Oil and the Debt

A HISTORICAL AND PROSPECTIVE ANALYSIS OF THE IMPACT OF U.S. OIL DEPENDENCE ON THE FEDERAL DEBT

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EXECUTIVE SUMMARY

This report focuses on the intersection of two issues that have concerned policymakers and the American public for decades: heavy U.S. dependence on oil and large federal budget deficits. Surging oil prices and trillion dollar federal deficits in recent years have magnified these concerns. While both topics have been independently studied, discussed, and debated, little attention has been paid to the interactions between these two factors.

This report explores the impact of oil prices and oil dependence on the U.S. federal budget. Specifically, it looks at how the quadrupling of oil prices over the last decade has affected federal budget deficits and debt. It also examines whether reducing dependence on oil in the future could improve the federal budget balance. This is done in a two-part analysis that uses the University of Maryland's Inforum LIFT macroeconomic model of the U.S. economy to help quantify the direct and indirect effects that oil prices and oil dependence have on the budget.

The Part One analysis estimates how historic federal deficits and debt levels would have been different if oil prices had risen at the same rate as the price of other goods and services from 2002 to 2012, instead of increasing dramatically over this period. The results from this modeling exercise indicate that, by 2012, lower oil prices would have resulted in the U.S. federal deficit being $235 billion lower; the accumulated U.S. government debt being $1.2 trillion lower; and the debt-to-GDP ratio being 6.6 percentage points lower.

Some of the drivers of the would-be impacts of lower oil prices are direct, such as the reduction in government expenditures on fuel. The more significant drivers, however, are indirect, and include reduced inflation, which reduces cost of living adjustments for Social Security payments, and higher economic growth, which raises incomes and therefore income tax receipts.

The Part Two analysis estimates how reducing petroleum dependence through improved fuel economy and the increased use of alternative fuel vehicles in the transportation sector could affect the U.S. economy and federal budget in the future. The analysis compares the economic and budgetary outcomes from such a scenario with those from a Baseline Scenario in which petroleum use remains roughly flat. The study finds that reducing oil dependence through the increased use of alternative fuel vehicles and improved fuel economy would make the federal budget deficit $492 billion lower in 2040, cause the federal government to accumulate $5 trillion less debt over the 2014-2040 period, and result in a federal debt-to-GDP ratio that is 10.3 percentage points lower in 2040.

Introduction

Two major deficits—the so-called "twin deficits"—have weighed on the American economy for years: the federal budget deficit and the trade deficit. The budget deficit has been particularly prominent in recent headlines, especially as it reached post-World War II highs in 2009, when the impacts of and policy responses to the Great Recession of 2008-09 were layered on top of the existing imbalance between revenues and spending. While the budget deficit has fallen notably in recent years, it remains large in terms of dollars and as a share of GDP, and official projections indicate that it will increase once again later this decade and beyond.

The other deficit, the trade deficit, has been a concern for many years. The trade deficit reached $702 billion in 2008, driven by a nearly $400 billion petroleum trade deficit as oil prices peaked at more than $140 per barrel.[1] Indeed, the nation's imbalance between petroleum consumption and production has represented more than half of the overall U.S. trade deficit every year since 2008, even with record growth of domestic oil production. Despite the continuation of the domestic oil production surge, the most widely used forecasts predict only a modest further reduction in the volume of oil imports.[2] These forecasts also project steadily increasing oil prices that will continue to raise the cost of America's oil dependence.

Policy actions that reduce the federal budget deficit and the petroleum trade deficit can contribute to improved economic growth. In particular, several analyses have focused on the degree to which the combination of rising oil prices and dependence on imported oil affect economic growth and job creation. Other studies have highlighted the negative impacts that large and persistent budget deficits can have on growth. It appears, however, that there is little available research to date on the relationship of high oil prices and oil dependence with the federal government's budget.

While recognizing that neither high oil prices nor oil dependence is the primary cause or principal driver of increased federal budget deficits, there are a number of links between high oil prices and the government's budget problems. This report explores and quantifies these relationships in order to inform policy decisions concerning energy production, consumption, and trade. Specifically, this report answers two key questions:

1) What has been the impact of rising oil prices over the last decade on U.S. fiscal deficits and on federal debt?

2) To what extent does reducing the nation's dependence on oil protect the federal budget from the negative impacts of high and volatile oil prices?

To answer these questions, this study offers a two-part economic modeling analysis. First, a historical analysis estimates how higher oil prices have affected the federal budget over the past decade—the period from 2002 through 2012. Second, a forward-looking analysis illustrates how high and volatile oil prices would have a reduced impact on the economy and the federal deficit in the coming years if the United States considerably reduces its dependence on oil.

The study is organized as follows. A pair of introductory sections provide policy context and background by examining the current and future federal budget situation and trends in the energy sector. These introductory sections are followed by a two-part analysis. The first part explores specific links between oil prices, import dependence, and the federal budget. This features a historical analysis of the impact of U.S. oil dependence on the federal budget over the past decade. The second analytic section then discusses technologies and policy approaches that could help reduce U.S. dependence on oil, and foreign oil in particular. The modeling analysis featured in this part demonstrates that success in reducing the dependence on oil would have positive overall impacts on future federal budgets. A concluding section summarizes the key findings. Appendices provide tables of additional results and a detailed description of the model used in the analysis.

Federal Budget Deficits & Debt

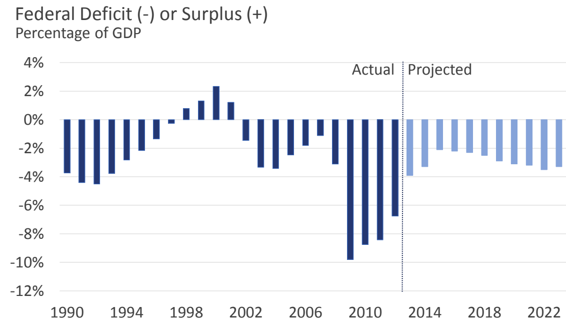
From debt ceilings to fiscal cliffs to sequesters, the U.S. budget deficit and debt situation feature prominently in economic and public policy debates and have been closely watched by concerned Americans as well as international investors. In 2012, U.S. federal debt held by the public increased to 70.1% of GDP, the highest level in the post-World War II era.[3] This debt is the result of nearly continuous annual budget deficits since 1973 — except for four years of surpluses from 1998-2001. Deficits from 1990 to 2012 averaged about 3.9% of GDP.[4]

In the first four fiscal years following the start of the Great Recession (fiscal years 2009-12), the federal government ran budget deficits equal to 9.8%, 8.7%, 8.4%, and 6.8% of GDP, as federal revenues plunged and expenditures rose due both to stimulus measures and automatic stabilizers.[5] During this time, federal government debt held by the public rose from 39.3% of GDP at the end of 2008 to 70.1% at the end of 2012.[6]

The Congressional Budget Office (CBO) projects that under current law deficits will decline until reaching 2.1% of GDP in 2015, but thereafter grow, reflecting spending pressures from an aging population, rising healthcare costs, and higher interest payments on federal debt.[7] CBO projects the budget shortfall will reach 3.1% of GDP in 2020 and 6.7% by 2040.[8]

Fiscal policy action that leads to higher deficits is appropriate in the face of a weak economy. Persistent budget deficits, however, are problematic for a variety of reasons, including the potential economic impacts from higher interest rates and the consequences of requiring future taxpayers to pay higher taxes in order to service the debt. Interest payments could become particularly burdensome if interest rates rise in the event that investors lose confidence in the ability of the U.S. government to service its debt obligation or worry that the debt burden will be inflated away. The United States is far from this situation. Even so, a global sell-off in U.S. government bonds could precipitate interest rate spikes and/or a dollar depreciation, both of which would weaken the U.S. economy. Moreover, problems in the U.S. economy or in the Treasury bond market could affect other nations and the global financial system, contributing to a weaker global economy or in a worst case, a renewed global financial crisis.

