

**The Impact, Shifting, And Incidence
Of An Increase In The
Gasoline Excise Tax**

A Study Prepared by

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of Taxation*

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INTRODUCTION

This study was prepared by IRET's economists in response to numerous inquiries from public policy makers about the economic consequences of an increase in the Federal gasoline excise tax. Financial support for the study was provided by the Shell Oil Company a number of whose personnel were kind enough to answer our questions about technical matters pertinent to our analysis. We are grateful for this financial and data assistance. We particularly appreciate that at no time during the course of our study effort was any attempt made by anyone at Shell to influence our analysis, findings, or conclusions.

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EXECUTIVE SUMMARY

Substantial increases in the federal highway motor fuels excise taxes (chiefly gasoline and diesel fuel) continue to be urged by some members of the Congress and by a number of business leaders. In virtually all cases, these proposals have lacked a careful assessment of the economic consequences of their adoption.

An increase in the gasoline and diesel fuel excise taxes would have repercussions throughout the economy. Production and consumption of motor fuel would be reduced, leading to changes in the levels and composition of the economy's total output.

The price of motor fuel would rise significantly, although by less than the increase in the excise, and unit production costs, inclusive of the tax, would also increase. The tax increase would not merely be "passed on" to gasoline buyers. At the higher price, the volume of gasoline sales would be less than if the tax were not increased; the lower sales volume and higher unit production costs would result in cutbacks in gasoline output and in the use of production inputs. Profit margins and revenues of the refining industry and gasoline retailers would be reduced.

In the short run, there would be a relatively limited reduction in the volume of gasoline and diesel fuel production and sales compared to levels that would prevail in the absence of the tax increase. The cutback in volume would be greater over the longer term, as gasoline users had time to make economizing adjustments to the higher gasoline price. In the long run, an increase in the tax of, say, \$0.10 per gallon would cut motor fuel consumption by 6.2 percent. In the longer term, there would be greater impetus for the use of alternative fuels. The higher price of gasoline would not only induce a cutback in driving, but would also create additional incentives for automobile producers to achieve increased fuel efficiency of auto and truck fleets.

The gasoline production cutbacks would fall most heavily on the least efficient refinery operations. Those with above average efficiency, i.e., lower than average unit costs, would experience smaller reductions in profit margins; they would, therefore, undertake proportionately smaller cutbacks in output than would other refineries. As a result, the more efficient refiners would eventually enjoy a larger share of a smaller market. Gasoline retailers would also feel a profit squeeze resulting from the gas tax increase. Marginal retailers would exit the industry.

The cost of driving and of all motor vehicle transportation would rise, differentially affecting production costs and, therefore, the volume of production and consumption of all goods and services, according to their motor transportation content. There would be alterations in methods of shipping and in the mix of production. The tax would be incorporated into the cost of all goods and services, raising the annual cost of living by about \$125 per household.

Because of the limited responsiveness of the volume of gasoline consumption to changes in the price of gasoline, outlays for gasoline would take a larger fraction of disposable income than if the gasoline excise were not increased. Although purchases of some other goods and services would be reduced, it is unlikely that total consumption outlays would fall by the full amount of the increase in spending on gasoline. Personal saving, accordingly, would decline.

If government spending were to increase along with the increase in gasoline excise revenues, as history strongly urges, national saving would also fall. The stock of capital in the private sector would be smaller than it would be in the absence of the tax increase. Moreover, the reduction in the stock of capital would be greater in industries more dependent than others on motor vehicle transportation.

With less capital, the productivity of labor would advance more slowly, and real wage rates and levels of employment would be lower than otherwise. In the tenth year after the excise increase, the shortfall in employment would be approximately 0.177 percent. There would be 247,000 fewer jobs than if the excise were not increased, reducing labor income by \$8.8 billion. For those still working, real wages would average more than 0.2 percent lower over the period, or about \$70 less per year per worker, reducing labor income by another \$9.9 billion.

The gasoline tax increase would produce a one-time downward adjustment in the level of the growth path of GNP, and a one-time upward shift in the path of the price level. In the year 2000, GNP (in constant 1990 dollars) would be \$26.6 billion less than if the excise were not increased. Assuming an unchanged path of the money supply over time, the price level would be slightly higher than otherwise in any given year, but the year-to-year change -- the inflation rate -- would not be significantly affected.

Federal revenue gains from a gasoline excise increase would fall short of the official static revenue estimates. A static estimate of the revenue gains from a 10-cent increase in the gasoline excise would be \$13.0 billion in 1991 and \$15.4 billion after 10 years. However, static revenue estimates do not take account of the decrease in gasoline sales that would result from an increase in the excise, nor do they account for the lower levels of employment, output, and GNP that would reduce virtually all other federal tax receipts. Taking account of the decrease in gasoline consumption would trim the projected increase in gasoline excise revenues to about \$12.3 billion in the first year and to about \$13.0 billion after 10 years. The offsetting declines in other revenues would result in net revenue gains of only about \$7.5 billion in each year of the period. Ultimately, revenues would rise by less than half the static estimate. Federal spending under existing entitlement programs would also increase due to the reduced GNP and employment, further offsetting the revenue gains.

The net effect of a gasoline excise increase on the U.S. trade and current account balances is uncertain. Imports of oil and of gasoline would fall, and the lower GNP resulting from the excise increase would also cut imports of a wide range of other products and services. By raising production costs widely throughout the economy, however, the excise increase would also impair U.S. business competitiveness in the world market, hence reduce U.S. exports. The higher production costs might also lead to a decrease in the net capital inflow; this, in turn, would mean a smaller current account deficit. However, any gain in the trade or current account balance would be associated with a smaller U.S. economy and less domestic investment, and would not contribute to economic expansion. Given the estimated magnitude of the changes in domestic output, the changes in the trade and capital accounts would be modest.

The true cost of the tax increase must include the lost output to the economy that the tax is certain to produce. As with most distorting taxes, the gasoline excise tax has numerous hidden costs that make it an economically unattractive option for raising Federal revenue. The economic gains often attributed to the tax through reduction in the Federal deficit or improvements in the international trade statistics appear to be an illusion.

Effects of a \$0.10 a Gallon Increase
in the Federal Gasoline Excise
(Dollar amounts in billions of 1990 dollars)

Changes relative to baseline in:		1991	2000
GNP	Amount	-\$23.4	-\$26.6
	Percent	-0.414	-0.376
Capital Services	Percent	-0.924	-0.838
Employment	Thousands of Jobs	-230	-247
	Percent	-0.195	-0.177
Gasoline Consumption	Billions of Gallons	-2.708	-9.564
	Percent	-2.08	-6.21
Federal Revenues	Gasoline Excise	+\$12.3	+\$13.0
	Other Federal Taxes	-\$4.9	-\$5.6

THE IMPACT, SHIFTING, AND INCIDENCE, OF AN INCREASE IN THE GASOLINE EXCISE TAX

I. The Occasion for This Study and Its Objectives

On numerous occasions over the past two decades, serious proposals have been advanced to raise the federal highway motor fuel excise taxes, chiefly gasoline and diesel fuel, by substantial amounts. The rationales offered on behalf of these proposals are many and varied, including, among others, conservation of petroleum resources, environmental control, and reducing dependence on foreign oil supplies in the interests of national defense and improving the U.S. balance of trade. In the last few years, substantial increases in the gasoline and diesel excises have been proposed as a means of increasing federal tax revenue to reduce federal budget deficits. The Omnibus Budget and Reconciliation Act of 1990 included a 5 cent per gallon increase in the gasoline and diesel excises, among other revenue raisers. This has not silenced calls for additional, larger increases in the excises. The Persian Gulf crisis gave additional impetus to such proposals, primarily with reference to balance of trade and "energy independence" considerations.

In virtually all cases, the proposals have lacked any solid assessment of the economic consequences of their adoption. Indeed, the persistence of these proposals may be explained in part by a widespread failure to take account of the economic effects of excises in general and of the gasoline excise in particular. The political support for a gasoline excise increase is also bolstered by what appears to be the conviction in policy-making circles that a gasoline excise increase may be easier to pass than most other tax increases.

Without an assessment of economic consequences, there is no way to determine the real costs that the excise increase would impose or whether it would be effective in achieving its assigned objective. As a corollary, it is not possible to decide whether the allegedly beneficial results are worth the costs they entail. As a single example, unless the proposed excise increase's effects on GNP and employment are taken into account, the federal tax revenue gains from the increase cannot be accurately estimated and the presumed benefits to be obtained from the federal deficit reduction financed by additional tax revenues cannot be weighed against their costs.

At least since 1988, motor fuel excise increases have been at the top of the list of federal revenue increases urged by many tax-increase proponents in the Congress, the media, the academic community, and even in the business community. Whatever may be their near-term disposition, the proposals to raise the excise are likely to continue to appear on tax-legislation agendas year after year. A detailed, objective study of the likely economic consequences of such an increase is timely now and for the foreseeable future.

Most of the analyses of proposed increases in the gasoline excise that surface in the political forum and in the media are "static," failing to examine how households and businesses would react to the increase, the economic effects on the petroleum industry and purchasers of gasoline in the short run and over longer periods of time, and who would bear the ultimate burden of the tax as it affects economic behavior throughout the economy. Instead, the focus is

on how much revenue the excise increase will raise and on whether the tax will bear more heavily on poor consumers or the well to do. The implicit assumption on which virtually all such "analyses" rely is that the tax is "passed forward" in the sense that the price of gasoline rises by the full amount of the tax with no decrease in the amount of gasoline that is sold. Moreover, no account is taken of any other adjustments that gasoline buyers necessarily would have to make and of the effects of these adjustments elsewhere in the economy.

In reality, of course, gasoline buyers would react to any significant price increase resulting from raising the excise, bringing about changes in the volume of gasoline sales and production, hence in the amount of and payment for the production inputs used to produce and distribute gasoline. Higher gasoline prices would exert upward pressure on costs confronting virtually all businesses and households. Further effects would include changes in the composition of consumption outlays and in total output and in the uses of production inputs throughout the economy. Associated with these effects would be changes in the earnings of labor and capital in various applications in sector after sector and industry after industry. Clearly, policy makers need to be aware of the dynamics of a tax increase and to understand the adjustments that will occur in order to know the costs to be incurred by raising the gasoline excise.

This study seeks to identify the principal economic issues that are posed by proposals for increasing the federal gasoline and diesel excises. Part II of the study provides a heuristic analysis of the major economic consequences of a gasoline and diesel excise increase. Part III provides quantitative estimates of these effects. Throughout the study, the term gasoline may be assumed to include diesel fuel for highway use, and it is assumed that the excise tax increase would apply to both fuels.

The analysis in Part II spells out in two steps the basic propositions concerning the initial impact, shifting, and ultimate incidence of excise taxes. The analysis first develops the adjustments undertaken by the buyers of the taxed product and by the firms and the industry producing it -- a partial equilibrium analysis. Because buyers and sellers of gasoline do not conduct their affairs in isolation, the consequences of the economic adjustments they make to the gasoline tax increase for economic activities elsewhere in the economy must also be rigorously delineated. Therefore, the partial equilibrium analysis is followed by an examination of the economy-wide adjustments -- a general equilibrium analysis.

II. The Impact, Shifting, and Incidence of a Gasoline Excise Tax

Political considerations of excises taxes are generally predicated on serious misapprehensions concerning the impact of these taxes, how they are shifted, and their ultimate incidence. Much of the popular treatment of the economic consequences of excises suffers from the same kinds of misapprehensions. Addressing both the political issues and economic concerns raised by proposals to increase the gasoline excise tax calls for a careful, rigorous examination of:

- the immediate effects of any such increase,
- how producers-sellers and buyers would adjust their activities in response to the increase and how these adjustments would affect activity throughout the economy, and
- when these adjustments were completed, how the resulting economic conditions would differ from those that would have prevailed if the excise had not been increased.

Some basic propositions about the impact of excises taxes in general, their shifting, and ultimate incidence will facilitate the subsequent analysis of the economics of the gasoline excise.

A. The Concepts of Impact, Shifting, and Incidence

1. Impact

The impact of any tax, its instantaneous effect, is best identified as the change in the implicit price or cost of the thing that is taxed relative to the prices of other things. The imposition of an X cents per unit tax on widgets, for example, means that for every widget that is produced and sold X cents must be collected from someone, whether the buyer, the seller, the producer, or those who supply the production services, raw materials, energy supplies, etc., used in widget production.¹

Unless the same tax is applied uniformly to all products, services, activities, etc., the X cents per unit widget tax raises the price of widgets compared to other things. The relative price change induced by the tax is the impact of the tax.

This relative price effect, sometimes referred to as the excise effect of a tax, is not peculiar to excise taxes. Virtually every tax alters the price of the thing that is taxed relative to something(s) else. An income tax, for example, increases the cost of using one's time and resources to produce income subject to the tax compared with the cost of devoting one's time and resources to other activities, e.g., recreational activity, household jobs, etc. Similarly, it increases the cost of saving relative to the cost of current consumption.²

2. Tax Shifting

Tax shifting is quite widely thought of in a literal sense as the transfer of the burden of a tax from the person with the statutory liability for the tax to another person(s). In this view, tax shifting is seen as little more than the efforts by producers or sellers of the taxed product or

service to make others pay the tax, either by raising the price of the product or service or by reducing the price paid for the production inputs used to produce it.

Tax shifting, however, is not usefully perceived merely as the "passing forward" or "passing backward" of the tax. Shifting is not simply the taxpayer's raising the price to the buyer of the taxed product or service or cutting the payments to the suppliers of the inputs used to produce the product or service. This is not to say that the taxpayer makes no attempt to pass the tax forward or backwards, in this sense, but that such efforts, whether or not they succeed, involve only a part of the shifting adjustments. Of at least equal importance is how buyers or suppliers respond to any such efforts. These responses, in turn involving adjustments by other persons elsewhere in the economy, are much more complex and extensive than merely the initial changes in prices of outputs or inputs that the taxpayer can effect.

Tax shifting is not a one-shot adjustment. Tax shifting is a process consisting of all of the economic adjustments that people make in response to the changes in relative prices and costs that result from the imposition of the tax. For the businesses directly affected, and their employees and suppliers, these responses result in:

- decreases in the amount of their output of the taxed commodity or service,
- higher prices for that reduced output,
- reduced use of the inputs employed in producing the taxed items,
- reduced prices or compensation of those inputs,
- changes in the composition of the businesses' product lines, and in time,
- reduction in the amount of plant and equipment devoted to producing the taxed items.

