation. Table 1 shows federal taxes on gasoline and diesel have been stagnant (in nominal terms) since 1993. Since receipts from the excise tax on gasoline are the largest source of overall excise tax revenues, these taxes represent an important funding source for federal spending on transportation infrastructure.

To understand how tax policies affect the behavior of consumers and producers, and impact government tax receipts, one must have estimates of the price elasticity of demand and supply for fuel. These elasticities are also necessary to uncover the incidence of such taxes. Yet, while there has been extensive study of the price elasticity of demand for gasoline (see Goodwin et al., (2004) for a recent survey), much less has been written about the price elasticity of supply. This study fills the gap by providing estimates of the price elasticities of both supply and demand for gasoline. Our analysis is novel in two ways. First, we use data from excise tax returns to provide quarterly observations on U.S. fuel consumption. Second, we are the first to estimate both supply and demand elasticities using the same data source and consistent models.

We use data on fuel consumption from 1990 to 2009 to estimate the short-run price elasticities of supply and demand for gasoline. Simultaneous equations models, which correct for the endogeneity of prices and quantities in the market equilibrium, suggest the price elasticity of demand for gasoline to be −0.07 and the price elasticity of supply for gasoline to be 0.29. These models yield an income elasticity of demand for gasoline of 0.41. The estimates of the price and income elasticities ofdemand fall within the range of estimates found in the vast literature on gasoline demand.[2] While we are unable to find model based estimates regarding gasoline supply, an EIA report, cited by CBO, (2003), suggests a long-run price elasticity of supply of 2. We find a short-run elasticity significantly lower than 2. Thus our estimates support the view that the supply is more inelastic in the short-run and provide a precise estimate of this elasticity. A more inelastic short-run supply curve implies that policies such as a gasoline tax holiday would have less of an impact on consumption and that relatively more of the resulting surplus would go to producers.

Much has been written on the price elasticity of demand for gasoline. Goodwin et al., (2004) provide a review of 69 published studies since

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[1] The views expressed are solely those of the authors and do not represent the views of the Office of Tax Analysis or the Department of the Treasury.

[2] See Espey, (1996), Goodwin et al., (2004) for surveys of the empirical literature on gasoline demand.

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Table 1
Federal excise tax rates on gasoline and diesel.

Gasoline	Diesel	Time Period
4	4	1959Q4–1983Q1
9	9	1983Q2–1984Q3
9	15	1984Q3–1986Q4
9.1	15.1	1987Q1–1990Q4
14.1	20.1	1990Q4–1993Q3
18.4	24.4	1993Q4–1995Q3
18.4	24.4	1995Q4
18.3	24.3	1996Q1–1997Q3
18.4	24.4	1997Q4–present

*All rates are nominal cents per gallon.

1990 that estimate price elasticities of demand for different countries, and present price elasticities ranging from 0.00 to −1.81 depending upon the estimation technique and data used. More recently, Hughes et al., (2008), Wadud et al., (2010) estimate demand elasticities with more current gasoline consumption data and innovative techniques. Hughes et al., (2008) control for macroeconomic factors such as inflation, and use supply disruptions in an instrumental variables model to control for the endogeneity of prices and quantities. The paper finds short-run price elasticities ranging from −0.03 to −0.34 depending upon the model, estimation technique, and time period. Wadud et al., (2010) control for household characteristics such as urban/rural residence and find a median price elasticity of −0.47.

Less is written on supply elasticities. Austin and Dinan, (2005) and a Congressional Budget Office study CBO, (2003) of fuel taxes and fuel economy standards assume a price elasticity of supply of 2.0. However, this value is from an U.S. Energy Information Administration (EIA) report and not based on any econometric analysis of fuel supply. Often, such as in Davis and Kilian, (2010), it is assumed that supply is perfectly elastic (i.e. the marginal cost of refining fuels is independent of the quantity supplied) in the long-run and perfectly inelastic in the short-run. Others, such as Hsing, (1994) attempt to make inferences about the effects of tax policy on gasoline consumption without specifying a supply function. Providing a precise estimate of the elasticity of supply is an important contribution of the paper.

The remainder of this paper is organized as follows. Section 2 describes the data. Section 3 outlines the econometric model and presents the main results. Section 4 discusses the results and the important strengths and limitations of the study. Section 5 concludes.