Figure 1. Federal Deficit or Surplus (% of GDP)



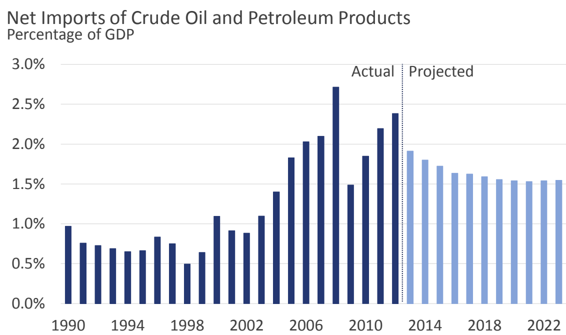
Source: CBO (August 2013), Historical Budget Data, Table 1; CBO (September 2013), "The 2013 Long-Term Budget Outlook," Table 1.

Imbalance of Oil Consumption & Production

For decades, the United States has been the largest consumer of petroleum in the world. In 2012, for example, the United States consumed approximately 18.6 million barrels per day (mbd) of crude oil and petroleum products.[9] In the same year, the United States produced just 6.5 mbd of crude oil.[10] While some of the 12.1 mbd difference between U.S. demand and domestic crude oil supply was made up by refinery gains, natural gas liquids, biofuels, and other domestic sources, the shortfall was largely closed through 7.4 mbd in net oil imports.[11] At an average price of just over $94 per barrel in 2012, U.S. refiners – and eventually consumers – sent nearly $291 billion to foreign nations in exchange for oil. This equals about $800 million a day.[12]

While the imbalance between domestic oil consumption and production, in physical volumes, is not much larger today than it was ten years ago, the amount of money that Americans pay for oil has quadrupled, as the average price for a barrel of crude oil has risen from $22.61 in 2002 to $101.16 in 2012.[13] For most products, a price increase of this magnitude would convince consumers to reduce their consumption and prompt domestic producers to dramatically raise production.

Figure 2. Petroleum Trade Deficit (% of GDP)



Source: EIA, Annual Energy Review (2012), Tables 3.9 and D1; EIA, Annual Energy Outlook (2013), Tables 11 and 20.

Oil, however, is different. Both the supply and demand for petroleum are price inelastic in the short run, meaning major price changes lead to only small changes in domestic production and consumption levels. For example, as oil prices quadrupled between 2002 and 2012, demand for petroleum products fell by just 1.2 mbd (6.1%) and domestic production increased by just 1.4 mbd (16.1%).[14] Moving forward, the EIA's 2013 Annual Energy Outlook—a highly cited U.S. long-term forecast—projects that oil consumption will remain relatively flat, falling by less than 1% from 2013 to 2040.[15]

Transportation Sector Oil Consumption

America's rigid demand for oil is the result of an economy that is structured around petroleum-powered technologies. In particular, the nearly exclusive reliance on gasoline, diesel, and other petroleum-based fuels within the transportation sector is the single largest driver of U.S. petroleum dependence. In 2012, more than 93% of the fuel used by that sector was petroleum-based.[16] Furthermore, with the nation's fueling infrastructure based almost entirely on stations that only sell gasoline and diesel, such fuels hold a formidable incumbent advantage over other potential transportation fuels, such as electricity and natural gas, even once other cost issues related to the use of these alternative fuels are addressed.

The United States is heavily dependent on petroleum use in the short and medium term. In the longer term, the purchase of more fuel efficient vehicles can reduce oil use, though in recent years rising oil prices have more than offset the impact of efficiency improvements on consumer pocketbooks. Indeed, the latest Annual Energy Outlook forecasts flat demand for transportation sector liquids through 2040 as the use of more fuel efficient vehicles is offset by an increasing population and growth in vehicle miles traveled (VMT).

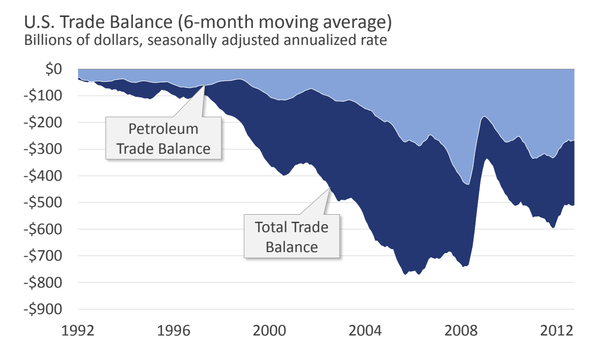
PART I: The Impact of Oil Prices on the Federal Budget

When policymakers and researchers talk about the impacts of the nation's petroleum dependence, they commonly point to the following four negative consequences.

- **Slower economic growth:** High oil prices and oil price volatility over the last four decades have had harmful effects on the economy. Each oil price increase translates into a greater leakage of income out of the country to pay for imports, directly reducing domestic expenditure and output growth. Abrupt behavioral adjustments to business and consumer activity in response to higher oil prices and the associated higher inflation further hurts economic growth. Indeed, some studies have documented that oil price shocks have triggered or exacerbated each U.S. recession since 1970.[17]

- **Larger trade deficits:** Net petroleum imports accounted for more than half of the United States' $535 billion trade deficit in 2012. Since trade deficits are largely financed by foreign borrowing, this suggests that increases in oil prices have resulted in a large-scale increase in U.S. indebtedness.[18]

Figure 3. U.S. Total and Petroleum Trade Balance



Source: Census Bureau, U.S. Trade in Goods and Services (FT900), Exhibit 9.

- **Weakened national security:** The United States imports oil from unstable regions of the world. At a minimum, U.S. dependence on oil from such regions reduces the country's flexibility and leverage in foreign policy negotiations and affects the balance of national interests that feed into policy decision-making. As a result, the country's foreign policy options and priorities in major oil producing regions are particularly prone to distortion.

- **Harm to the environment.** Petroleum is both more carbon-intensive and poses a greater risk to local environments than many alternative energy sources. For example, natural gas vehicles produce about 5-9% less greenhouse gas emissions per mile driven and 20-45% less smog-producing pollutants on a well-to-wheels basis.[19]

Each of these negative consequences of oil dependence is well known. One major consequence, however, is often overlooked: the impact of oil dependence on the U.S. federal budget. The next section of this report discusses the different channels through which oil prices – and America's dependence on oil – impact the federal budget.