For the buyers of the taxed product, the shifting process includes decreases in the purchases of the product and changes in the composition of buyers' total outlays, as well as decreases in their disposable incomes. These changes may be identified as the partial equilibrium adjustments made by the directly affected businesses in their product and input markets and by the buyers of the taxed product.

In turn, these adjustments lead to changes throughout the economy in the composition of spending, in the use of production inputs, in the mix of products and services that come to the market, and often in the volume of total production. These changes are the processes by which the economy as a whole moves toward a new general equilibrium. Together, these changes, the indirect as well as direct consequences of the imposition of the tax, clearly go significantly beyond merely the efforts of producers or sellers of the taxed products or services to transfer the tax to their customers in the form of higher prices or to their input suppliers in the form of lower prices.

3. Tax Incidence

As described above, tax shifting refers to the processes of adjustment to the imposition of a tax. Tax incidence is usefully interpreted as the differences between the economic state of

affairs that prevails when the shifting or adjustment process is completed and that which would have prevailed if the tax had not been imposed. In this context, incidence includes the differences in the uses of production inputs and the payments made for their use, in the level and composition of output, in the level and composition of income, and in the distribution of income and wealth by income and wealth levels.

This concept of incidence is much broader, yet more useful, than a more conventional view which focuses only on the tax-induced changes in the income-level distribution of income and wealth. This concept, moreover, goes far beyond the question of who, in a narrow sense, ultimately pays the tax or bears its burden. Many differing groups of persons are affected in many differing ways by the tax. When one takes account of the very large number of adjustments of a great many sorts that are made in the process of adjusting to a tax, identifying the persons who wind up bearing the tax is clearly impossible.³

Viewing incidence in this way, incidentally, highlights the inadequacies of the customary estimates of the revenue consequences of the imposition of, or changes in, a tax. Revenue estimates, for the most part, are "static," i.e., they largely ignore the shifting and incidence of the tax or tax change and implicitly assume that those on whom the tax is levied do not change their behavior in any respect, i.e., are totally unresponsive to the changes in the relative prices and costs they confront as a consequence of the tax or tax change. The concepts of shifting and incidence proposed above demand a quite different kind of revenue estimate, one that takes account of the changes in the volume and composition of economic activity and in the income claims generated thereby. These "dynamic" revenue estimates are much more difficult to make in the present state of the econometric art, but even crude dynamic estimates are likely to be more nearly on the mark than refined static estimates.

B. Impact, Shifting and Incidence of an Increase in the Gasoline Excise Tax⁴

The federal government imposes a variety of manufacturers' and consumers' excise taxes on motor fuels for automobiles, trucks, ships, and aircraft.⁵ For purposes of this analysis, it is assumed that only the excises on gasoline and diesel fuels would be increased. (Throughout this discussion, reference will be made to the gasoline excise, taken to include the diesel fuel excise, as well.) It is also assumed that, following current practice, the increases in these excises would apply to imported supplies, in order to avoid any significant displacement of domestic production by imports and erosion of the excises' revenue bases.

An extremely important assumption for this analysis is that the increase in the gasoline excise is enacted as a permanent increase and that producers and sellers as well as buyers proceed on this assumption. All of the adjustments in production and purchases that would be made in response to an increase in the excise would impose costs on producers and buyers. If the excise increase were deemed to be short lived, producers and buyers would make only limited adjustments to avoid incurring adjustment costs that exceeded the cost of the additional excise tax. If the duration of the excise were specified to be, say, five years, producers and buyers

would make some adjustments, but these would be different both in character and in magnitude from those that would be undertaken if the increase were known to be permanent.

Enactment of an increase in the gasoline excise would change the relative price of gasoline versus other goods and services and would set in motion adjustments by both producers and buyers of gasoline; these adjustments in the gasoline industry and market would, in turn, lead to changes in the mix of aggregate consumption and production, in the use of production inputs, in the compensation of suppliers of production inputs, in the levels of aggregate output and incomes, in international trade and capital flows, and in federal tax revenues from virtually all revenue sources. Tracking these adjustments requires first an analysis of the short-run and long-run effects of the excise increase on participants in the gasoline market -- a partial equilibrium analysis -- and then consideration of the ways in which these effects are transmitted in the short term and the long term throughout the economy -- the general equilibrium analysis.

1. Partial Equilibrium Analysis

a. Short-run Adjustments

In very summary terms, an increase in the federal excise on gasoline would raise the retail price of gasoline, in the short run, by somewhat less than the amount of the tax increase and reduce the net-of-tax price received by the producer from its pre-tax-increase level by somewhat less than the amount of the tax increase. Along with these price changes, the excise increase would somewhat reduce output, sales, and consumption of gasoline, resulting in some cutback in employment in petroleum refining and distribution. Net revenue and profits of the petroleum industry in general and of the refining sector in particular would be reduced. The magnitude of the price, sales, consumption, and output effects would grow over time.

An increase in the gasoline tax would be equivalent to increasing the variable costs of production of gasoline. At the prices for gasoline prevailing before the tax increase, this cost increase must generate either reduced profits or losses for gasoline refiners. Refiners would have to choose between increasing the price of gasoline they charge to wholesalers or cutting back production to reduce their costs. To the extent that refiners raised prices to cover their higher costs, gasoline distributors would also seek to raise the prices they charge to their customers.

The producers and distributors obviously would prefer only to raise price by the amount of the tax while maintaining output and sales, leaving the businesses' bottom lines unaffected. In reality, of course, this option is not available, because buyers will reduce their purchases as the product's price is increased. Rather than build up unwanted inventories, refiners would cut output. Almost invariably, cutting output reduces total costs.⁶ Consequently, the price paid by buyers would rise by some portion of the tax increase, and the price received by the refiner would fall by the remaining portion of the tax increase.

How much of the tax increase would manifest itself as a rise in the price to gasoline users and how much as a fall in the price received by the refiner would depend on the short run elasti-

cities of demand for and supply of gasoline. The higher is the short run elasticity of demand for gasoline, the greater would be the reduction in sales for any given increase in the price, and the smaller would be the increase in gasoline prices as a result of the tax increase. By the same token, the lower is the price elasticity of gasoline demand, the greater would be the increase in gasoline price and the smaller would be the reduction in gasoline sales.

(1) Effects on Sales of Gasoline

The reduction in purchases of gasoline by consumers, although it may not be in evidence immediately upon the increase in price, is as certain as anything in economic behavior. To assume that purchasers of the taxed product would continue to buy the same amount of it when its price is raised to cover the tax is to posit a perfectly inelastic -- or zero-elastic -- demand for the product. Basic propositions about the nature of demand rule very strongly against the notion of zero-elastic demand for any product or service.

The demand for a product or service -- the schedule of the quantities of the product or service that people will be willing to buy at differing prices⁷ -- is principally influenced by the tastes and preferences and the incomes of the buyers and the prices of products or services that the buyers deem to be more or less substitutable for the product or service in question.

The larger are people's incomes, the greater will be the demand for a product or service (assuming their tastes and preferences lead them to want to buy the product at all). Given people's tastes and preferences, there are few products or services that are uniquely capable of satisfying people's demands, i.e., almost everything has substitutes. Given the prices of the substitutes, an increase in the price of the product or service in question, with no offsetting decrease in other prices or increase in buyers' money incomes, will lead to a decrease in its purchases relative to the purchases of the substitutes. The closer are the substitutes in terms of satisfying buyers' wants, the greater will be the decrease in the purchases of the product the price of which is increased, and the greater the relative shift to the substitutes.⁸

The imposition of the tax certainly doesn't increase buyers' incomes, nor can it be seen as somehow making the taxed product more desirable compared to other, substitute products. Buyers, therefore, are never completely unresponsive in their purchases to changes in the product's price. In other words, the elasticity of demand for any product -- the percentage change in the quantity of a product that will be purchased in response to a given (small) percentage change in its price -- is not zero. Mother Nature abhors a zero price elasticity of demand even more than she abhors a vacuum.

Consequently, as businesses producing the taxed product seek to raise its price, sales of the product must decline. To be sure, this decrease in sales volume does not necessarily occur immediately. If the higher price persists, however, buyers are virtually certain, sooner or later, to reduce their purchases of the taxed product and to shift the composition and amount of their purchases.

In the case of an increase in the gasoline excise tax, the extent of the increase in price and decrease in sales would depend to a substantial extent on the price elasticities of demand for and supply of gasoline.⁹ Because gasoline is a production input to motor vehicle transportation, the demand for gasoline is derived from the demand for that transportation service.

Motor vehicle transportation services are highly varied, ranging from pleasure driving by households through a very large number of differing business travel, delivery, and other materials-moving uses. The demand for some of these services may be relatively price elastic in the short run, particularly if the magnitude of the excise increase and the resulting initial relative price impact is as large as is widely proposed.¹⁰ This short-run elasticity clearly depends on the options available to businesses and households to curb their use of motor vehicles and on the savings they obtain by doing so compared to the costs they must incur in the process.

In the short run, the substitutability of other transportation modes, particularly for moving materials, is probably quite limited. Insofar as other, more fuel-economical vehicles are available, businesses might accelerate replacement of existing vehicles.¹¹ Apart from such changes in automotive equipment, businesses might seek to economize on their use of their existing equipment; they might curtail use of company cars, route deliveries and pickups more carefully, reduce their frequency, and otherwise attempt to economize on motor vehicle use in moving materials. All of these efforts are likely to entail costs in terms of providing less satisfactory services to customers and, perhaps, loss of operating efficiency, assuming that prior to the price increase, vehicle use was carefully and efficiently managed.

The impetus to seek any such economies and to incur the costs of doing so depends to a large extent on how large a share of the business's total costs are represented by motor vehicle transportation. The larger is this share, the more substantial will be a business's response to a given increase in gasoline costs. This share varies widely across the spectrum of business activities, in differing parts of the country, and with respect to the spatial dimensions of the markets in which the business sells its products and buys its materials inputs. The magnitude of business adjustments to an increase in the gasoline excise, accordingly, would vary widely. The burden of the tax would be far from uniform in the business community.

Because the economizing options available to businesses in the short run are limited, business use of motor vehicle transportation services would not be curtailed to the same proportionate extent as the increase in the cost of these services. The price elasticity of business demand for motor vehicle transportation services, in other words, is significantly less than unitary.

The chief option open to households in the short run is to drive less, which means curtailing driving thought to be non-essential -- fewer pleasure trips and less frequent shopping trips. Some persons who drive to work might shift to public transportation and carpooling. Like businesses, household drivers would seek to improve auto maintenance, adjust engines and tire pressure to produce better fuel economy, etc. And like businesses, household drivers would accelerate automobile replacement in an effort to save fuel, subject to constraints comparable to

those confronting business users. A substantial increase in the price of gasoline as a result of a large hike in the gasoline excise would very likely exert a significant restraint on household driving even in the near term. Household demand for motor vehicle transportation services is, very likely, more price elastic than business demand, in the short run.

The overall demand for motor vehicle services, heavily influenced as it is by business use, is probably price inelastic in the short run, even over a considerable range of price increases. Motor vehicle use would certainly be curtailed by the gasoline price increases that would follow from the substantial excise increase assumed in this analysis, but the percentage drop in use would be less than the percentage increase in price.

The demand for a production input tends to be less elastic than that of the product or service to the production of which it contributes. Moreover, as in the case of production inputs generally, the demand for gasoline depends to a very significant extent on the elasticity of its substitution for other inputs in the production of motor vehicle transportation.¹²

Few of these other inputs are, in fact, substitutable for gasoline; for the most part, the other inputs are complements to motor fuels. The price elasticity of demand for gasoline in the short run, accordingly, is quite small. Estimates of the short run elasticity of demand for gasoline cluster around 0.2, i.e., a 1 percent increase in the price of gasoline would cause gasoline users to cut the number of gallons they would purchase by 0.2 percent.¹³

It is important to keep in mind that elasticities estimated on the basis of past behavior may not be reliable indicators of the reaction of gasoline buyers and suppliers to future price changes. Changes in the technical attributes of fuels and in motor vehicle characteristics may have altered the responsiveness of gasoline buyers to price changes since earlier periods, from which the data used to generate elasticity estimates were obtained.

At 1991 retail prices for gasoline and diesel fuel, an increase of, say, \$.10 in the gasoline excise, passed through to and charged by the retailer, would represent a roughly 8.4 percent increase in the retail price. Assuming a price elasticity of 0.2 throughout the range of prices from current retail to the \$.10 a gallon higher price, this would result in a nearly 1.7 percent reduction in the volume of gasoline that would be sold.¹⁴ At 1991 consumption levels this would amount to a nearly 2.2 billion gallon decrease in physical sales volume, at an annual rate.

The limited cutback in the number of gallons of gasoline consumed in response to the tax-induced higher price per gallon would result in an increase in the total amount spent for gasoline by consumers. The increase in outlays would be less than the increase in the amount of taxes paid, resulting in a drop in after-excise-tax receipts for refiners.

(2) Effects on Production of Gasoline

Unless producers are willing endlessly to accumulate inventories of the taxed product, its production will also be reduced. As production is cut back, variable production costs will be

decreased, both net of and inclusive of the tax.¹⁵ The extent of this decrease in costs depends on the elasticity of the business's supply of the product, i.e., on the percentage change in total costs incurred in response to a (small) percentage change in output. This cost reduction offsets, but only in part, the decrease in producers' revenues resulting from the reduction in sales in response to the increase in price.¹⁶ The producers' profit margins and profits, therefore, decline in the short term.

This does not deny the likelihood that, in any but very highly competitive industries, each business will attempt to make its own adjustments to the imposition of the tax on its product. These efforts, however, are constrained by the responses of other businesses in the industry, so that, in the last analysis, the results for each business are largely determined by the conditions of demand for the product and of the demand for and supply of production inputs confronting the industry as a whole.