2. Data description

We approximate fuel consumption with gallons of fuel sold, as reported on excise tax Form 720. This form is required to be filed quarterly by any individual or business that is liable for, or responsible for collecting, the tax associated with gasoline or diesel fuel, as well as other goods and services that face a federal excise tax. Form 720 contains gallon sold and taxes owed by type of fuel. The Internal Revenue Service (IRS) processes the filing and tabulates the total tax revenue by fuel type and by tax liability and processing quarter. The liability quarter corresponds to the quarter in which the fuel was sold (and the tax liability created). The processing quarter is the quarter the IRS receives and tabulates the payment. Late payments and corrections to past returns may be processed later, but the tax liability is attributed to the quarter in which the fuel was sold. Because we are interested in fuel consumption, we use the IRS tabulations for the liability quarter. These data correspond to the time of sale and track consumption better than does the processing quarter data.

Excise taxes are generally remitted by producers. In the case of gasoline and diesel, this is generally the refinery from which the fuel was first sold. We therefore cannot identify consumption by geographic area. Our analysis is thus restricted to the national level and is comparable to that done using the aggregate series on fuel supply provided by EIA. The

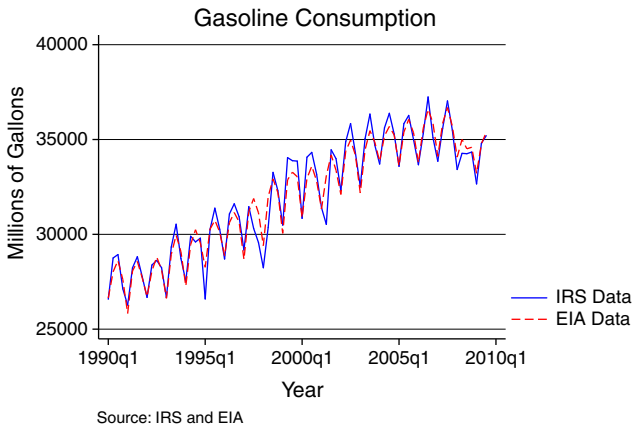

Fig. 1. Gasoline consumption, 1990–2009.

EIA series is the source of fuel consumption data for almost all aggregate studies of the price elasticity of demand for U.S. consumers.[3] Fig. 1 shows gasoline consumption as measured by the IRS and EIA data.[4] These two data sources find very similar quantities of gasoline sold in each quarter from 1990 to 2009.

IRS data has advantages over other available data. The data are available quarterly, providing relatively high frequency observations. Despite the incentive to misrepresent tax return information, the cost of an audit and subsequent penalties associated with non-compliance deter this behavior. Such incentives for compliance are not present in survey data. Furthermore, this paper aims to inform policy makers tasked with evaluating excise taxes associated with fuels. Using data on actual, taxable fuel sales provides the most appropriate basis and provides consistency in the discussion. It is these tax data that policy makers at Treasury, the Congressional Budget Office, and the Joint Committee on Taxation are likely to use when evaluating gasoline tax policy proposals.

EIA data suffer from two shortcomings that tax data do not. Neither of these are large errors, but they provide motivation for the use of an alternative data source, if only as a robustness check.[5] The goal of many studies, such as ours, is to measure U.S. demand for gasoline. Typically, gasoline supplied is used as a proxy for gasoline demand. One must be careful to add net imports to the production data, such as that measured by the EIA, in order to get the correct measure of domestic demand. While the EIA surveys refineries and gathers information on imports, it does not do the same for exports. In order to calculate U.S. supply, the EIA uses historical trends to impute exports in its weekly supply projections. The *Petroleum Supply Monthly* then uses aggregate export data from the U.S. Census to more accurately account for gasoline exports. This opens the door for potential errors when using EIA gasoline production data as a measure of domestic gasoline supply and demand. The potential errors have become more important, as gasoline exports have increased since 2008. The tax data correctly and consistently account for exports and imports because imports face a federal excise tax, but exports do not.

In addition, EIA data may suffer from non-trivial non-sampling error. The explanatory notes for the *Petroleum Supply Monthly* data suggest that as much as 2% of the sample is non-respondent. EIA sampling errors, particularly for calculations of inventory, have been noted to be problematic for oil industry analysts who use weekly

[3] The Consumer Expenditure Survey is the common source for studies of gasoline demand at the individual level.

[4] In making these series comparable, we add gallons of gasohol to gallons of gasoline in the IRS data. These two fuels are taxed at different rates and therefore separated on Form 720. However, the EIA reports the sum of the supply of the two fuels. The supply of gasohol is equivalent to about 5% of the supply of gasoline.

[5] In addition, recent budget cuts have threatened the EIA's ability to conduct its surveys. See, for example, Bird, (2011).