1.1 Oil prices and the Federal Deficit

Oil prices impact the U.S. budget in a variety of ways. Higher oil prices directly influence the U.S. budget on the expenditure side through federal fuel purchases and on the revenue side through royalty payments for fuel produced on federal lands. The most significant impacts of higher oil prices on government expenditures and revenue, however, are indirect, through their effect on inflation and economic growth.

1.1.1 DIRECT IMPACTS

The most direct impacts of increasing oil prices on the federal budget come through increases in federal fuel expenditures and increases in oil royalty payments. These effects are relatively small, however, relative to the size of overall government revenues and expenditures. In 2011, the U.S. government consumed approximately 133 million barrels of petroleum products. This cost the government about $18.2 billion in annual spending. In 2002, however, when oil prices were much lower, the government consumed just 10% less petroleum (120 million barrels), but because petroleum was much less expensive, its total oil bill was roughly 80% lower ($4.5 billion).[20]

The Department of Defense (DOD) accounts for the vast majority of federal petroleum use: 91% in 2011.[21] DOD is the largest organizational user of petroleum in the world, consuming approximately 121 million barrels of oil in 2011 (equal to nearly 2% of total U.S. petroleum consumption).[22] For fiscal year 2013, the department anticipated that it would spend $16 billion on fuel, almost double what UPS, FedEx, and DHL spend on global shipping operations combined.[23] At these levels of consumption, a sustained increase of $10 per barrel would add $1.3 billion to the Department of Defense budget.[24] As previously mentioned, oil prices have risen by nearly $75 over the past decade, resulting in a considerable increase in DOD's annual fuel spending.[25]

At the same time, increasing oil prices have some positive direct impacts on the revenue side of the federal budget by increasing the royalties collected by the federal government for crude oil produced offshore and on federal lands. Oil royalties are structured as a percentage – typically about 12.5% for onshore and 18.75% for offshore – of the value of oil produced on federal lands, which means increases in both price and production generate higher revenue. In recent years, oil production royalty revenue (excluding rents and bonus bids) has risen dramatically from $1.1 billion in 2003 to $6.2 billion in 2012, reflecting increases in both prices and production.[26] Corporate income taxes on energy companies are another closely-related source of revenue. In 2010 (the most recent year for which data is available), companies in the oil and gas extraction sector paid nearly $3 billion in taxes on corporate profits, which equates to an annual rate of just over 20%.[27] While this source of revenue is impacted by a number of factors, oil prices are a major driver of the taxable profits generated by these companies.

Table 1: Summary of Direct Impacts

Direct Budget Impacts of High Oil Prices	
Budget Item	Direction of Budgetary Impact
Federal Non-Defense Expenditures	⬆ (dark blue)
Federal Defense Expenditures	⬆ (dark blue)
Federal Oil Royalty Receipts	⬇ (light blue)
Corporate Income Tax Receipts (Energy Companies)	⬇ (light blue)

Dark Blue Arrow: Positive Net Budget Impact
Light Blue Arrow: Negative Net Budget Impact

One other revenue source often associated with oil prices is the federal gas tax. Unlike oil royalties, however, the federal gas tax is a fixed 18.4 cents per gallon gasoline fee – 24.4 cents per gallon of diesel – meaning that revenue levels vary with consumption and are not directly impacted by changes in prices.[28] In fact, an increase in oil prices may indirectly decrease gas tax revenues by leading consumers to drive less.

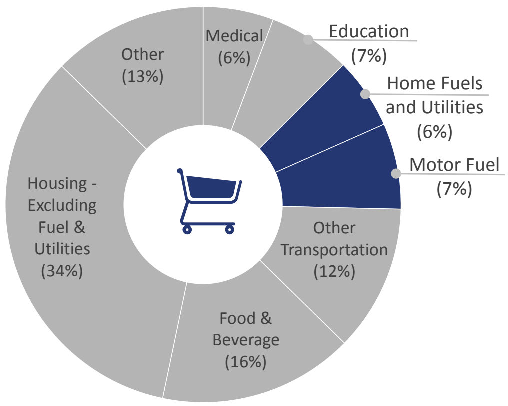
1.1.2 INDIRECT IMPACTS

Higher oil prices indirectly impact the budget through two key mechanisms: the consumer price index (CPI) and economic growth.

Oil Prices and CPI

Oil prices indirectly impact both budget revenues and expenditures through their effect on the consumer price index and inflation. The index, which is calculated by the U.S. Bureau of Labor Statistics, measures changes in the cost of a typical basket of consumer goods and services. Because petroleum products are such an important component of American households' budgets – both directly through gasoline and home heating oil purchases and indirectly through commercial flight, transit, and food prices – crude oil prices have a significant impact on CPI-calculations. Indeed, energy commodities, including fuel oil and motor fuel, represent 7.0% of the CPI goods and services "basket", meaning that even small price increases can significantly increase CPI levels.[29] Oil price changes similarly feed into the prices charged by businesses for nearly all goods and services.

Figure 4. CPI-W Basket Weights



Source: Bureau of Labor Statistics, CPI Detailed Report (July 2013).

The CPI, specifically the CPI for Urban Wage Earners and Clerical Workers (CPI-W), in turn is used to determine the cost of living adjustments (COLAs) for government wages, Social Security, and federal pensions. From 2002-2012, the price level for the basket of goods including energy prices (CPI-W, All Items) increased 28.1%. When excluding energy prices, however, the index (CPI-W, All Items less Energy) increased by only 22.3% over the same period.[30] Hence, the rapid increases in energy prices (primarily petroleum products) over the last decade have caused COLA adjustments to be at least 20% larger than they would have been if energy prices had risen at the rate of all other goods. These higher Social Security payments are appropriate policy—they protect senior citizens, pensioners, and valued employees against inflation. Still, the impact of this change is that federal outlays are tens of billions of dollars higher than they otherwise would be.

From a budgetary standpoint, higher inflation is better for debtors including the federal government because it drives down the real value of debt (only a small share of Treasury bonds include payments indexed to inflation). For the same reason, higher inflation is generally bad for creditors including individual savers, including for groups such as those elderly who have accumulated significant savings. Similarly, higher inflation can put upward pressure on nominal interest rates and thereby slow the economy and increase future federal interest payments.