The extent of the price increase would also be affected by the conditions of supply of gasoline. These supply conditions, in turn, are determined by the existing production technology and conditions of supply of the production inputs. Refining is highly capital intensive, i.e., the production services provided by plant and equipment account for a substantial fraction of refinery output. Over a substantial range of output, differing production levels entail relatively small changes in marginal costs. The relatively flat short-run cost conditions mean that there are relatively slight unit cost savings to be obtained from cutting production, so that much of the tax increase would show up as an increase in the market price of gasoline. The resulting reductions in sales and in production, therefore, will depend principally on the elasticity of gasoline demand in the short run. The estimated .2 short-run gasoline demand elasticity, noted above, implies that the cutback in production would be relatively slight, in the short run, while the market price increase would be a substantial fraction of the excise increase. Only a relatively small fraction of the excise increase, accordingly, would come out of the profits of refineries and distributors.

The erosion in the profitability of gasoline refining operations, modest though it would be, would induce some shift in the composition of output away from gasoline and toward petroleum products on which no tax or a lesser tax is imposed or to which the gasoline excise increase would not apply. Within the constraints of the existing production facilities and technology, labor and capital services would be shifted toward production and marketing of lesser-taxed products.

Insofar as resources could not be shifted to alternative uses in the short term, aggregate industry employment of labor and capital services would decrease relative to the levels of use of these services absent the tax increase. Some refining capacity would be idled or operated at lower rates, and refinery employment would be reduced. The employment effects at the retail level, where the production process is somewhat more labor intensive than in refining, would be somewhat greater.

The short-run adjustments to a gasoline excise increase would not be uniform among the businesses in the refining and distributing industries. Relatively less efficient businesses might

undertake greater percentage cutbacks in output than more efficient producers. The greater efficiency of some businesses presumably reflects their access to and use of more highly specialized -- more productive -- production inputs compared with less efficient companies. In this event, the payments made for the use of these more specialized inputs exceeds the opportunity costs of their use by the more efficient companies. As a result, cutbacks in these excess payments would not impel those providing these inputs to shift them to other employments. For this reason, decreases in the greater than average profitability of the more efficient businesses would not induce them to the same extent as less efficient companies to shift capital use to other production. The more efficient companies, accordingly, would reduce output relatively less, if at all, than other companies.

(3) Effects on Production Inputs

The tax-induced cutback in production necessarily involves decreases in the producer's use of the labor and capital services and other inputs employed in producing the taxed product. The extent of the decrease in input use depends on the conditions of demand and supply of the production inputs.

The demand for production inputs is derived from the demand for the products to the output of which they contribute; the more elastic is the demand for the final product, the more elastic is the demand for the production inputs.¹⁷ With given conditions of their supply, the more elastic is the demand for the production inputs the greater will be the reduction in the quantity of them employed.

By the same token, the more elastic are the conditions of supply of these production services and inputs, the greater will be the decrease in their use, given the change in the demand for them. If those supplying these production services and inputs have other equally or almost equally rewarding opportunities for their use, there will be -- can be -- little reduction in the rates of compensation for their use in the taxed production. Any effort to cut their compensation significantly will lead the input suppliers to move elsewhere. The decreases in their employment in the taxed use, hence the cuts in production, will be relatively substantial as producers attempt to adjust to the imposition of the tax.

On the other hand, to the extent that the production services and/or inputs are specialized to the production of the taxed product, therefore have few alternative employments available, the decreases in their employment in that production will be more modest. For the same reason, the cuts in their compensation rates will be more substantial. Cost reductions, in this case of inelastic supply of production inputs, will be primarily in the form of wage and salary cuts, lower rates of return on capital, and/or price reductions for the raw materials and other production inputs. A high degree of input specialization is a temporary phenomenon, however. In time, suppliers of these inputs will seek out alternative, more rewarding uses.

(4) Influence of Foreign Production

The scope of these short-term business and industry adjustments may be influenced by the extent of the market for the taxed product. Generally, an excise tax on a specific product is imposed on imported as well as domestically-produced output sold in the taxing jurisdiction. If the product's output and purchase is substantially confined to the market lying within the jurisdiction of the government imposing the tax, the adjustments made in response to the tax will not be significantly subject to foreign influences. However, if the taxed product is also produced in other jurisdictions and sold in the taxing jurisdiction, the magnitude of the adjustments delineated above will depend to a significant degree on (1) how much of the domestic sales of the taxed product is accounted for by domestic and how much by foreign production; and (2) what fraction of total foreign production is represented by the exports to the taxing jurisdiction.

The imposition of the tax on the imported product will induce foreign producers to reallocate their output to other markets. On the appealing assumption that prior to the tax, foreign producers had so arranged the distribution of the output as to maximize profits (or minimize losses), the increase in costs in the market subject to tax must induce a shift in market focus by foreign producers. If imports represent a small fraction of the total amount supplied in the pretax domestic market situation as well as a small share of foreign production, the decrease in imports can have only a slight effect on the conditions of supply in the domestic market, hence only a modest effect on the adjustments made by domestic producers and buyers.

If, on the other hand, imports represent a substantial share of domestic sales but a small fraction of total world-wide sales, foreign producers are likely to shift a substantial amount of their output away from the market in the taxing jurisdiction to other markets. In this event, the decrease in supply offered by foreign producers materially reduces the total supply in the taxing jurisdiction's market. By the same token, the increase in the product's price inclusive of tax is likely to be greater by virtue of the greater reduction in supply than would occur if less of the product were foreign produced. The reduction in domestic supply, accordingly, will also be less, and the attendant adjustments by domestic producers will be less severe.

Just as foreign producers are likely to shift the locus of their sales, domestic producers may well seek to substitute exports for domestic sales. In virtually all cases, excises taxes either are not imposed or are rebated on products that are exported to foreign markets. The imposition of an excise must reduce the net-of-tax price received by the producer or seller on domestic sales relative to that received on foreign sales. This relative price shift may well be sufficient to offset the increase in transportation and shipping costs of export sales. To the extent that this shift from domestic to export sales by domestic producers occurs, it further reduces domestic supply, hence leads to greater increases in the price of the taxed product in the domestic market.

b. Long-run Adjustments

Over the long-run, adjustments in the gasoline industry would involve changes in the composition of both business and household outlays, hence in the conditions of demand

confronting gasoline refining and distribution. Changes in cost conditions as well as in demand conditions would lead to changes in the composition of production and in the use of production inputs. These changes would increase over time.

(1) Effects on Sales of Gasoline

As suggested earlier in the discussion, buyers of the product may not be able to effectuate all of the changes in their purchases in a short period of time following the imposition of the tax. As time goes on, however, the demand for the taxed product is likely to decrease, i.e., less of it is sold at any given price, and the elasticity of demand for it increases as substituting other products becomes more feasible. These changes in demand conditions mean that with the passage of time, the decrease in sales of the taxed product compared with the levels that otherwise would have been realized will be greater than that which occurs in the short-run adjustment process. The consequence of these demand changes is greater pressure on producers of the taxed product to reduce their rates of output as time goes by.

In the long run, the gasoline excise increase would lead to changes in the basic determinants of the demand for gasoline. As noted above, the low short-run price elasticity of demand for gasoline means that total outlays for gasoline would increase above the levels that would prevail without the excise increase. By the same token, the after-tax income of gasoline buyers would fall. Unless these buyers were to reduce their purchases of other products and services by an amount at least equal to the difference between the tax collections and the decrease in the net-of-tax outlays on gasoline, private saving would fall. On the plausible assumption that government spending would increase at least as much as the increase in tax revenues, the decline in private saving would involve a decrease in private capital formation.

In turn, the decrease in the stock of capital compared to levels that would otherwise prevail would mean less capital services, less output produced by capital, lower labor productivity, employment, and wage rates, hence lower aggregate levels of income than otherwise. This income effect would be associated with a reduced demand for motor vehicle transportation, hence a reduced demand for gasoline. At any given price per gallon, in other words, fewer gallons of gasoline would be purchased.

Through time, moreover, more of the stock of automotive vehicles in place at the time the excise increase took effect would be replaced, to a substantial extent by more fuel-efficient vehicles. In addition, at least some of the so-called alternative fuels that are now submarginal would become more economical as a result of the gasoline price increases produced by the gasoline excise hike. In short, not only would the demand for gasoline be depressed by the reduction in motor vehicle use, but it also would become more elastic as the availability of substitute fuels increased.

Estimates of the long run demand for gasoline cluster around 0.7.¹⁸ This implies that a 1 percent increase in the price of gasoline would result in a 0.7 percent reduction in the

quantity demanded by consumers. Although the elasticity of gasoline demand in the long run would remain relatively low, it would be sharply higher than in the short run.

For this reason, the effect of the excise increase in depressing gasoline sales would be substantially greater over time than in the short term. If gasoline prices were to increase by nearly 8.4 percent in response to a \$.10 a gallon excise increase, gasoline sales would fall by nearly 5.9 percent in the long run, compared to the sales volume that would prevail in the absence of the excise increase. At projected sales volume for gasoline and diesel fuel the year 2000, this would amount to a reduction in annual sales of about 9 billion gallons.

To be sure, the increase in gasoline prices would be slightly less over the longer term than in the near term following the excise increase, implying less of a decrease in the quantity of gasoline demanded than suggested by the preceding example. As a result, the reduction in net-of-excise receipts to gasoline refiners and distributors would be modestly greater. The erosion of profitability in gasoline refining and distribution would intensify, leading to further adjustments in gasoline supply conditions.

(2) Effects on Production of Gasoline

The curtailment of sales volume over the longer term necessarily impels producers to cut back output of the taxed product to a greater extent, relative to levels that otherwise would have been realized, than is undertaken in the short run. As part of the process of adjusting production to the changed conditions of demand, producers will attempt to identify more profitable uses for at least some of the capital services used in producing the taxed product. If the capital facilities and the labor services with which the capital is used are relatively unspecialized, they will be adapted to other productive uses in a relatively short period of time. Even very highly specialized production inputs can be despecialized and respecialized, given enough time. In time, therefore, some of the production services used in producing the taxed product are likely to be reallocated to other production.

For the most part, this reallocation of capital and other production inputs entails a decrease in the capacity (plant and machinery) dedicated to the production of the taxed product. These long-run reductions in capacity and in output result in rising prices for the taxed product, given the demand for the product. The cutbacks in capacity and in output continue until the market price of the product has increased sufficiently to cover the costs, including the cost of capital as well as the tax, of the lower level of output. At that time, there is no further impetus, attributable to the excise tax, for further adjustment of capacity and of output.

At permanently lower levels of sales and reduced profitability, producers and distributors would eventually seek to adjust capacity to achieve the lowest possible unit production costs. This would lead to a scaling back of industry capacity compared to what it would have been without the tax increase.

Cutbacks in output in the short run with existing plant would achieve some cost savings. With either constant or increasing long-run costs, however, lower fixed costs can be realized, without increases and possibly with decreases in variable unit costs, by cutting back the scale of plant. In time, therefore, investment in refining and distribution capacity would fall off, resulting ultimately in a smaller industry than would have existed had the excise not been increased.

The magnitude of the scaling back of capacity in the industry might appear to be relatively modest, given the relatively low estimate of long-run price elasticity of demand. Two considerations, however, suggest a somewhat larger adjustment in capacity. One is the reduction in income and the consequent decrease in demand for gasoline, discussed above, that would occur along with the increase in price elasticity. The other is that production inputs that are significantly specialized to gasoline refining and distribution in the short run become much less so as time goes on.

Despecialization of these inputs implies expanding opportunities for their suppliers to shift them to other uses in which their productivity would be greater compared to that in the gasoline industry after the tax increase, hence in which their rates of compensation are relatively higher. With a narrowing, or possibly even a reversal, of the gap between remuneration rates in gasoline compared to other production, the opportunity costs of the inputs' use in gasoline refining and distribution would increase. In turn, this would raise the supply prices of these inputs for gasoline production and distribution, hence production costs at any given scale of plant. The impetus to reduce capacity, accordingly, would be greater than might appear by focusing only on the estimated demand elasticity.

Adjustments in the industry's capacity would result in further cutbacks in production and in higher prices. The adjustment would continue until prices had risen enough to restore acceptable profit margins and rates of return on capital in the industry.

The extent of the cutbacks in capacity would not necessarily be uniform among the businesses in the industry. Businesses of average or below-average efficiency, i.e., of average or higher unit costs, would curtail capacity to a greater extent than the more efficient companies. After all adjustments, the more efficient businesses would find their relative position in the industry enhanced, and enjoy a higher share of a reduced market. Total sales and profits of the more efficient businesses might well be restored to close to their pre-excise-increase levels.

If foreign producers were among the most efficient refiners in the industry, the cutback in gasoline production for the U.S. market would fall primarily on U.S. refineries. If the foreign refineries were among the less efficient businesses, there would be some cutback in imports of refined gasoline as a result of the tax, and less of a cutback in the output of domestic refineries.

(3) World Market Influences on Long-run Adjustments

The U.S. market for gasoline is not isolated from the influences of foreign gasoline markets. Although gasoline imports account for a relatively small fraction of total U.S. gasoline

sales, the adjustments to an increase in gasoline prices in response to an increase in the gasoline excise would be influenced by developments in the world market.

In the absence of an international oil cartel, an increase in the U.S. gasoline tax would reduce U.S. demand for crude oil and would somewhat lower the world price of oil. Although consumption of petroleum products outside of the United States would rise slightly, world production would fall slightly.

The effect on the world price would be modest for several reasons. For one thing, the decrease in U.S. gasoline consumption would be relatively modest, on the basis of the assumptions noted above concerning the decline in the demand for gasoline and the estimate of the long-run price elasticity of demand for gasoline. Moreover, only part of crude oil output is refined into gasoline, so that any given percentage reduction in U.S. consumption of gasoline would translate into a smaller percentage decrease in the U.S. demand for crude oil. In addition, because U.S. demand for crude oil is only a fraction of world demand, any given reduction in U.S. demand for crude would reduce worldwide demand to a much smaller degree.

There is, however, a world oil cartel, and its response to the decline in the world demand for oil must be taken into account. OPEC could respond to the lower world demand in various ways. It might, for example, do nothing, i.e., accept the lower oil price while maintaining current production quotas. It would, of course, suffer some reduction in oil revenues as a result. U.S. and foreign oil producers would bear part of the cost of the tax increase.

Alternatively, OPEC might act in unison to cut back production, on the assumption that the worldwide demand for oil is sufficiently inelastic to result in an increase in the price sufficient to recoup revenues lost as a result of the reduced U.S. oil consumption. U.S. and foreign oil producers would bear less of the cost of the tax increase, while U.S. gasoline buyers and refiners would bear more.