Oil Prices and Economic Growth

Another channel through which high oil prices affect the federal budget, however, is through the impact on economic growth. As explained in a recent analysis by Greene *et. al.* (2013), oil dependence imposes costs on the U.S. economy in three key ways: (1) a transfer of wealth to oil exporters; (2) the deadweight loss of GDP from the higher price of oil; and (3) dislocation losses from "unexpected" oil price changes (so-called oil shocks).[31] The researchers estimate that through these impacts, high and volatile oil prices over the past four decades reduced the overall size of the U.S. economy by nearly $3 trillion.[32]

A number of other studies quantify the economic impact of an increase in the price of oil in a given year. A 2012 CBO report estimated that a sustained $10 increase in the price per barrel would reduce GDP by 0.1% to 0.2%.[33] Various other economic analyses have estimated that the impact of such an increase would be even larger, in the range of 0.2% to 1.0% of GDP.[34]

High oil prices are also likely a key factor in exacerbating and even triggering recessions. Hamilton (2005), for example, notes that 9 out of 10 recessions in the post-World War II era were preceded by significant oil price increases.[35] In a more recent paper, the same author further examines the relationship between the increase in oil prices from 2007 to 2008 and the recession, concluding that oil prices materially contributed to the recession with particularly significant impacts on consumer spending and automobile purchases.[36]

Figure 5. Oil Price and Economic Recessions

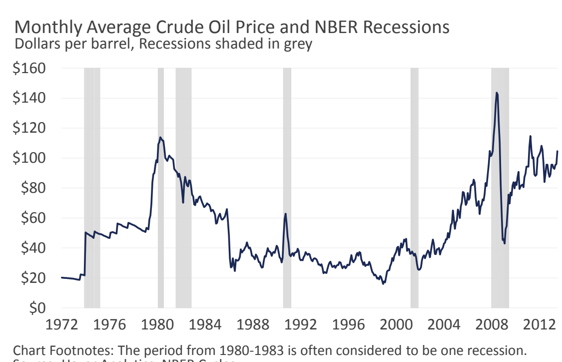


Chart Footnotes: The period from 1980-1983 is often considered to be one recession.
Source: Haver Analytics; NBER Cycles

While the magnitude of the impact of high and volatile oil prices on the U.S. economy is debated, it is widely accepted that the impact is negative. Slower growth means lower income levels and lower individual revenue collections. Reduced growth also translates to lower profits for corporations, slower earnings growth for individuals, and an overall decline in the value of financial assets for both corporations and individuals.

From a budgetary standpoint, these changes all lead to lower tax receipts through lower taxes on corporations, personal income, and capital gains. Slower economic growth leads to higher unemployment, further contributing to the reduction in income tax receipts. Slower growth also drives increased federal government expenditures through higher spending on unemployment insurance payments, Supplemental Nutrition Assistance Program (SNAP) payments, and a variety of other social aid programs. Increased state-level aid payments such as for Medicaid can further affect the federal deficit through cost-sharing provisions.

These mechanisms through which oil prices affect the economy are deeply interconnected with one another and the general economy, making it difficult to estimate the aggregate effect of oil prices on the federal budget. While the weight of the evidence discussed above suggests that the sharp increases in oil prices experienced over the last decade worsened the federal government's fiscal situation, little or no analysis has thus far been performed to estimate the magnitude of the impact. The analysis discussed below uses a detailed macroeconomic model of the U.S. economy to untangle the complexities of the interactions among these different effects and provide a quantification of the overall impact of oil prices on the economy and federal budget.

1.2 Historical Modeling Framework

The objective of the historical analysis is to illustrate the federal budgetary impact of high oil prices over the past ten years. This analysis provides estimates for how historic federal deficits and debt might have unfolded had oil prices increased with overall inflation, instead of the large increase in oil prices that actually occurred over the 2002-2012 period.

1.2.1 THE INFORUM LIFT MODEL OF THE U.S. ECONOMY

This analysis was performed using the University of Maryland's Inforum LIFT model — a widely used econometric model of the U.S. economy. The LIFT (Long-term Interindustry Forecasting Tool) model is unique among large-scale models of the U.S. economy; combining an interindustry (input-output) formulation with extensive use of regression analysis, the LIFT model utilizes a dynamic general equilibrium structure that portrays the economy in a "bottom-up" fashion and allows effects to be captured at the detailed industry and product level. For example, aggregate investment, employment, and total exports are not determined directly but are computed by the sum of their parts: investment and employment by industry and exports by commodity. LIFT contains full demand and supply accounting for 97 productive sectors.

This bottom-up technique possesses several desirable properties for analyzing the impact of oil prices on key economic outcomes, including federal deficits and debt:

- The model works like the actual economy, building the macroeconomic totals from details of industry activity rather than distributing predetermined macroeconomic quantities among industries.
- The model describes how changes in one industry, such as changing international trade patterns, affect related sectors and the aggregate quantities.
- Parameters in the behavioral equations differ among products, reflecting differences in consumer preferences, price elasticities in foreign trade, and industrial structure.
- The detailed level of disaggregation permits the modeling of prices by industry, allowing one to explore the effects of relative price changes, such as those due to exogenous oil price shocks.

Despite its industry basis, LIFT is a full macroeconomic model with more than 800 macroeconomic variables determined consistently with the underlying industry detail. This macroeconomic "superstructure" contains key functions for household savings behavior, interest rates, exchange rates, unemployment, taxes, government spending and current account balances.[37] The model also

has a detailed federal government fiscal accounting, which allows it to describe revenue collection and spending for any given scenario.

Importantly, the LIFT model simulates the economy year by year, allowing modelers to analyze both the ultimate economic impact of a policy change and the dynamics of the economy's adjustment process over time. As a result of this dynamic and bottom-up framework, the model is well suited to explore the economic relationships among key energy industries and to examine the initial dislocation and subsequent adjustment to equilibrium associated with energy price shocks. In summary, the LIFT model is particularly suited for examining and assessing the macroeconomic and fiscal impacts of the oil prices and changes in oil dependence on U.S. economic growth, inflation, employment, and ultimately, the U.S. fiscal position.[38]

1.2.2 METHODOLOGY

This analysis develops a LIFT model scenario that represents an alternative state of the world assuming lower oil prices, and then compares outcomes from this scenario to actual history. The differences in macroeconomic variables and federal budget outcomes between the alternative scenarios and historic data represent the estimated impacts of the alternative assumptions. In this case, the only significant exogenous change is the oil price trajectory. The "High Oil Price Baseline" scenario models the real world increase in prices over the past decade, while the alternate "Low Oil Price" scenario aims to model the most plausible outcomes if oil prices had been significantly lower over the same period.

Isolating the impacts of oil prices on key variables such as GDP and federal expenditures is complicated to some degree by the occurrence of the Great Recession during the study period. Not only did the recession contribute to greater volatility in world oil prices, but it also led to a collapse of federal revenue and a large uptick in federal spending over 2007 to 2012. It is therefore difficult to separate the federal budget impacts of high oil prices from the consequences of such a large recession. Since the current objective is to isolate the budgetary effects of rising oil prices alone, the modeling procedure is configured in a two-stage process to factor out the recession-induced volatility of both oil prices and federal receipts and expenditures. This process is explained below.

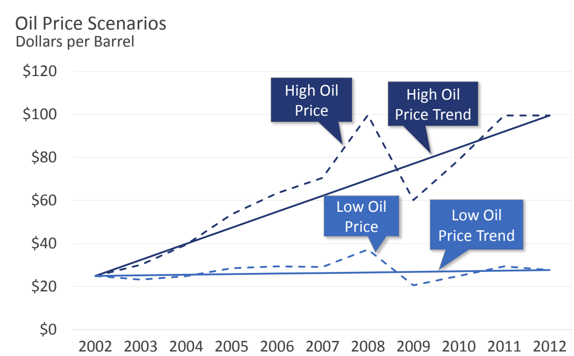
Stage 1: Develop Scenarios Based on Oil Price Trends

In the first stage, two model-based simulations that assume away the volatility of both the oil price and the Great Recession were established. To remove the volatility from the oil price, two additional scenarios were created, as shown in Figure 6. The "High Oil Price Trend" scenario assumes a real oil price that increases linearly from the average price of $24.96 per barrel in 2002 to the average price of $99.49 per barrel in 2012. As indicated by Figure 6, this straight-line trajectory follows the general trend of rising oil prices, but removes the volatility from the price.