Another possibility is that OPEC would fragment, with each member attempting to recoup lost revenues by increasing output above existing quotas, driving the world price lower. U.S. gasoline buyers and refiners would bear less of the cost of the tax increase. Foreign consumers would benefit the most.

The response of OPEC to the assumed change in demand conditions is difficult to assess with confidence. However, it seems clear that the consequences of a gasoline tax increase of the magnitude found in most of the excise-increase proposals would not be confined to the U.S. gasoline market.

The increase in the gasoline excise would impose more of a burden on U.S. buyers of gasoline than on foreign users of gasoline. If the world (non-U.S) price were to fall as a result of the U.S. tax increase, foreign users would escape the burden of the tax increase altogether and would benefit in absolute terms. Meanwhile, the excise increase would raise production costs in varying degrees for virtually all U.S. businesses, both in absolute terms and relative to those

of foreign businesses. This would trigger changes in the composition of imports and exports, exchange rates, and, possibly, the current account balance, as discussed below.

(4) Long-run Forward Shifting

When long-term partial equilibrium is attained, the new price is high enough to cover production costs, including the required rate of return on capital, plus the full amount of the tax. In one sense, the tax has been "shifted forward," because the new price is higher than that prevailing before the tax was imposed.¹⁹ The tax has not, however, been fully shifted forward, as the phrase is generally understood; full forward shifting is generally perceived to mean that the post-adjustment price exceeds the price prevailing before the tax was imposed by the full amount of the tax with no decrease in the amount of output and purchases of the taxed product. As pointed out above, this notion of full forward shifting implies a zero price elasticity of demand for the product, a situation that is never found in the real world.

(5) Long-run Backward Shifting

The higher price prevailing in the long-run partial equilibrium is associated with decreases in the output of the taxed product and therefore with decreases in the amount of capital, labor, and other production services employed in the industry. The cutback in the use of these production inputs is likely to reduce the rates of compensation for their use, at least compared to the compensation rates that otherwise would have prevailed. The aggregate payments made to these production inputs, accordingly, will be less than otherwise. In this very real sense, therefore, the tax has been "passed backward." Unless the production inputs were completely specialized to producing the taxed product, however, the decrease in their rates of compensation is less than the tax per unit of output. The tax, accordingly, is not fully passed backward.

The point, of course, is that the responses to the imposition of (or increase in) an excise tax necessarily involve changes in output, hence in the use and compensation of production inputs, as well as changes in the price of the taxed product. Forward shifting of the tax, whether as a result of a deliberate price-increasing effort by the businesses producing the taxed product or as part of a market process reflecting the businesses' adjustment to changes in their costs, necessarily goes along with reductions in output and in inputs, both in the short run and over the longer term. In the latter case, the adjustment also involves decreases in the aggregate amount of capital committed to the production of the taxed product, relative to the amounts that otherwise would be in place. The shifting process, in short, involves far more than mere increases in the price of the taxed product.

2. General Equilibrium Analysis

a. Economy-wide Adjustments and Ultimate Tax Incidence

The adjustments to the imposition of an excise by the buyers and producers-sellers of the taxed product do not occur in economic isolation. These adjustments affect economic behavior

throughout the economy, changing the way in which people produce income and the uses they make of it. In the process, economic efficiency would be impaired, private saving and, probably, national saving would be retarded, and investment and GNP would be lower than in the absence of the tax. The overall levels of employment, output, and income would be affected, and the distribution of income by source and by income level would differ from that which would prevail in the absence of the excise increase. These changes must be factored into any calculation of the ultimate incidence of the excise tax.

(1) Widespread Impact of the Tax

The increase in motor vehicle transportation costs resulting from the increase in the gasoline excise would change the composition of output and the use of labor and capital by most, if not all, industries as well as petroleum refining. Longer-term consumer responses would involve not only automobiles and other modes of transportation, but all other products as well.

As noted, the imposition of an excise tax leads to decreases in the output and purchases of the taxed product or service, in the amount of production inputs allocated to its output, and in the compensation for use of these inputs, as well as increases in the market price of the taxed item. Buyers of the taxed product, having reduced the quantity of their purchases of it, may seek substitutes that have become, at least for the moment, relatively cheaper. They may also increase their purchases of other products or services that are less direct substitutes.

Although the relative price shift will make substitute products more attractive, it is not certain that spending on substitutes will rise. If the demand for the taxed product is inelastic, the disposable income of its purchasers is reduced by the imposition of the tax. Their aggregate purchases of substitute products or services clearly could increase only if they were to reduce their saving by more than the reduction in their after-tax incomes. If outlays for substitutes fall, there will be downward pressure on their prices, inducing shifts in the composition of purchases even by nonpurchasers of the taxed product.

If buyers increase their purchases of substitutes, the prices of the substitutes would rise and producers would seek to increase their production. Some of the producers' additional demand for production inputs may be satisfied by those released from producing the taxed product. To the extent this occurs, the supply of at least some of the production inputs used to produce the substitutes increases. Of itself, this increase in input supply tends to reduce the price paid for their use. On the other hand, the increase in the demand for the substitute products and services, insofar as it occurs, also increases the derived demand for the inputs used in their production, exerting upward pressure on the prices to be paid for them. Whether the prices paid for production inputs by producers of the substitute products increase or fall, accordingly, cannot be generalized. Depending on the changes in the demand for the substitutes and in the conditions of input supply, respectively, rates of return and total profits earned by businesses producing the substitutes may increase, in relative terms and/or in absolute amount.

These adjustments must alter the distribution of income among suppliers of production inputs. Although these changes in the distribution of income are not commonly perceived, they are nonetheless extremely important components of the shifts in income induced by the imposition of the tax.

Determination of the magnitude of all of these compositional changes requires an appropriate econometric analysis that lies beyond the scope of this report.²⁰ In an economy as large, as diversified, and as adaptable as that of the United States, it is extremely unlikely that the effects of a gasoline excise increase, even of the dimension that is included in most of the excise-increase proposals, would impose substantial long-term damage. The excise increase, however, should not be perceived as inconsequential or benign. It would exert a significantly disruptive effect on the economy and impair economic efficiency.

(2) Impact on Efficiency and GNP

Widely overlooked is that these changes in the allocation of production inputs and in the composition of spending must entail losses of efficiency and of total output.²¹ In their new uses, the inputs released from production of the taxed product must be less productive than formerly; if they weren't, one must assume they would have been drawn to the other production uses before the tax was imposed.²² For very much the same reasons, the shift in input use must result in a lower level of total output than otherwise would have been obtained. The increase in the excise tax on gasoline must have the effect of reducing GNP.

(3) Impact on Saving and GNP

In addition, the imposition of the tax results in the transfer of income claims, in an amount equal to the tax collected, from producers-sellers and purchasers of the taxed product to the government, which presumably spends the additional tax revenue. Unless the elasticity of demand for the taxed product is quite high -- sufficiently so that the net-of-tax outlays for it fall by no less than the amount of the tax collected -- the disposable income of the product's buyers available for purchases of other products and services and for saving is reduced by the imposition of the tax. If private saving is not to fall, purchasers of the taxed product must reduce their outlays for substitutes by more than the increase in their total outlays for the taxed product. The imposition of an excise tax on a product with a low demand elasticity, therefore, will likely erode private saving.

In the case of gasoline, the elasticity of demand is low, and disposable income and private saving are likely to fall in the wake of a gasoline tax increase. If government spending were to increase along with the increase in gasoline excise revenues, as history urges, national saving would decline.

The decrease in saving resulting from the excise, if it occurs, necessarily means an equal decrease in investment (unless for some perverse reason foreign investors were to invest more because the tax was imposed). Less investment means a smaller stock of capital than otherwise,

hence a lower level of capital services, and less output produced by these services. Moreover, the lower amount of capital services reduces the productivity of labor services, further reducing total output from the levels that otherwise would be produced. These negative effects on employment and output throughout the economy must reduce tax revenues, hence partially offset, possibly more than offset, the tax revenues obtained from the excise tax.

The possibility of this adverse effect of excise taxes on private saving is virtually ignored in discussions of the desirability of relying on such taxes to reduce the federal budget deficit. Indeed, the conventional wisdom is that levying or increasing excises will induce a shift from current consumption to saving out of current income, hence increase the private saving rate. In fact, however, excise taxes not only alter the composition of current consumption outlays, they may also depress saving relative to consumption.

Because of this adverse effect on private saving, excise taxes may well exert upward pressure on the cost of capital, just as do income taxes. It may well be true that the anti-saving effect of excises is less pronounced, per dollar of tax collection, than that of income taxes.²³ Nonetheless, the possible depressing effect of excises on saving and capital formation should be explicitly recognized in evaluating proposals to impose or to increase these levies.

(4) Tax Incidence

The ultimate incidence of the gasoline excise tax is the difference between the economic state of affairs that prevails when the adjustments to the tax are complete and that which would have prevailed if the tax had not been imposed. It includes all the differences in the use and composition of inputs, the level and composition of output and income, and the distribution of wealth and income, that result from the imposition of the tax.

Even in the very narrow sense of who buys gasoline and therefore "pays the tax", it is virtually impossible to construct a distribution of the tax burden. The regressivity of any excise, cannot be determined merely by reference to the income-level distribution of the tax based on pre-tax consumption levels. Also required for this purpose is information about how buyers of the taxed product at differing income levels will rearrange the composition of their purchases.

To the extent that buyers reduce their purchases of the taxed product, they avoid payment of the excise tax and prevent the tax from reducing their after-tax incomes. However, this is not costless to the consumer, resulting in a decline in satisfaction unless there are perfect substitutes for the taxed product. There is surely no perfect substitute in the case for gasoline.

Furthermore, not all buyers of the taxed product are inclined, or are able, to reduce their purchases of the taxed product and to substitute other products or services to the same extent. Differences among buyers in this respect may be associated with their income levels, but numerous other factors, not directly related to income, may also be significant. Insofar as the differences among buyers in the extent to which they curtail purchases of the taxed product are closely related to the amount of buyers' incomes, the imposition of the tax results in changes in

the distribution of after-tax income among income levels. Insofar as other factors also influence shifts in consumption, the tax involves changes in the distribution of after-tax income that are not related to the income level of the buyers. At any income level, indeed, the income effect of the tax is likely to vary among buyers.

But a broader objection to such calculations is that they omit the impact of the tax on employment, wages, and profits of suppliers of labor and capital to the gasoline industry and throughout the economy. They neglect the general reduction in productivity and real wages induced by the tax, and the impact on consumers of lower output and higher prices of virtually all goods and services. These effects may exceed, for many persons and families, the direct effects of the tax on their purchases of gasoline, and be very differently distributed.

As a simple example, spending on gasoline may constitute a higher portion of the family budget for a low income, blue collar, two commuter family than for a higher income family with one professional bread-winner commuting by train. An elderly nursing home resident may buy no gasoline at all. But if the higher income professional is an oil company geologist laid off in a tax-induced retrenchment of oil drilling activity, if the nursing home resident has only his Social Security and a small dividend income from a trucking company, and if the low income commuters readily find agreeable carpools, the incidence of the tax may be quite different than initial levels of spending on gasoline by the three households might indicate.

b. Impact on Sectors and Specific Economic Variables

(1) Transportation

Household and business efforts to reduce gasoline use would have repercussions for vehicle manufacturers and the broader energy industry. The higher price of gasoline would impel a shift to vehicles affording greater fuel economy. This would entail reducing the average size and weight of many vehicles, particularly those for household use. This shift, in turn, would result in changes in the materials used in motor vehicle production, with significant implications for the producers of these materials. The effects of this shift would vary across domestic auto makers, and between makers of imports and domestic producers, depending on their current concentration on the large or small car end of the market, as well as on differences in materials-moving vehicles.

The tax increase would also spur changes in automotive fuel technology, very likely emphasizing the development of economically feasible substitute fuels. Although it is unlikely that there would be any significant short-run or even intermediate-term substitution of other motor fuels for gasoline, in the long run there would be a substantial probability of changes in automotive technology to accommodate alternative fuels.

Overall, it must be expected that motor vehicle transportation would become more costly than otherwise. Any shift to alternative technologies and fuels which depends on a tax for its

impetus must imply higher costs. If the alternative technologies were truly less expensive than existing methods, someone would be leading the shift now, without the tax impetus.

Higher transportation costs would affect virtually all production in the economy. Overland truck transportation would become more expensive whether powered by gasoline or diesel fuel. Assuming the tax were not imposed on aviation and bunker fuels, there would be some shift of shipping away from land transport to air and water, though waterway capacity and weight considerations regarding air freight would limit the shift. Any such shift obviously would entail increases in transportation costs above the costs that otherwise would prevail.

The production and distribution of all goods involves transportation costs in varying degrees, according to both the amount and type of transportation required. The effects of the gasoline tax increase would spread differentially throughout the economy, causing adjustments of relative prices of all products. This would trigger changes in the levels, methods, and locations of production, and levels of consumption, of all products. Employment of labor and capital in all industries would be affected by the tax increase.

The increase in transportation costs attendant on an increase in the gasoline excise would also make many markets more localized in extent. The geographical extension of markets generally is impelled by opportunities for economizing on production inputs, as well as by the increase in demand resulting from market expansion. The increase in transportation costs would exert a constricting influence on market size, presumably with some loss in efficiency.

The increases in transportation costs, and the responses thereto, would be greater in the years immediately following the excise increase. As alternative transportation and fuel technologies are developed, the initial cost increase and cutback in use of transportation services will be somewhat mitigated.