The "Low Oil Price Trend" scenario assumes that the real price of oil increases at the rate of GDP inflation (i.e., the change in price of all goods and services). Figure 6 shows both the *Low Oil Price Trend* trajectory as well as a "*Low Oil Price Alternative*" trajectory, which includes volatility. The "Trend" scenarios thus ignore the oil price spike in 2008, the dramatic oil price decline in 2009, and other volatility over the period.

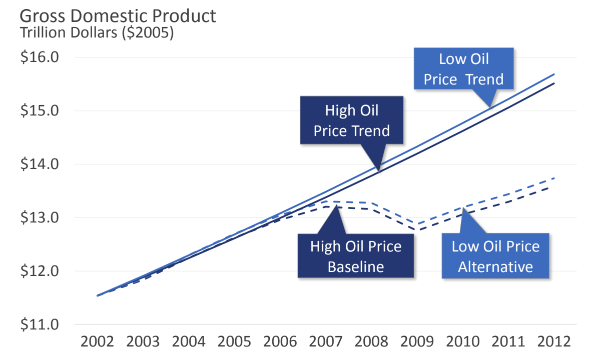
Assuming the *High Oil Price Trend* trajectory, but ignoring other key economic disruptions from the decade, a simulation is developed which produces trend economic growth over the 2002 to 2012 period. In other words, this simulation assumes that while steady oil price inflation did occur, the financial crisis and subsequent recession did not materialize. The trajectory for real GDP in this scenario is shown in Figure 7 as the *High Oil Price Trend* Scenario. Using this scenario as a point of departure, a second

Figure 6. Oil Price Scenarios



historical simulation is developed that assumes the lower oil price trend. The GDP path for this scenario is shown in Figure 7 as the *Low Oil Price Trend* Scenario. This allows the modeling exercise to focus in on the impacts of the lower oil price as distinct from the consequences of the financial crisis and ensuing recession.

Figure 7. Economic Growth Scenarios



Stage 2: Superimpose the Estimated Impacts onto the Historical Data

In the second stage of the analysis, the differences between the *High* and *Low Oil Price Trend* simulations are overlaid on the actual historic data. For most macroeconomic and federal budget variables, this estimation is accomplished by multiplying the percent deviation of those variables between the *Low Oil Price Trend* and *High Oil Price Trend* scenarios by the actual historic data. The general result is displayed in Figure 7. In the lower part of the graph, the line labeled *High Oil Price Baseline* is equal to the actual historic GDP and therefore displays the catastrophic impact of the Great Recession through 2012. A *Low Oil Price Alternative* GDP line is roughly parallel to the actual GDP. The difference between these two lines is roughly proportional to the difference in GDP between the two Trend scenarios.

This transformation produces a low-price alternative scenario which is relative to the actual historic outcomes. In the analysis that follows, the differences between this new scenario (the *Low Oil Price Alternative* scenario) and the historic record for macroeconomic and federal budget figures represent the effects of higher oil prices, as distinct from impacts of the volatility of both the oil prices and economic growth.

Once again, this two-stage process explicitly attempts to separate the economic and budgetary effects of elevated oil prices from the economic and budgetary effects of the financial and economic crisis. The reason for this assumption is that it is difficult to distinguish the role that rising oil prices played in the financial crisis and the deep recession that followed. It is likely true that the rapid increase in oil prices between late 2007 and mid-2008 played a role in inducing and exacerbating the recession; the question is whether the subsequent financial crisis was triggered primarily by this recession or whether the crisis was inevitable given the underlying problems in housing and financial markets. This analysis does not attempt to weigh in on this debate. Rather, it concentrates on isolating the growth and budgetary impacts of high oil prices alone.

The isolation of effects due to differences in trend oil prices also recognizes the limits of using a dynamic annual economic model to capture impacts not only of volatile oil prices, but also of financial upheaval. Furthermore, this methodology makes the interpretation of results more straightforward than scenarios complicated by many other factors. Nevertheless, by leaving aside the impacts of oil price volatility (which as previously discussed is widely believed to negatively impact key outcomes), this trend-price strategy probably understates the actual budget impacts of high and volatile oil prices from 2002 through 2012. The results of this exercise might thus be seen as a lower-bound estimate of the negative impacts of oil price increases on the federal deficit.

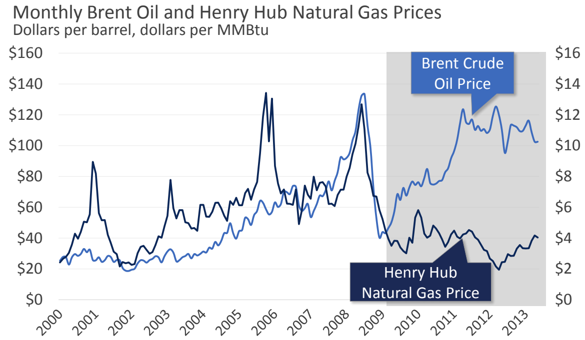
1.2.3 OTHER MODELING ASSUMPTIONS

The analysis is relatively simple because few exogenous variables are modified between the baseline and alternative simulations. As explained above, the principal change is to oil prices; however, two other modeling assumptions also deserve discussion.

Natural Gas Prices

As oil prices surged during the 2002-2008 period, natural gas prices also increased. Although the relationship is imperfect because the two fuels are not perfect substitutes (not many cars run on natural gas), oil and natural gas prices have been related in history, with the prices of both commodities spiking in 2008 and then crashing the

Figure 8. Oil and Natural Gas Price Scenarios



Source: U.S. Energy Information Administration, Data Tables, Spot Prices.

following year. Hence, one could argue that in an alternative scenario with flat real oil prices, real natural gas prices should also remain flat.

However, the relationship between U.S. oil and natural gas prices is quite complicated and changed dramatically over the decade, especially since 2009. Given these complexities, natural gas prices were assumed to be the same between the *High* and *Low Oil Price Trend* simulations. This means that the lower oil price case does not include any additional economic or budget benefits that might have resulted if natural gas prices remained low through 2008. This assumption helps simplify the analysis and sharpen the clarity of its interpretation. However, it is also a conservative assumption in that it probably results in an underestimation of the true impact of high oil prices on the economy, especially through 2008. Like the assumption of constant growth, the natural gas price assumption likely leads to a conservative estimate of the degree to which oil prices affect the fiscal balance.

Petroleum Production

A side benefit of high oil prices over the last decade has been the surge in domestic oil production, especially since 2007. While much of this additional production has been enabled by technological breakthroughs such as hydraulic fracturing and horizontal drilling, high energy prices played a role by increasing (or even creating) profit potential for particularly capital-intensive production that had been previously deemed uneconomical. To capture this impact, the simulations assume that lower oil prices would have resulted in lower domestic investment, and eventually lower production. Specifically the simulations show that, starting in 2007, lower oil prices cause imports to represent a growing share of the oil supply in the *Low Oil Price Trend Scenario* vs. the *High Oil Price Trend Scenario*.

1.3 Modeling Results

This study finds that the increase in oil prices experienced over the last decade contributed significantly to federal deficits. Most strikingly, the study finds that had oil prices risen at the rate of the overall GDP deflator rather than quadrupling as they did, then:

- The 2012 federal deficit would have been $235 billion lower than it actually was;
- The debt accumulated between 2003-2012 would have been $1.2 trillion lower; and
- The debt-to-GDP ratio would have been 6.6 percentage points lower in 2012.

Table 2 displays the figures for major indicators examined in this study, comparing the low price alternative with the actual historic data for 2012, the last year of the analysis.

Table 2: Summary of Part I Modeling Analysis in 2012

Key Assumption for 2012			
Indicator	Actual	Low Oil Price	Difference
Refiner's Acquisition Oil Price ($/bbl)	$99.49	$27.67	-$71.82
Economic Impacts for 2012			
Indicator	Actual	Low Oil Price	Difference
Real Gross Domestic Product (billions of 2012 dollars*)	$15,747	$15,921	+ 1.1 %
Cumulative Change in GDP Deflator from 2002 to 2012	25.7%	22.8%	- 2.9%
Cumulative Change in PCE Deflator from 2002 to 2012**	24.9%	20.5%	- 4.3%
Total Employment (millions of jobs)	147.8	149.1	+ 1.3
Real Disposable Income per Household (2012 dollars)**	$99,724	$101,806	+ $2,082
Budget Impacts for 2012			
Indicator	Actual	Low Oil Price	Difference
Federal Revenue Receipts (billions of current dollars)	$2,708	$2,754	+$46
Federal Expenditures (billions of current dollars)	$3,886	$3,697	-$189
Net Lending or Borrowing (-) (billions of current dollars)	-$1,178	-$943	+$235
Federal Debt in Hands of Public (billions of current dollars)	$11,272	$10,067	-$1,205
Federal Debt-to-GDP Ratio, end of 2012 (percent)	71.6%	65.0%	-6.6

*GDP converted from 2005$ to 2012$ using historic GDP deflator.
**Real disposable Income converted from 2005$ to 2012$ using historic PCE (Personal Consumption Expenditure) deflator.

The first line indicates that in the *Low Oil Price Alternative Scenario*, the price of oil was about 73 percent lower by 2012. By that year, cheaper oil boosts the level of real GDP in 2012 by 1.1 percent, reduces consumer prices by 5%, and increases employment by 1.3 million jobs. Meanwhile, real disposable income per household is $2,000 higher by 2012.

The bottom half of Table 2 shows the federal budget outcomes for 2012. This cumulative savings to the budget are roughly equivalent in magnitude to the entire 2012

budget deficit. The drivers for these budget savings are described in more detail below.

1.3.1 DIRECT IMPACTS

Lower oil prices most directly impact the budget through decreased federal fuel expenditures and decreased oil royalty receipts. Most significantly, the model estimates that lower oil prices would result in a $12 billion reduction in the federal government's fuel expenditures in 2012, and a cumulative reduction of $63 billion over the decade. More than 90% of these savings are the result of lower fuel spending by the Department of Defense.

Reduced royalty payments from resource production on federal lands partially offset some of the benefits of decreased fuel expenditures. In 2012, Taxes on Production and Imports – a model output that includes royalties – is one of the few variables that is estimated to be reduced because of low oil prices. By 2012, taxes on production and imports are down $3.9 billion and over the decade by $17.3 billion. As previously discussed, oil royalty payments are calculated as a percentage of the value of oil produced on federal lands, meaning both lower prices and lower production decrease royalty collections through 2012. Actual oil royalties would likely be down even further, but this composite variable includes offsetting impacts on other taxes due to higher economic growth and increases royalty revenue from the production of additional natural gas or other resources on federal lands.

1.3.2 INFLATION

As previously discussed, the most significant budgetary effects of lower oil prices are indirect, and result from lower inflation and higher real economic growth. In the model simulation, lower oil prices push the consumer price index about 4.0 percent lower by 2012 compared to the high oil price baseline. By itself, lower inflation implies that federal government spending will be lower. First, the annual cost of living adjustments (COLAs) that the government applies to federal wages, Social Security payments, and other transfers would be lower. Second, several other large expenditure categories are sensitive to inflation, including Medicare, defense procurement, and purchased services. In the *Low Oil Price Alternative Scenario*, for instance, lower COLAs lead to lower entitlement spending, saving the government an estimated $48 billion in 2012 and $207 billion cumulatively over the decade.

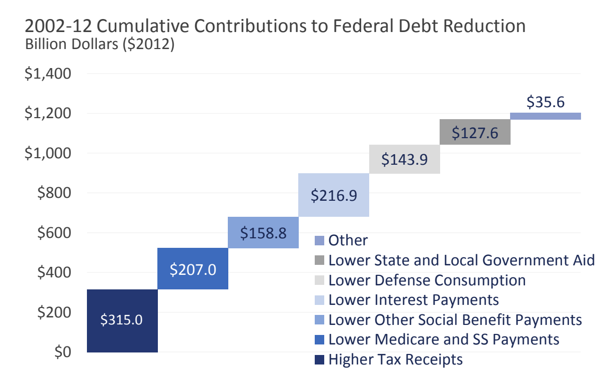
1.3.3 ECONOMIC GROWTH

As indicated in Table 1, the LIFT model estimates that lower oil prices would have boosted real gross domestic product by 1.1 percent (about $175 billion) by 2012. This stronger economy would boost employment, adding an additional 1.3 million jobs to the U.S economy by 2012 and lowering the unemployment rate by 0.6 percentage points. The stronger economy provides several budgetary benefits. First, higher employment helps reduce the government's expenditures on unemployment payments, food stamps, and Medicaid. Indeed, the model estimates that in the *Low Oil Price Alternative Scenario*, unemployment benefits are about 18% lower in 2012, saving the government $16 billion in that year and $97 billion cumulatively over the decade.

While some of the reduction in spending can be attributed to stronger economic growth, most can be attributed to lower inflation. In sum, the model estimates that stronger growth and lower inflation in the *Low Oil Price Alternative Scenario* reduce total transfer payments (excluding Social Security, Medicare, and unemployment insurance, which are all discussed above) by about $39 billion in 2012, and by $190 billion cumulatively.

On balance, stronger economic growth outweighs the inflation effect to modestly boost tax revenues. In the *Low Oil Price Alternative Scenario*, higher real incomes induce $32 billion in additional personal income taxes payments

Figure 9. Federal Debt Reduction by Budget Item



in 2012. The cumulative increase in personal taxes is $188 billion. Similarly, better growth boosts corporate taxes by a cumulative $146 billion from 2003 to 2012. Overall, tax revenues increase by $315 billion over the decade.