(2) Effect on Users of Other Oil Products

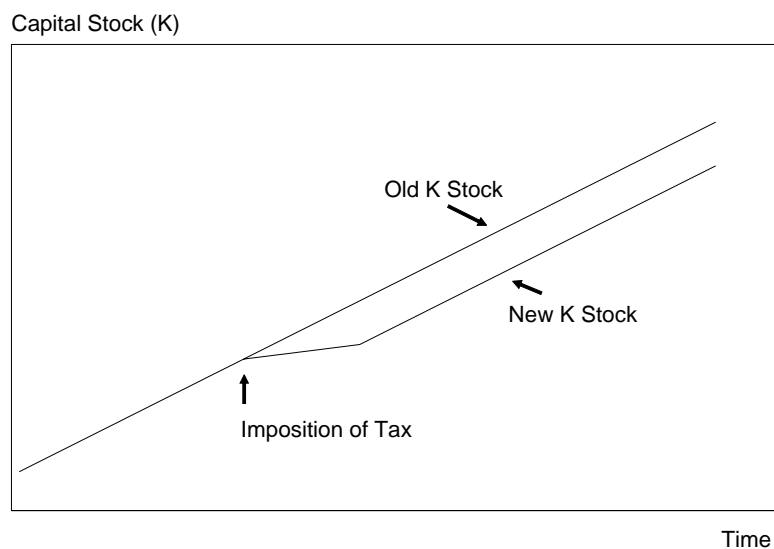
The gasoline tax increase would affect users of other oil products. If the decrease in the U.S. demand for gasoline were to result in a decrease in world crude oil prices, production of goods using oil as feed stocks (e.g. chemicals) might expand relative to production of other goods. Oil might capture a larger share of the home heating and industrial boiler fuel market at the expense of natural gas and coal. If cartel behavior in response to the gasoline tax increase were to cause an increase in the world price of crude oil, these conclusions would be reversed.

(3) Effects on Capital Formation

On the assumption that the stock of capital is currently allocated and employed efficiently, i.e., in such a way as to maximize the value of output, an increase in the gasoline tax would cause an artificial, efficiency-lowering shift in the utilization of existing capital and a reduction in the acquisition of new capital. Any given product would be made in a less gasoline-intensive and transportation-intensive manner. For example, as noted above, the geographic range of

markets would tend to decline, and production would tend to be more decentralized. There would also be a shift of output away from gasoline-intensive and transportation-intensive products toward those that are less so. In addition, some capital would be retired earlier, and new capital would be acquired of a different type and mix than would have been purchased without the tax increase. The added product generated by capital transferred to new uses would undoubtedly

Figure 1
Time Path Of Stock Of Capital Following
A Gasoline Tax Increase



be less than the product of that capital in its old uses. If the contrary were true, then it would have paid to have reallocated the capital in the absence of the tax hike.

In addition to reducing the efficiency of capital, the excise tax increase would raise the cost of capital in two ways. First, it would increase the tax burden on capital to the extent that businesses that use gasoline bear a portion of the tax. Second, as described above, it would reduce private saving and potentially reduce national saving.

The reduction in the efficiency and earnings of capital and the increase in the cost of capital would reduce the utilization of capital services and the reduce the desired stock of capital. The drop in utilization of capital services could occur immediately through a reduction in the utilization rate of existing capital. The actual reduction in the capital stock would be somewhat

more gradual, requiring a period of reduced investment until the lower stock of capital was achieved. Although the rate of investment would return to a more normal pace thereafter, the level of the stock of capital would be permanently lower over time than if the gasoline tax had not been increased. Technological changes to economize on gasoline inputs would likely induce changes in the technical conditions of production. These production changes would entail the substitution of capital services for energy inputs. This would offset a portion, but not all, of the decline in the level of the stock of capital relative to that in the absence of an excise increase. (See Figure 1.)

(4) Effects on Labor Efficiency

A similar analysis holds for the labor market. It is assumed that the labor force is currently allocated and employed efficiently to maximize output. An increase in the gasoline tax would cause an artificial shift in labor use with a consequent loss in efficiency. Furthermore, the reduction in the quantity and efficiency of capital would virtually ensure a drop in the productivity of labor. Thus, the over-all efficiency of labor would fall relative to the level it would have attained, and the levels of real wages and employment would be less than if the gasoline tax had not been increased. Some of the losses in employment would be reversed as capital and labor services are substituted for energy inputs.

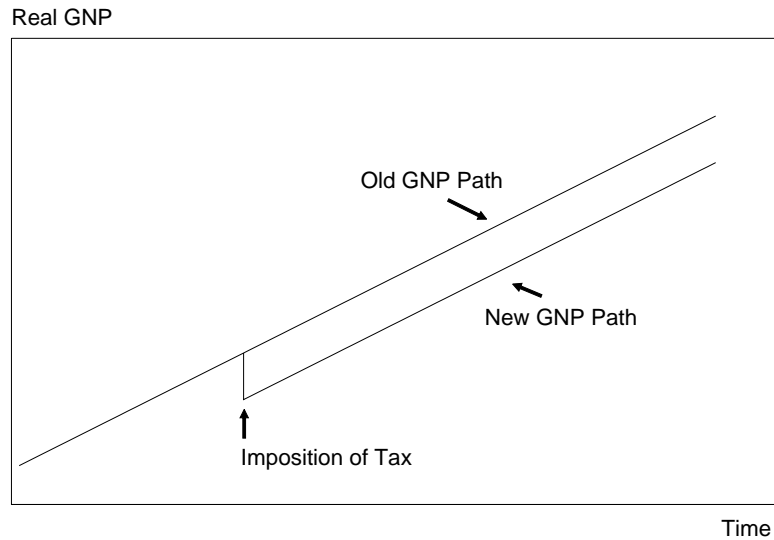
(5) Effects on GNP

The reductions in private saving and capital formation, the distortions in production input use and in output, and the attendant losses in labor and capital productivity resulting from the higher tax on gasoline would cause real GNP to decline relative to the levels it would have reached in the absence of the tax increase. As the early adjustments to the tax increase occurred, the rate of growth of real GNP would be lower than otherwise. Although the growth rate would return to a more normal pace thereafter, the level of real GNP would be permanently lower over time than if the gasoline tax had not been increased. (See Figure 2.) There would be less capital and labor employed, and each unit would be employed at less than maximum efficiency. As the changes in the technical conditions of production occur, with the substitution of capital and labor services for energy inputs, the shortfall of GNP from levels that would have been attained absent the excise increase would be moderated, but would not be entirely eliminated.

(6) Effects on the Price Level and Inflation

It is difficult to generalize the impact of an increase in the gasoline tax on the price level and the rate of inflation, because the outcome depends on the response of the Federal Reserve to its anticipations of the effects of the tax increase on real GNP and to the initial price level impact of the tax. As has often occurred in the past, the Federal Reserve might attempt to prevent the tax hike from adversely affecting aggregate output by more rapidly expanding

Figure 2
Time Path Of Real GNP Following
A Gasoline Tax Increase

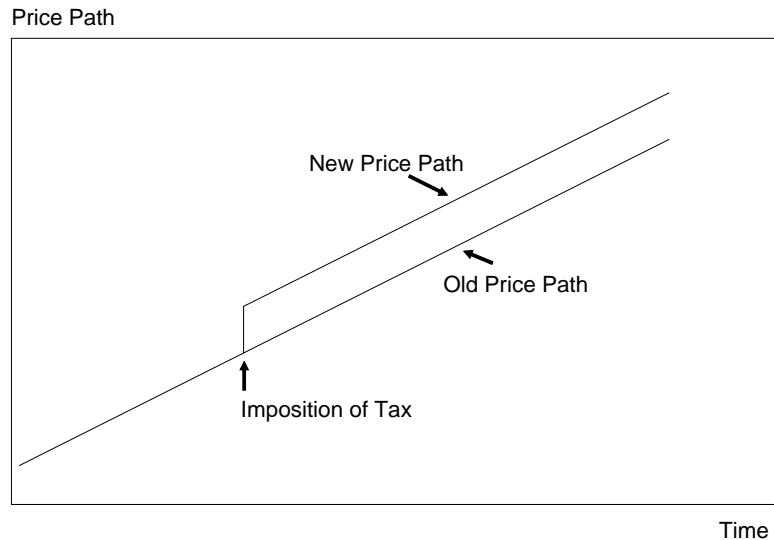


monetary aggregates. The real consequences of the tax increase could not be offset, however, by an easier monetary policy. For any given growth path of the money supply over time, the price level would be higher as a result of the tax increase because aggregate output of real goods and services in the economy would be lower due to the distortions and reduced efficiency of labor and capital caused by the tax increase. Faster money growth would raise inflation.

The higher inflation rate, moreover, would depress GNP, rather than avert its decline. The real value of capital consumption allowances (depreciation and depletion) based on historic costs would be eroded by the higher inflation rate; this would raise the effective tax rate on capital, and investment would decline further.

Contrary to the expectations of the monetary authorities, interest rates would not fall in response to the faster monetary growth. On the contrary, the increased inflationary fears generated by the more rapid monetary expansion would raise nominal interest rates, especially long rates. Real interest rates, which follow the real return on capital, not financial oscillations, would not be lowered. Any hopes that a more expansionary monetary policy would offset the

Figure 3
Time Path Of Price Level Following
A Gasoline Tax Increase



adverse effects of the excise increase on capital formation would not be realized.

Nor would the decline (if any) in the Federal deficit per se reduce interest rates and restore GNP growth. General equilibrium theory and historical evidence show no link between deficit reduction via a tax increase and lower interest rates. Tax increases directly reduce investment by taxing capital more heavily, and they fail to increase national saving because tax increases generally reduce private saving by at least as much as they cut government borrowing. There is a theoretical and empirical link between government spending restraint and reduced interest rates in that spending restraint returns real resources to more efficient private sector use. However, a gasoline tax increase would be more likely to raise than to reduce federal spending.

Absent acceleration of monetary expansion, the gasoline excise increase might result in a one-time jump in the price level, with the price path thereafter displaying the same slope (rate of change, or rate of inflation) as would have occurred in the absence of a tax increase. (See Figure 3.) In itself, the gasoline excise increase should not be identified as a source of a higher inflation rate.

(7) Effect on Trade and Current Account Balances

A gasoline tax increase would change the mix of both imported and exported products, but whether there would be a significant effect on the balance between imports and exports is unclear. The tax increase would reduce U.S. oil consumption and oil imports, and by reducing U.S. output and national income, it would reduce imports of other raw materials and finished goods as well. At the same time, the tax increase would raise the cost of production in the United States, and this increase in production costs would erode U.S. businesses' competitiveness and tend to reduce exports.

Whether the trade and current account deficits would fall or rise would depend upon whether domestic investment would fall by more or less than national saving. If domestic investment were to fall by more than national saving, the "excess" saving would find its way into increases in direct foreign investment by U.S. companies. The net capital inflow (foreign lending and direct investment in the U.S. less U.S. lending and direct investment abroad) would decline, and the current account deficit would fall. If, however, national saving were to fall by more than investment, the net capital inflow would rise, and the current account deficit would rise.²⁴

Whether the decrease in national saving would be greater or less than the decrease in investment in the United States in response to a gasoline tax hike cannot be predicted with confidence. Domestic investment would decrease in response to the higher costs of production as well as to the increase in the cost of capital resulting from the less efficient allocation of capital and the erosion of its productivity attendant on the tax increase. These same cost increases would also tend to cut back direct investment by foreign companies in the United States. In sum, capital formation in the United States would decline until the new, lower desired stock of capital was achieved.

At the same time, the increase in the gasoline excise would cut back national saving. Private saving would very likely be reduced, particularly in view of the low elasticity of demand for gasoline. As shown earlier, private saving would have to fall unless gasoline buyers were to reduce their outlays for all products and services by an amount at least equal to the increase in gasoline tax payments. Experience has shown, on the contrary, that at least for some time following a tax increase, households reduce their saving rather than their consumption, possibly because so large a fraction of current consumption outlays are based on long-term contracts, hence can't readily be curtailed. Thus, even if the tax increase were to result in an equal decline in the Federal budget deficit, national saving would not increase. In fact, the tax increase would not equally reduce the federal deficit; experience shows that some or all of the additional tax revenues would be spent by the government, producing a net decline in national saving. In addition, the gasoline tax increase would cause a decline in GNP and national income, generating a drop in national saving.

Although the short-term changes in the balance of payments accounts can't be confidently assessed, the longer-term effects of a gasoline tax increase on these accounts would tend to moderate the short-run changes. Over the longer term, there would be less of a decline, if any,

in the trade and current account deficits. As the stock of capital resumed its growth along a lower path through time, capital formation would tend to recover to a more normal pace, although it would remain slightly below pre-tax increase levels, reflecting the permanently lower level of the growth path of capital. Direct foreign investment in the United States would also resume very much its former rate of increase. Although, due to the lower levels of national income, national saving might remain below pre-tax increase levels, its year-over-year rates of increase would tend to return to the earlier trend. The net capital inflow and current account deficit would move toward pretax-increase levels.

Whatever the ultimate outcome of these changes for the trade balance, there would be a shift in the mix of traded products and services. The United States would be producing and exporting less and importing more of gasoline-intensive products. The United States would be producing and exporting more and importing less of non-gasoline-intensive products. The reduced GNP would probably mean a lower over-all level of both imports and exports, i.e., less trade, though the share of trade in GNP might not be altered appreciably.

(8) Impact on Federal Revenue and Budget

The revenue gain from a gasoline tax increase would be less than the increase estimated by the government on the basis of static analysis. The gasoline price increase resulting from the tax would reduce gasoline sales and excise revenue. In addition, the reduced growth of GNP, due to efficiency losses, a higher cost of capital, and a reduction in private sector saving, would depress other Federal revenues.

The revenue gain could not be determined with any accuracy merely by multiplying the increase in the tax per gallon by the number of gallons purchased before the tax increase. Unfortunately, this static revenue estimation is relied upon by federal policy makers, producing grossly misleading assessments by them of the revenue consequences of their policy initiatives.

An accurate estimate of the revenue consequences of an increase in the gasoline tax requires an analysis that takes account of the changes in economic activity that would be induced by the tax increase. For this purpose, a dynamic general equilibrium analysis is required.

For example, approximately 128 billion gallons of gasoline and diesel fuel were sold in 1990. Had the growth of GNP and gasoline use continued at a normal pace in 1991, approximately 131 billion gallons would have been consumed. The 1990 gasoline excise tax rate was 9.1 cents per gallon, and that of diesel fuel 15.1 cents per gallon. With gasoline use about 87 percent of the total, the weighted average tax rate was about \$0.0988. A revenue estimator would have projected that the excises would have yielded nearly \$12.94 billion in revenue in 1991, at the 1990 tax rates. However, the Omnibus Budget Reconciliation Act of 1990 raised both tax rates by 5 cents per gallon, to a weighted average of \$.1488. Static revenue estimation would assume that the 5 cent increase would be fully reflected in the price of gasoline, and that the volume of gasoline consumption would be unaffected by the tax. The static revenue estimation would show an increase in excise revenues of \$6.55 billion (\$0.05 times 131 billion),

to a new total of about \$19.49 billion in that year. In the static approach, this roughly 51 percent increase in the tax rate would be assumed to produce a proportional increase in tax revenue.

In reality, the increase in the price of gasoline following the excise increase would reduce gasoline consumption and the gain in tax revenue. Again assume that the \$0.05 per gallon tax increase would have raised the price of gasoline by 5 cents from roughly \$1.15 to \$1.20 per gallon (an increase of about 4.35 percent). At a short run elasticity of 0.2, 1991 gasoline consumption would have dropped by about 0.87 percent in the short run (to about 130 billion gallons). Revenue would have increased to \$19.34 billion, a rise of about \$6.4 billion in the short run as opposed to the \$6.55 billion static revenue estimate gain.

The overstatement of revenue gain by use of static revenue estimates increases over the long term as the economy adjusts to the rise in the gasoline price resulting from the excise increase. In the absence of the excise increase, annual consumption of gasoline (and diesel fuel) might have increased to about 159 billion gallons. At this volume, the static estimate would show that the \$0.05 excise increase would raise revenues by about \$7.94 billion. If the long-run elasticity is 0.7, and if the price of gasoline were to rise by the full 5 cents (about 4.35 percent), then annual gasoline consumption would increase to only about 154 billion gallons (about 3 percent less than 159 billion gallons). The revenue gain from the excise increase would be the difference between the amount of revenue that would have been generated by the prior excise rate, \$15.7 billion (\$0.0988 time 159 billion gallons) and the \$22.9 billion that would be collected by the new rate (\$0.1488 times 154 billion gallons), or \$7.2 billion, about \$0.75 billion less than the static estimate.²⁵

There would also be dynamic consequences with respect to other revenue sources. The reduction in GNP would reduce the tax receipts from virtually all other taxes, including the corporate income tax, the personal income tax, the payroll tax, and the capital gains tax.

Federal outlays would also be affected. Reduced GNP would raise Federal spending on welfare and unemployment compensation, and other income support programs. Furthermore, even a one-time jump in the price level would raise Federal outlays on Social Security, Federal pensions, and other price-indexed programs. There is also the possibility, discussed above, that the Federal government would spend the (overly-optimistic) projected increase in gasoline excise revenues. Such an outcome would be almost certain to reduce national saving and investment.

One must conclude that the ultimate impact of the increase in the gasoline excise tax increase on the Federal budget and budget deficit would be substantially less favorable than assumed under static partial equilibrium analysis.

III. Quantitative Results

A \$0.10 a gallon increase in the gasoline (and diesel) excise tax effective January 1, 1991 is assumed in order to examine the quantitative effects on the economy. Dollar estimates are expressed in real 1990 dollars. This tax increase is assumed to be in addition to the \$0.05 increase which actually occurred at that time under 1990 legislation, the results of which are factored into the baseline developed for this estimation exercise.

The effects of the excise increase in the price of gasoline on gasoline consumption, employment, the use of capital services, GNP, and federal tax receipts were estimated using a reduced form econometric model.²⁶ The increase in the excise tax is identified in terms of its effects in increasing the cost of labor and capital services. The higher tax burden on labor and capital inputs necessarily entails fewer man hours of labor services and a reduced flow of capital services in production, and a consequent reduction in GNP.

Initially, a substantial portion of the tax may be borne by labor and capital employed in the petroleum production and refining industry. However, the market reaction to the tax and the resulting price increase in gasoline would quickly spread the impact to other industries in which gasoline is an input, and to consumers, who are themselves providers of labor and capital services for the production of goods and services throughout the economy.

By focusing on the impact of the tax on the economy's total supplies of labor and capital, the model finesses the need to trace the thousands of industry-by-industry and product-by-product channels through which the tax operates to reduce economic activity. That calculation is performed by the marketplace. The model reflects the outcome. The results of the model simulation are presented in Table 1.

The initial impact of the tax depends on the amount of gasoline consumed. If gasoline use were to grow as indicated in the baseline, the \$0.10 increase in the excise tax would yield additional federal revenue of \$13.0 billion in 1991 and \$15.4 billion by 2000. However, the imposition of the tax would increase the price of gasoline by roughly the amount of the tax. The price increase would lead to a reduction in the use of gasoline. In the near term, the opportunities for substituting other production inputs for gasoline and otherwise economizing on gasoline use are limited. As time goes by, however, economizing on gasoline use in production and changes in the mix of total output become more and more likely.

The \$0.10 increase in the tax would equal 8.36 percent of the average 1991 price of gasoline and diesel fuel. With a short-term price elasticity of demand for gasoline of .2, the 10 cent initial price rise would lead in the near term to a 1.67 percent reduction in sales volume, and in the long term to a decline of 5.85 percent. Taking into account the estimated decrease in gasoline volume relative to trend increases, the additional \$.10 per gallon tax would represent a tax hike of about \$12.3 billion in 1991 and about \$13.0 billion in 2000 on the economic activity employing the remaining fuel. These figures, apportioned between and taken as a percent of labor and capital income, represent increases in the marginal tax rates on labor and capital.

Although the dollar amount of the tax would rise over time, it would represent a declining share of the rising baseline labor and capital income and GNP. Therefore, the increase in the effective marginal tax rate would be greatest initially, and decline slightly with time.

In other words, as the use of gasoline fell as a result of the price hike, a portion of the tax increase would thereby be avoided. Consequently, the percentage reduction in the use of labor and capital inputs and GNP would be proportionately greater in the short term than over the longer term, though the reductions might well increase in absolute amount as the baseline labor force and capital stock increase.

In the first full year of the excise increase, for example, there would be 230,000 fewer full-time-equivalent jobs than otherwise, a reduction from trend of about 0.195 percent. In the tenth year the cutback in labor use would be 247,000 full time equivalent jobs, about 0.177 percent of the baseline in that year.

Similarly, utilization of capital inputs in the first year of the tax increase would be 0.924 percent below the baseline forecast; in the tenth year, the reduction in the use of capital services would be 0.838 percent. Because it is difficult to alter the quantity of physical capital in the very short run, the decrease in the employment of capital would initially involve a reduction in the utilization rate of existing stock of capital. Over the ten year period, the reduction in capital services would increasingly come from a reduction in investment and a slower growth of the capital stock than would have occurred in the absence of the tax increase. By the year 2000, the capital stock would be about \$170 billion less than in the baseline forecast projection.

The impact on GNP would parallel that on labor and capital. In 1991, it is estimated that GNP would fall about 0.414 percent, or \$23.4 billion (constant 1990 dollars) short of the projected trend output. By 2000, the GNP would be 0.376 percent, or \$26.6 billion, below the baseline projection.

The loss of 247,000 jobs, at an average full time salary of about \$35,438 in the absence of the tax increase, would reduce total labor income by \$8.8 billion. The reduction in capital formation would exceed the reduction in employment, because the elasticity of the supply of capital with respect to changes in its rate of return is far higher than that of labor. The result would be a decline in the capital labor ratio and a drop in the productivity of labor and in the real wage. The real wage would be reduced by roughly 0.2 percent below trend throughout the period, which would represent a decrease in annual real income per worker of about \$70. In the year 2000, this would lower total labor income by an additional \$9.9 billion. The remainder of the GNP decrease, about \$6.7 billion, would be borne by savers and investors. On top of these losses, the roughly 100 million households would of course be paying the increase in the excise tax, which would be incorporated into the cost of all goods and services, raising the cost of living in 2000 by about \$125 per household.

The reduction in GNP would reduce the use of gasoline as a production input, and the consumption of gasoline would fall as the use of labor and capital fell below baseline levels. This reduction in the use of gasoline would be in addition to the cutback due to the price increase described above. The combined effect would result in a drop in the use of gasoline by nearly 2.1 percent, or 2.7 billion gallons, relative to the baseline in 1991, and a drop of 6.2 percent, or nearly 9.6 billion gallons, by 2000.

This cutback in the use of gasoline would have to be factored into the computation of the ultimate impact of the gasoline excise increase on gasoline excise revenue. Each gallon of lost gasoline sales would cost the Treasury the full excise tax on that gallon, not merely the increase in the excise rate. The model projects an increase in excise collections of \$12.3 billion in 1991 and \$13.0 billion in 2000, substantially less than the "static" projection .

The full federal tax revenue effects of the federal gasoline excise increase would consist of the increase in the excise tax revenues less the offsetting reduction in other federal tax revenues. The decreases in total employment, output, and incomes associated with the adjustments to the increase in the cost of gasoline would decrease federal revenues from the individual and corporate income taxes, the payroll tax, tariffs, and other excise taxes. On the basis of the prevailing relationship between changes in aggregate federal tax revenues and in GNP, all tax revenues other than those from the gasoline excise are estimated to fall by about \$.21 per dollar decrease in GNP from its trend value. In 1991, these other federal tax receipts would be about \$4.9 billion less than their trend amount; this shortfall would increase to about \$5.6 billion in the year 2000. Subtracting these revenue losses from the projected gasoline excise gains gives a net increase in federal tax revenues of about \$7.5 billion per year throughout the period.

The simulations do not take into account the alternative international adjustments that might occur, discussed in Part II of the study. Nor is the consequence of any change in monetary policy that might be made in response to the gasoline excise increase and its economic effects allowed for in the estimates. Finally, no effort is made to capture in the simulation results the changes in the composition of input use and of output that would certainly occur over time. Estimating those changes requires a greater, more refined econometric capacity than is now available.

A detailed description of the estimating procedures and of data sources is provided in Appendix B.

Table I. EFFECTS OF A \$0.10 A GALLON INCREASE IN THE FEDERAL GASOLINE EXCISE

	Changes Relative to Baseline								Revenue Effects		
	GNP		Capital Services	Employment		Real Wage Rate	Gasoline Consumption		Gasoline Excise	Other Federal Taxes	Net Revenue Effects
	%	billions (1990 \$)	%	%	Jobs (000s)	%	%	billion gallons per year	billions (1990 \$)	billions (1990 \$)	billions (1990 \$)
1991	-0.414%	-\$23.4	-0.924%	-0.195%	-230	-0.220%	-2.08%	-2.708	\$12.3	-\$4.9	\$7.4
1992	-0.410%	-\$23.8	-0.916%	-0.193%	-232	-0.218%	-2.33%	-3.084	\$12.5	-\$5.0	\$7.5
1993	-0.407%	-\$24.2	-0.908%	-0.191%	-234	-0.216%	-2.61%	-3.524	\$12.6	-\$5.1	\$7.6
1994	-0.403%	-\$24.6	-0.899%	-0.190%	-237	-0.214%	-2.93%	-4.038	\$12.8	-\$5.2	\$7.6
1995	-0.399%	-\$24.9	-0.891%	-0.188%	-239	-0.212%	-3.31%	-4.639	\$12.9	-\$5.2	\$7.6
1996	-0.395%	-\$25.3	-0.881%	-0.186%	-241	-0.210%	-3.74%	-5.341	\$13.0	-\$5.3	\$7.7
1997	-0.390%	-\$25.6	-0.872%	-0.184%	-243	-0.207%	-4.23%	-6.163	\$13.0	-\$5.4	\$7.7
1998	-0.386%	-\$26.0	-0.861%	-0.181%	-244	-0.205%	-4.80%	-7.124	\$13.1	-\$5.5	\$7.6
1999	-0.381%	-\$26.3	-0.850%	-0.179%	-246	-0.202%	-5.45%	-8.248	\$13.1	-\$5.5	\$7.6
2000	-0.376%	-\$26.6	-0.838%	-0.177%	-247	-0.199%	-6.21%	-9.564	\$13.0	-\$5.6	\$7.5
<p>Note: All changes are with respect to a baseline incorporating 2.5% real annual growth of GNP after 1990 consisting of 1.9 percent annual growth of factor inputs and 0.6 percent growth due to technological advances. The excise tax increase is assumed to have been effective 1/1/91 and to apply to gasoline and diesel fuel for highway use. <i>Other Federal Taxes</i> includes federal individual and corporate income taxes, payroll, excise, and estate and gift taxes.</p>											

IV. Conclusion

Gasoline tax increases have been proposed on many occasions, and ostensibly for many reasons, including to encourage petroleum conservation, improve the environment, enhance U.S. security by reducing U.S. dependence on foreign oil, and reduce the trade deficit. More recently, the rationale has included reducing the Federal deficit. A close look at the likely outcome of a gasoline tax increase casts grave doubts on the effectiveness of such a move in achieving any of these goals.

A gasoline tax increase on the order of \$0.10 per gallon would significantly raise the price of gasoline to users. The decline in gasoline consumption, however, would be small in the short run and modest in the longer term, on the order of 2 percent to 6 percent, respectively. The tax increase would not therefore, contribute significantly to cleaner air or to the other non-revenue objectives for which it would, ostensibly, be enacted.

An increase in the gasoline excise tax would have adverse effects throughout the economy, including lost output and employment. As with most distorting taxes, the gasoline excise tax has numerous hidden costs that make it an economically unattractive option for raising Federal revenue. The true cost of the tax increase, including its economic impact, must be assessed in evaluating the proposed gasoline excise tax. The economic gains often attributed to the tax through reduction in the federal budget deficit or improvements in the international trade statistics appear to be an illusion.

Appendix A

Federal Excises on Motor Fuels as Amended by the Omnibus Budget Reconciliation Act of 1990

Federal excise taxes are generally imposed on gasoline, diesel, and special motor fuels used in highway transportation and motorboats. The Omnibus Budget Reconciliation Act of 1990 (OBRA90) increased the manufacturers' excise taxes on these fuels by 5 cents per gallon effective December 1, 1990, and extended the expiration date for these taxes, formerly September 30, 1993, to September 30, 1995. Half of the increases are to go to the general fund of the Treasury for "deficit reduction" rather than to the trust funds which had received these taxes in the past. A portion of these taxes was extended to fuels used by trains for the first time. Aviation fuel taxes were also increased and extended.

The motor vehicles fuels taxes dedicated to the Highway Trust Fund are rationalized as a highway user fee. (This is in addition to the highway "user fees" imposed on tires and trucks.) In line with this rationale, the motor fuels taxes are refunded or rebated for off-highway uses of gasoline and diesel fuel, such as for farm equipment, industrial equipment, and fishing vessels. The tax on fuels used by buses is partially rebated to encourage the use of buses to reduce road congestion and encourage conservation (buses have higher fuel economy per passenger mile than cars). Purchases by certain tax exempt organizations, local governments, the military, and exporters are exempt from the taxes.