1.3.4 INTEREST PAYMENTS

Finally, lower nominal interest rates and smaller budget deficits lower interest payments when oil prices are lower. Lower inflation reduces interest rates. Moreover, the reduction in deficits over the decade would have led to a slower accumulation of debt over the period. Together the impact of slower debt accumulation and lower interest rates save the federal government an estimated $49 billion in 2012 and $217 billion cumulatively over the decade.

1.3.5 TOTAL FEDERAL REVENUES, EXPENDITURES, BORROWING AND DEBT

In the *Low Oil Price Alternative Scenario*, federal expenditures are $187 billion lower by 2012 and $886 billion lower over the 10-year period. Similarly, this analysis estimates that the direct and indirect effects of lower oil prices increase federal revenue collections by $46 billion in 2012, and by $306 billion cumulatively over the 10-year period from 2003 to 2012. Taken together, these changes cause net federal borrowing to shrink by $234 billion in 2012. In sum, lower oil prices would have reduced the federal debt level by an estimated $1.2 trillion, lowering the debt-to-GDP ratio by 6.6 percentage points below the actual 71.6% mark at the end of 2012.[39]

PART 2: Insulating the Federal Budget from High and Volatile Oil Prices

2.1 Introduction

Part One of this report demonstrated the negative fiscal effects of U.S. dependence on increasingly expensive oil from 2002 to 2012. In Part Two, the potential future budgetary effects of oil dependence are analyzed, including an examination of measures that could buffer the federal budget and national debt from the negative effects of oil dependence. Specifically, it focuses on the following questions:

- Might an economy that relied more on non-petroleum domestic energy sources and less on foreign oil have faster economic growth and improved budget outcomes in coming years and decades?
- Might such an economy be more insulated from negative effects of sustained higher oil prices?
- Might such an economy be better equipped to deal with a sudden sharp spike in oil prices, as has occurred repeatedly in recent decades?

The analysis again examines these questions using the Inforum LIFT model of the U.S. economy.

The study concludes that a reduction in oil dependence could help the U.S. economy grow faster, make the economy more resilient in the face of structurally high oil prices, and insulate the United States from the negative effects of a potential future oil price shock. At the same time, reduced oil dependence would lead to improved U.S. fiscal outcomes and lower debt-to-GDP ratios than would otherwise be the case. Fortunately, innovations in vehicle technology are making it increasingly feasible to consider such a changed energy path for the United States.

2.2 Background: Budget Impacts of Changes in Production and Consumption

The use of new crude oil extraction technologies to access unconventional resources has greatly increased American self-sufficiency in liquid fuel supplies. The Department of Energy estimates that the United States will import one-third of its liquid fuel supplies in 2013—or approximately 6.3 million barrels per day (mbd). This is a sharp decline from levels as recently as 2005, when U.S. net imports totaled 12.6 mbd—equal to nearly 60 percent of total supplies.[40,41]

Current forecasts suggest that America will become increasingly self-sufficient in oil supplies over the coming decade. This is an important change from the previous decade, and one that could ameliorate several of the economic and budgetary problems discussed in Part One. For example, more domestic supplies from federal lands would increase royalty payments to Treasury's General Fund. Increased domestic production would also increase the profits of energy companies and taxes that they pay on those profits.

However, the negative impacts of high and volatile oil prices for households, businesses, and public agencies would remain largely unaddressed by an energy strategy focused strictly on increasing domestic oil production. For example, while increased domestic supply would put some downward pressure on oil prices, the changes would likely be small, because oil prices are determined in a global market. This means that the inflation-related impacts on the budget that oil prices have had in the past could be repeated. Furthermore, high fuel costs would continue to take a toll on consumers, and oil price increases and volatility would continue to hurt the budget through reduced economic growth.

Successful strategies to reduce domestic oil consumption, on the other hand, could help insulate the economy and federal budget from these negative inflation- and growth-related impacts. Specifically, increased efficiency and greater use of non-petroleum fuels could provide a significant measure of resilience in the face of high oil prices to both the U.S. economy and the federal budget going forward.

2.3 Background: Prospects for Reducing Petroleum Consumption

U.S. petroleum consumption is largely driven by the transportation sector, which consumes almost three quarters of the petroleum fuel used in this country. From 1990 to 2007, total petroleum consumption rose from below 17.0 mbd to 20.7 mbd.[42] Nearly all of this increase was due to rising demand within the transportation sector. In contrast, petroleum consumption in residential and commercial uses and for electric power generation has been steadily declining for decades as those sectors have switched to lower-cost alternative fuels.[43]

U.S. transportation petroleum demand peaked in 2007, and has been declining since due to the combined impact of the Great Recession, high oil prices, and fuel-economy standards.[44] Nevertheless, even with continued improvements in fuel economy, further reductions in economy-wide petroleum use are not expected according to EIA forecasts. Petroleum-based fuels are projected to retain a near monopoly on fuel use within the transportation sector, representing 90% of the fuel consumed in the sector in 2013-2040.[45]

Changing these prospects, however, is becoming increasingly possible as fuel efficiency and alternative fuel technologies become feasible and cost-competitive. The next sections discuss these alternative technologies and their potential to reduce petroleum dependence in the transportation sector.

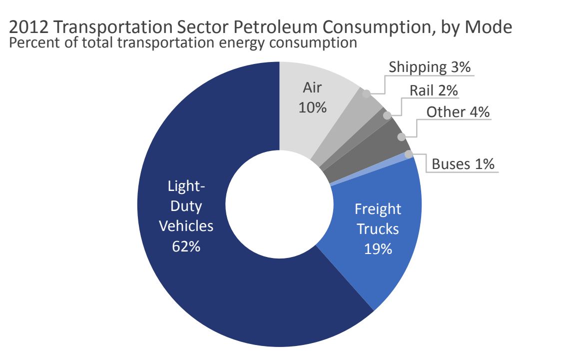
2.3.1 NON-HIGHWAY FUEL CONSUMPTION

Within the transportation sector, non-highway transportation — including rail, aviation, maritime shipping, and pipelines — account for about one-fifth of petroleum consumption. Going forward, the EIA projects non-highway petroleum consumption will increase by about 0.4 mbd (or 18%) by 2040, primarily due to increased air and shipping demand.[46] These projections expect only minimal penetration levels for alternative fuels. However, several promising opportunities for fuel-switching, particularly within the aviation and rail sectors, could lead to lower than expected petroleum consumption for non-highway transportation. For example, the aviation industry has been testing biofuels that could eventually displace jet fuel. Also, while natural gas use is currently limited within the rail industry, analysts at Citi GPS predict that "natural gas looks set to start displacing diesel in a transition similar to the shift from coal to oil decades ago."[47] Three of the largest U.S. rail carriers – BNSF, Union Pacific, and Norfolk Southern – are currently working with manufacturers to develop natural gas freight trains.[48]

2.3.2 HIGHWAY FUEL CONSUMPTION

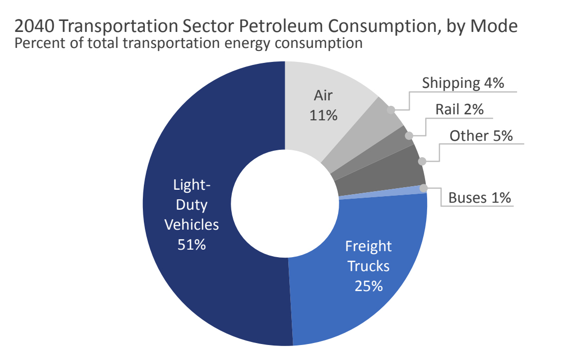
Much larger opportunities to reduce petroleum fuel consumption exist among highway vehicles – cars, trucks, buses, and motorcycles – which represent nearly four fifths of all transportation petroleum consumption.[49] Although fuel economy standards will greatly reduce the fuel consumption per mile for both passenger and freight vehicles over the next decade and beyond, increases in population and vehicle miles travelled (VMT) will keep energy use among highway vehicles largely flat through

Figure 10. Transportation Sector Petroleum Consumption



Source: EIA, Annual Energy Outlook (2013), Table 37.