Gasoline: 14.1 cents per gallon. A manufacturers' excise tax of 14.1 cents per gallon (formerly 9.1 cents) is imposed on gasoline sold by any refiner or importer. Of this amount, 11.5 cents is dedicated to the Highway Trust Fund (if the fuel is for use in motor vehicles) or the Aquatic Resources Trust Fund (if the fuel is for use in motorboats), 2.5 cents to the general fund of the Treasury, and 0.1 cent to the Leaking Underground Storage Tank Fund (LUST). The Trust Fund portions of the tax are now scheduled to expire after September 30, 1995, but, as in the past, they are likely to be extended. The deficit reduction portion of the tax is also scheduled to expire after September 30, 1995.

Diesel fuel: 20.1 cents per gallon. There is a tax on diesel fuel of 20.1 cents per gallon (formerly 15.1 cents) applied at the refiners' or importers' level, or at retail if not taxed earlier. (The tax is 5.4 cents less per gallon (formerly 6 cents less) for diesel fuel containing 10% alcohol.) Of the total 20.1 cent tax, 17.5 cents per gallon is dedicated to the Highway Trust Fund, 2.5 cents per gallon to the general fund of the Treasury, and 0.1 cent per gallon to LUST. The Highway Trust Fund and deficit reduction portions of the tax are now scheduled to expire after September 30, 1995, but, as in the past, they are likely to be extended.

Fuel for trains: 2.5 cents per gallon. The new deficit reduction portion of the diesel fuel tax, 2.5 cents per gallon, has been made applicable to diesel fuel used for trains. The tax is dedicated to the general fund of the Treasury, and is scheduled to expire after September 30, 1995.

Special motor fuels: 14.1 cents per gallon. There is a tax on sales of special motor fuels by manufacturers and importers of 14.1 cents per gallon (formerly 9.1 cents). On sales not taxed at the manufacturer's or importer's level, the tax is imposed at retail. "Special motor fuels" include benzol, benzene, naphtha, and liquified petroleum gas for use in motor vehicles or motor boats. As with gasoline, the 0.1 cent is for LUST, and the 11.5 cent Trust Funds portions and the 2.5 cent deficit reduction portions of the tax are scheduled to expire after September 30, 1995.

Methanol, ethanol fuels. There is a retail sales tax on fuels consisting of 85 percent methanol, ethanol, and other alcohol derived from natural gas of half the rate applied to regular fuels, or 7 cents per gallon, plus 0.1 cent for LUST. There is a reduced rate on such fuels derived from sources other than petroleum and natural gas, 8.65 cents if the mixture contains some ethanol, 8.05 cents without ethanol.

Aviation fuel other than gasoline: 17.6 cents per gallon; gasoline used in aviation: 15.1. There is a tax on sales of commercial and non-commercial aviation fuel other than gasoline by manufacturers and importers of 17.5 cents per gallon (formerly 14 cents) plus 0.1 cent for LUST. For gasoline used in non-commercial general aviation, the tax is 15 cents per gallon (formerly 12 cents) plus 0.1 cent for LUST. On sales not taxed at the manufacturer's or importer's level, the tax is imposed at retail. The tax is extended through December 31, 1995. The revenues from the increases in the tax rates are to go to the general fund of the Treasury through 1992, and to the Airport Trust Fund for 1993-1995. The revenues from the extension of the former rates continue to go to the Trust Fund throughout the period.

Fuel used in a vessel in commercial waterway transportation. The basic rate is currently 13 cents per gallon plus 0.1 cent per gallon for LUST. The basic rate will rise to 15 cents per gallon in 1992, 17 cents per gallon in 1993, 19 cents per gallon in 1994, and 20 cents per gallon thereafter.

Appendix B

Estimating Procedures

The effects of a change in the federal gasoline excise are estimated as changes in the values of various economic aggregates compared with their values in the absence of the excise increase. The estimation procedure implicitly assumes that the gasoline excise increase is the only policy change that occurs over the period under consideration; this assumption is necessary in order to distinguish the effects of the tax change from those of all other factors that might change the volume or composition of economic activity.

The Economy's Production Function

Measuring the impact of a gasoline excise increase²⁷ on the economy involves estimating a relationship between total output and factor inputs. The relationship estimated in this analysis is derived from a standard Cobb-Douglas production function, with two factors, labor and capital. The gasoline tax increase is treated as an increase in the tax rate on labor and capital to finesse the need for shifting to a three factor model. The data for determining the proportion of gasoline and diesel fuel used as production inputs as opposed to final consumption are not adequate to justify a three factor approach. In addition, although the initial impact of the tax may fall primarily on labor and capital employed in the oil production and refining industry, it will quickly spread to the cost of other products and to the cost of labor and capital throughout the economy.

The general two-factor relationship takes the form

$$Q = \alpha K^{\beta} L^{1-\beta}$$

where Q is total output, L is labor services (measured as employment on a full-time-equivalent basis), and K is capital services (measured as the stock of capital, assuming a steady capital utilization rate). The exponents β and $1-\beta$ are measures of the shares of GNP accruing as income to capital and labor, as well as the contribution of each to the national output. The division of the GNP between capital and labor has been amazingly stable over many decades. The simulation uses a share of capital of 30% of GNP ($\beta = 0.3$) and a share of labor of 0.7 percent of GNP ($1 - \beta = 0.7$), reflecting this division. The coefficient α is a scalar incorporating trend growth of productivity.

Creation of Baseline

The initial step in the analysis is the estimation of a baseline that delineates the time path of a number of economic aggregates, assuming no changes in public policies and no externally-originating shocks to the economy. This baseline contains the reference levels of GNP,

employment, stock of capital, and other major economic variables. The estimates of the effect of the gasoline excise increase are all reported relative to this baseline.

The baseline projections extend over a period of time in which the adjustments to gasoline excise increases are substantially completed. The baseline was constructed in real terms, using constant 1990 dollars, for the period 1991 through the year 2000. The principal assumptions on which the baseline relies are the following:

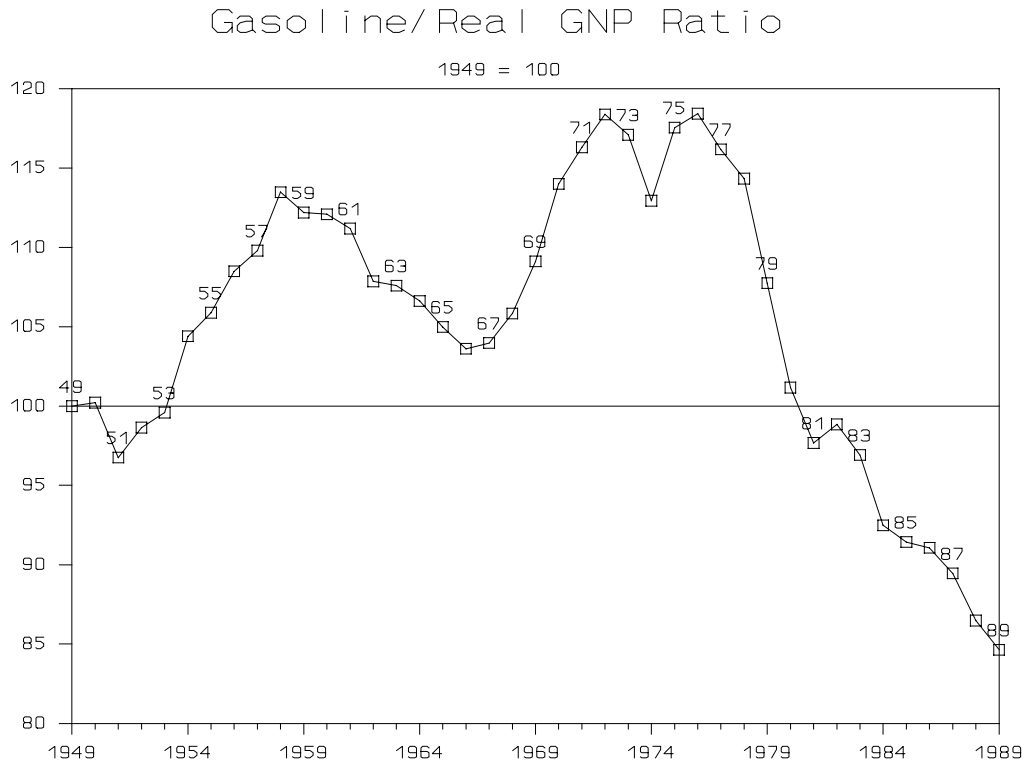
- Real GNP is projected to grow at 2.5 percent a year from 1990.
- Technological advances were assumed to increase total factor productivity by 0.6 percent per year.
- Labor and capital inputs were therefore projected to grow at nearly 1.9 percent per year ($1.025/1.006 = 1.01889$). This projection of the baseline labor force is reasonable given the projected growth of the population and an assumption of a continued increase in the labor force participation rate at a somewhat slower pace than over the last ten years. The equality of the capital and labor input growth results in no change in the capital/labor ratio, such that all increases in real wages come from technological advances rather than from capital deepening. This reflects the relatively low saving and investment rate of recent years.
- Gasoline consumption was also assumed to grow at about 1.9 percent, representing a decline in the gasoline-to-output ratio over time. Gasoline use as a share of GNP has been falling over time (see Figure 4), at a rate slightly greater than assumed in this projection. Figure 4 illustrates the ratio of gasoline use to real GNP over the last 40 years. The 1973 oil shock led to a modest change in the ratio for a few years, but beginning in 1977-78, gasoline intensity dropped off precipitously. It is assumed that the rate of decline will slow as the bulk of the adjustments to the oil shocks of the 1970s, the CAFE (automobile fuel economy) standards, and the 1991 5-cent a gallon tax increase are completed. The gasoline excise increase would augment the decline in the ratio of gas-to-GNP.

Plugging the projected levels of GNP, labor, and capital services into the production function sets α for each year of the projection period, and determines the baseline production functions used to calculate the effects of tax-induced changes in labor and capital inputs on GNP.

Methodology

The simulation is initiated by the imposition of the excise, which results in a gasoline price increase. This price increase, times the quantity of gasoline consumed, represents the initial tax increase, which is assumed to be split 30% - 70% between capital and labor. The ratio of the tax increase to GNP represents an increase in the marginal tax rate on both factors, and reduces the amount of labor and capital inputs in the production process. The growth of gasoline

Figure 4



consumption is assumed to be curtailed relative to the baseline quantities as a result of the price increase. Initially, the cutback is calculated in accordance with a short run elasticity of demand of 0.2, with the elasticity increasing steadily to a long run value of 0.7 percent over ten years. A 10 cent increase in the excise, assumed to result in a 10 cent increase in the price of gasoline, would be roughly an 8.36 percent increase in the price prevailing in 1991. This yields a 1.67 percent reduction in the amount of gasoline purchased in the short run and a roughly 5.8 percent reduction in the long term, before changes in GNP. The cutback in consumption of gasoline somewhat reduces the dollar amount, T , of the tax each year relative to the income of capital and labor, and trims the effective increase in the marginal tax rate, (T/Q) . This procedure generates a schedule of tax increases for each year of the projection period.

The degree to which labor and capital will shrink in response to a tax increase is largely determined by the exponents in the production function, the elasticity of the supply of the factors with respect to their after-tax rewards, and their marginal tax rates.

The exponents are elements in the determination of the marginal products of the factors. For example, the marginal product of a given quantity of labor, MPL, -- the change in total quantity of output resulting from a unit change in labor input -- is denoted by $\delta Q/\delta L$; in the Cobb-Douglas production function this equals $(1-\beta)\frac{Q}{L}$. Similarly, the marginal product of capital, MPK, is $\beta\frac{Q}{K}$. The marginal product of a factor falls (rises) as its quantity increases (decreases) relative to that of the other factor.

Marginal products are important in that each factor is worth employing up to the point at which its marginal product equals its prevailing market wage. Thus, each factor is normally paid its marginal product. The return on capital is equal to the marginal product of capital, and the wage of labor is equal to the marginal product of labor.

In a Cobb-Douglas production function, the rate at which the marginal product of a factor rises or falls as the quantity of that same factor falls or rises is reflected in that factor's exponent. The marginal product of a factor rises by the percentage reduction of that factor times one minus the share (exponent) of that factor. That is, a 1% reduction in the capital stock would increase its marginal product (and gross rate of return) by $(1-\beta)$, or 0.7 percent. A 1% reduction in the quantity of labor employed would increase its marginal product (and gross wage) by $1-(1-\beta)$, or β , or 0.3 percent. These relationships are referred to as the own-quantity elasticities of the marginal product of each factor -- μ_{KK} and μ_{LL} for capital and labor, respectively.

Having less labor to work with reduces the productivity of capital, and vice versa. In a Cobb-Douglas production function, the marginal product of any factor falls by the share (exponent) of the other factor times the percent reduction in the quantity of the other factor. That is, a 1% reduction in the quantity of labor would reduce the marginal product of capital by $(1-\beta)$. A 1% reduction in the quantity of capital would reduce the marginal product of labor by β . These relationships are referred to as the cross-quantity elasticities of the marginal product of each factor -- μ_{KL} and μ_{LK} for capital and labor, respectively.

Following the tax increase, the quantity of capital is reduced until its marginal product rises to the point at which its after-tax return is restored to its pre-tax-increase value. In other words, capital is assumed not to tolerate a reduction in its after-tax return. Indeed, the historical record suggests that capital maintains a real after-tax return of about 3.3 percent over time. A tax increase does not reduce this return; instead, the capital stock shrinks until its marginal product increases to cover the additional tax and restore the 3.3 percent after-tax return²⁸. That is, the supply of capital may be considered infinitely elastic in the long term at this rate of return.

The labor supply will contract in the presence of a tax increase, but by less than the supply of capital. In the case of labor, much of the tax increase will be absorbed by a reduction in the real after-tax wage, requiring a relatively small reduction in employment to raise the marginal product by enough to cover the remainder of the tax. The simulation assumes an

elasticity of supply of labor "e" of 0.3, which means that a 1% decrease in the after-tax wage will reduce employment by 0.3%, or inversely, that a drop in employment of 1% in response to a tax increase would be associated with a decrease in the after-tax wage by 3-1/3%. As we have seen, the marginal product of labor rises by 0.3 for a 1% drop in the labor supply. The fraction of a tax increase to be covered by a rise in the marginal product (gross wage) is represented by the formula: $E = \mu_{LL}/(\mu_{LL} + 1/e)$. With $\mu_{LL} = 0.3$ and $e = 0.3$, this fraction becomes 8.257 percent.

The shares of GNP going to capital (0.3) and labor (0.7) represent the gross returns to capital and labor, before taxes. To determine how much the gross compensation of either factor would have to rise to provide a dollar of additional after-tax income to either, one would have to "gross up" the after-tax dollar by dividing by $(1-t_L)$ or $(1-t_K)$, where t_L and t_K stand for the marginal tax rates on an additional dollar of labor or capital income, as the case may be. Under current tax laws, including all federal, state, and local taxes, the mean value nationwide of the marginal tax rate on capital is 0.557 (55.7 percent), and that of labor is 0.442 (44.2 percent)²⁹. The marginal tax rate must be used in calculating the changes in the amounts of labor and capital services supplied to the market in response to changes in taxes, rates of return, and the real wage. On the other hand, it is a blend of average and marginal tax rates that must be used to compute changes in federal tax revenues resulting from changes in the size of the GNP. A change in GNP involves changes in the real wage per worker as well as increases or decreases in the number of people employed, and changes in the real incomes of suppliers of capital and changes in the size of the capital stock. In recent years, federal receipts have risen by approximately 21 percent of each additional dollar of GNP.

These considerations lead to the following equations for the percent change in capital and labor as the result of an excise tax increase. Let k and l represent the percent changes in capital and labor, respectively. (T/Q) is the excise tax increase divided by GNP, or the increase in the tax rate on labor and capital represented by the excise increase for a given quantity of consumption of gasoline.

Then, for capital:

$$k = 1 + (T/Q)/[\mu_{KK}(1-t_K)] = 1 + (T/Q)/[-(1-\beta)(1-t_K)]$$

The first term in this equation indicates that the capital stock will have to fall in proportion to the drop in the labor supply induced by the tax hike to prevent a rise in the labor/capital ratio that would depress the MPK. The second term measures the percent reduction in the capital stock needed to raise the MPK by enough to cover the added tax on capital income.

For labor:

$$l = e\mu_{KL}k + [(T/Q)E]/[\mu_{LL}(1-t_L)] = e\beta k + [(T/Q)E]/[-\beta(1-t_L)]$$

The first term in this equation represents the decline in the labor supply in response to the fall in the real wage caused by the decline in the capital stock induced by the tax increase. The second term measures the decline in employment needed to boost the MPL enough to raise the after-tax wage to cover that portion of the tax increase not absorbed by the real wage reduction.

Entering the appropriate values for e , β , t_L , and t_K , and solving, yields:

$$k = -4.086(T/Q)$$

$$l = -0.861(T/Q)$$

For each year of the period, the appropriate excise increase, (T/Q) , is entered, and the resulting percentage reductions in labor and capital inputs are computed. These in turn are applied to the baseline labor and capital figures and entered into the production function for that year to compute the new level of GNP. The reduction in GNP in turn is assumed to reduce gasoline use further, in proportion to the decrease in output. The new levels of all the variables are compared to those that were predicted by the baseline estimates.

The federal revenue effects are calculated as the increase in excise revenues less the revenue loss from the curtailment of output and labor and capital inputs compared with the baseline case. The change in the excise revenues equals the new tax rate times the reduced levels of gasoline consumption less the old tax rate times the baseline consumption. The revenue loss from the reduction in GNP is computed by using a tax/GNP ratio of 21 percent -- \$100 billion of lost GNP reduces federal revenues by \$21 billion. This assumes, of course, that the reduction in GNP is spread in such a manner as to preserve the tax/GNP relationship. Systematic changes in the composition of output could change this relationship either up or down.

Data Sources

Capital stock series were from the National Income and Products Accounts, Bureau of Economic Analysis, U.S. Department of Commerce. **Labor inputs** were also derived from the National Income and Products Accounts.

Data on **gasoline consumption and prices** were from the Federal Highway Administration (*Highway Statistics*, various years) and the Energy Information Agency of the Department of Energy.

Endnotes

1. This does not mean that the tax must immediately show up in the price at which transactions in widgets occur. Rather it means only that a price of X cents per widget must be paid by some one or more persons in the production and distribution chain.

2. For an explanation and illustration of these relative price effects of an income tax, see Norman B. Ture, "Supply Side Analysis and Public Policy," in *Essays in Supply Side Economics*, David G. Raboy, Ed., Institute for Research on the Economics of Taxation (Washington, D.C., 1982), pages 16-21. Identifying the impact of a tax as the implicit change in some relative prices or costs differs, it must be acknowledged, from the customary treatment of the initial impact of taxes. For most taxes, the impact is usually identified in terms of the reduction in the net-of-tax income of the taxpayer, i.e., the persons with the legal obligation to pay the tax. The effect of the tax on the relative prices and costs confronting the taxpayer is generally ignored, except in the case of excise taxes. For most excises, the conventional treatment is to assume that the initial impact is to raise the price of the taxed product or service by the amount of the tax and to reduce the income of the purchasers by an amount equal to the tax times the quantity of the product or service purchased before the tax was imposed.

In fact as well as in theory, however, there are few if any cases in which the imposition of an excise tax results in the short run in raising the price of the product or service by the amount of the tax. Similarly, there are virtually no cases in which the imposition of an excise tax reduces purchasers' incomes by the amount of the tax times the quantity of the product that was purchased before the tax was imposed.

For a discussion of the distinction between the relative price and income effects of taxes and of the relevance of this distinction for public policy, see Norman B. Ture, "The Economic Effects of Tax Changes: A Neoclassical Analysis," in Richard H. Fink, Ed., *Supply-Side Economics: A Critical Appraisal*, University Publications of America (Frederick, Maryland: 1982), pages 33-69, esp. pages 38-52.

3. Much of the conventional public finance literature concentrates on the literal "who ultimately pays the tax" view of incidence, even though recognizing the myriad changes in the composition and volume of economic activity that occur in response to taxes. For an example of this, see Richard A. Musgrave, *The Theory of Public Finance*, McGraw-Hill Book Company, Inc. (New York, 1959), pages 211-231. In an earlier era of the public finance literature, the incidence analysis was focused more on the results of the partial equilibrium adjustments, for both producers-sellers and buyers, than on identifying the particular persons who bear the burden. See, for example, Alfred Marshall, *Principles of Economics*, Eighth Edition, Macmillan and Co., Limited (London: 1947), pages 413-424, 432-439, and 833-837.

4. Throughout this discussion the analysis pertains to an ad rem rather than an ad valorem excise tax. The analysis is not significantly altered by focusing on an ad valorem tax.

5. A listing of these excises is presented in Appendix A.

6. In virtually all cases, total variable cost and marginal cost -- the increase in total cost associated with an increase in output -- increase as output increases, hence decrease as output is reduced, in the range of output in which production occurs in a given size of plant. The production technology of some products may be such that over a considerable range of output marginal costs seem to be constant. Production is seldom, if ever, undertaken in that range of output in which marginal cost decreases as output increases. See Gary S. Becker, *Economic Theory*, Alfred A. Knopf, Inc., (New York: 1971), page 76. In the usual case, therefore, reducing output decreases marginal costs.

7. The term "demand" is properly used to describe the various quantities of a product that people would wish to buy at different prices -- a schedule of potential purchases. The greater the demand for a product, the greater will be the quantity of it that people will want to buy at any given price, or equivalently, the higher will be the

price people will be willing to pay for any given quantity of it. "Demand" is often incorrectly used to mean the quantity of something that is demanded rather in the schedule sense used here. Typically, projections of "demand" for a specific product or service concern the amount that will be sold at some future time; such projections either implicitly assume or ignore all of the conditions that determine the demand schedule, as well as the conditions that will determine the supply schedule of the product or service.

8. Cross elasticity is the percentage change in the quantity of the substitute product that is purchased in response to a given percentage change in the product for which it substitutes. If, for example, buyers think of a particular California wine as a close substitute for a specific French wine, the cross elasticity of demand for the California wine is likely to be greater than 1. If this cross elasticity were, say, 1.5., a 1 percent increase in the price of the French wine would lead to a 1.5 percent increase in the amount of the California wine purchased (ignoring income effects).

9. The "short run" is defined as the period within which there is no significant change in gasoline refining capacity or in the existing stock of motor vehicles. More precisely in a dynamic context, the short run is the period in which there is no change, induced by the gasoline excise increase, in the growth paths of refining capacity and the stock of motor vehicles.

10. As noted earlier in this analysis, the price elasticity of demand is not likely to remain constant over the entire demand schedule. The larger the price change, the greater is the likelihood that the price elasticity of demand will differ from the elasticity that might be observed at some given price and output.

11. In general, it will pay the household to replace a gas guzzler with a more fuel-efficient model when the present value of the expected savings in gasoline at least equals the cost of the new car less the trade-in allowance, if any, of the old car.

12. The elasticity of substitution is the percentage change in the ratio of a given input to the other inputs with which it is combined in the production process with respect to the percentage change in the ratio of the input prices.

13. See Douglas R. Bohi, *Analyzing Demand Behavior, A Study of Energy Elasticities*, The Johns Hopkins University Press (Baltimore: 1981), page 116.

14. As noted in earlier discussion, however, it is unlikely that the price elasticity would remain constant over so wide a range of prices. It is likely that the appropriate measure of elasticity for so large an increase in price would be noticeably higher, implying a larger percentage reduction in sales volume.

15. In the short run, i.e., before the business undertakes to change the scale of its plant, total variable costs must decrease as production is reduced. Asserting the contrary, that these costs increase as production is curbed, implies that the business is operating subject to decreasing total costs, i.e., as the business adds to its output, given its existing production capacity, its total costs go down. If this cost situation in fact prevailed, it would pay the business to produce its least cost output and simply throw away that amount of its output that it couldn't sell. The same would be true if, contrary to fact, the business enjoyed constant total costs in the short run.

16. The tax-induced increase in price and decrease in sales and production must decrease revenues more than the reduction in costs. If this were not the case, producers could have increased their profits by raising their prices, in the absence of the tax.

17. The elasticity of demand for a production input is influenced by a number of factors, e.g., how readily other inputs may be substituted for the input in question, the elasticity of demand for the final product, and the

elasticity of the supply of other production inputs with which the input in question is used. For a discussion of the demand for production inputs, see, e.g., George J. Stigler, *op. cit.*, pages 239-245.

18. Bohi, *op. cit.*, p. 116.

19. If the industry operates subject to constant costs, when long-run equilibrium is attained the price of the taxed product will exceed, by the amount of the tax, the price prevailing before the tax was imposed. If the industry operates subject to decreasing costs, the equilibrium price will exceed the pretax price by more than the tax.

20. Part III of this report provides quantitative estimates of some of the principal economic effects, but does not deal with many of the compositional and distributional consequences suggested in the heuristic analysis.

21. This presupposes that, prior to the introduction or increase of the excise tax, the product was taxed at roughly the same rate as, or higher than, other products, and that the tax increase creates or exacerbates a distortion. If a product were taxed less than all other products, the case could be made that an increase in its tax rate could improve economic efficiency. It is certainly not the case that gasoline is undertaxed relative to other production inputs or consumption products.

22. Some of the released inputs may be so highly specialized that they cannot be quickly assigned to other production. To the extent that this is so, of course, the total production level would fall by amount of the output that these inputs would have produced in their former uses but for the imposition of the tax.

23. On the other hand, excise taxes may have more severe effects in distorting the composition of consumption outlays and the allocation of production inputs than equal amounts of income taxes. As Milton Friedman and a number of other writers on the subject have shown, this conclusion is far likelier to be valid for any one individual than for the economy as a whole. Indeed, there are severe analytical limitations concerning the relative distorting effects of excise and income taxes. See Milton Friedman, "The 'Welfare' Effects of an Income Tax and an Excise Tax," in *Essays in Positive Economics*, The University of Chicago Press (Chicago: 1953).

24. There is a basic relationship between trade, international capital flows, and the balance between saving and investment in the economy.

In order to keep the demand for and supply of dollars in balance on the foreign exchange markets, the balance on capital account (a net capital inflow = surplus, net outflow = deficit) must be just equal in size and opposite in sign to the balance on current account. That is, a current account deficit (surplus) must be matched by a corresponding capital account surplus (deficit). If the movements in these accounts are not exactly offsetting, the exchange rate will move until the current account and capital account are of equal magnitude. Furthermore, these balances must just equal the gap between domestic investment and national saving. National saving is defined as private saving by U.S. residents (individuals and businesses) less the net federal, state, and local government budget deficit. That is, national saving plus the net capital inflow are just equal to domestic investment.

25. This example somewhat overstates the revenue offset from reduced consumption, because the price at retail would not rise by the full amount of the tax increase. A portion of the tax increase would be absorbed by a reduction in the net price to the producer. However, for reasons described above, the reduction in the price to the producer would be fairly small due to the high elasticity of supply, particularly in the long run. Therefore, the real world outcome would be much closer to the dynamic example than to the static estimate.

Consider, then, the case of a hypothetical long run elasticity of supply of gasoline of 2.8 and a long run elasticity of demand of 0.7, with an initial price of \$1.15 per gallon and initial volume of 159 billion gallons per year. A \$0.05 per gallon tax increase would be split between an increase of \$0.04 in the retail price and a

decrease of \$0.01 in the price to producers. Consumption would fall by about 4 billion gallons, 80 percent of the 5 billion gallon decrease assumed in the text, and the revenue shortfall vis-a-vis the static revenue estimate would be about 80 percent as large, or about \$0.6 billion.

26. A reduced form econometric model relies on a set of summary statements to capture the effects of the interactions of all of the relationships that determine the consequences of an economic disturbance.

27. Although almost any version of a gasoline excise increase would include non-gasoline motor fuels, data limitations mandated a reliance solely on gasoline and diesel fuel. This should not impose any major bias on the estimates shown here, since gasoline is the largest component of aggregate motor fuels.

28. Gary Robbins and Aldona Robbins, "Capital, Taxes, and Growth", National Center for Policy Analysis, Dallas, January, 1992, p.14.

29. Ibid. p.20.

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