Figure 11. Transportation Sector Petroleum Consumption



Source: EIA, Annual Energy Outlook (2013), Table 37.

2040. Alternative fuel vehicles, however, provide promising pathways to reducing petroleum use among highway vehicles. In the United States, electric vehicles are achieving traction in the light-duty passenger vehicle market while natural gas vehicles have made significant inroads among buses and some fleet vehicles, and are poised to make substantial inroads among freight vehicles, including medium- and heavy-duty commercial vehicles.

Electrification

There are two major types of light-duty electric vehicles – plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). BEVs have no internal combustion engine and are powered entirely by electric power derived from the grid and stored in the cars' batteries. PHEVs, like traditional hybrids, include both an electric motor and an internal combustion engine, but unlike traditional hybrids can store electricity from the electric grid in their batteries in order to travel a limited number of miles – typically 10-40 – without using any gasoline.[50]

Both PHEVs and BEVs significantly reduce gasoline consumption compared to conventional vehicles. BEVs use electricity only, while PHEVs use electricity to power on average 20-70% of the miles they drive, depending on the size of the battery and driving behavior.[51] DOE estimates that this substitution of electricity for gasoline cuts fuel costs by nearly 75%—or by about $10 for a 100-mile trip—when comparing a BEV with a conventional vehicle of the same class.[52]

The main drawbacks of electric vehicles include the higher initial purchase price, shorter driving range (for BEVs but not PHEVs), and limited recharging infrastructure, but it is possible that these will be overcome through technological advancements and improved economies of scale with more widespread deployment. Indeed, battery costs have already fallen dramatically. The Department of Energy estimates that prices fell by more than half from 2008 to 2012. In 2013, the makers of the most popular PHEV and BEV in the U.S. market reduced their sticker prices on those vehicles by 14% and 18% respectively.[53,54] Additionally, the number of public electric vehicle charging outlets has increased exponentially in recent years from less than 1,000 in 2008 to nearly 13,400 in 2012.[55]

Finally, the most important barrier for these vehicles to overcome is consumer acceptance. While far from mainstream, plug-in electric vehicles have been gaining traction in the market. Since January of 2011, more than 130,000 plug-in electric vehicles have been sold in the United States, including more than 11,000 in August 2013 alone.[56] And while total PEV sales still only account for a small share of the auto market, some electric models have been capturing significant shares in their respective classes. For example, it was recently reported that the Tesla Model S captured more than 8 percent of the luxury sedan market in the first half of 2013, outselling competing conventional models from BMW and Mercedes-Benz.[57] Of course, this is a small market segment.

As an added point of context, it is worth noting that the market introduction of plug-in electric vehicles between 2011 and 2013 outperformed the U.S. introduction of traditional hybrids over the comparable time period in 2000-2002. Sales of today's plug-in electric vehicles have been more than double the early sales of traditional hybrids.[58] Meanwhile, nearly all major manufacturers are producing plug-in electric vehicles, with 20 plug-in models available today, whereas there were just two traditional hybrid models available mid-way through 2002.[59] Together, these market forces and developments signal that electric vehicle sales could provide a viable path forward toward reducing petroleum dependence among light-duty vehicles.

Natural Gas Vehicles

Natural gas vehicles provide another alternative to conventional gasoline- and diesel-powered engines for highway vehicles. Like electric vehicles, natural gas vehicles provide significant fuel cost savings as the current price differential between a gallon of diesel and natural gas (diesel gas equivalent) is about $1.50.[60] Despite these benefits, high upfront vehicles costs and limited refueling infrastructure currently pose significant barriers for widespread penetration within the passenger vehicle market.

However, natural gas vehicles have been making headway within other highway sectors, specifically the fleet/municipal vehicle and long-haul truck markets. Dozens of natural gas-powered medium- and heavy-duty commercial vehicles are now available, and major U.S. automakers have begun introducing natural gas-powered pick-up trucks. Meanwhile, private investment in refueling

infrastructure has accelerated substantially, particularly for projects aimed at meeting the needs of long-haul trucking. Though natural gas vehicles currently account for a small share of new vehicle sales in these sectors, significant and growing industry and political support indicates that natural gas vehicle penetration could increase rapidly in the coming years.

Compressed natural gas (CNG) vehicles are particularly well suited to use as fleet vehicles that operate in local markets on fixed routes and return to central locations for refueling. Medium-duty municipal vehicles such as buses and garbage trucks represent a relatively small portion of the overall vehicle fleet, but often have considerably higher than average fuel consumption, providing a meaningful incentive for fuel switching. Transit buses are currently one of the largest markets for natural gas vehicles, with nearly one fifth of all transit buses running on liquefied natural gas (LNG) or CNG.[61] Similarly, waste collection and transfer vehicles are the fastest growing natural gas vehicle segment, with natural gas vehicles representing 40% of new vehicle sales in 2011.[62]

Similarly, a number of characteristics of long-haul trucking make this industry particularly well suited for the adoption of LNG vehicles. Most importantly, the high average annual miles traveled by long-haul trucks allow them to more quickly recoup up-front costs through fuel savings from relatively low natural gas prices. Within the freight industry, fuel switching is particularly suitable for trucks that travel set routes or through densely populated areas, facilitating strategic placement of natural gas fueling stations. The transition toward a "hub and spoke" structure within the trucking industry could also further reduce the required investment in new fueling stations.[63] For areas that do not currently possess sufficient refueling stations, large trucking companies also possess the size and access to capital to expand the infrastructure.[64] Indeed, a number of key players have announced plans to purchase hundreds of LNG 18-wheel trucks over the next year.[65] In 2012, Shell North America and Clean Energy Fuels each invested approximately $300 million in LNG refueling infrastructure projects aimed at long-haul trucks and Clean Energy Fuels built 70 LNG fueling stations specifically for long-haul trucks to create "America's Natural Gas Highway".[66]

It will take longer for small/independent truck companies to adopt LNG technology, reflecting the incremental upfront vehicle costs involved (typically about $70,000-100,000).[67] Moreover, LNG engine technology, while market-ready, is still relatively young and will likely achieve greater efficiency and cost reductions with time and improved economies of scale. The combination of these market forces and potential for favorable public policies make it plausible for natural gas vehicles to make significant inroads within the medium- and heavy-duty freight industry, chipping away at the dominance of diesel engines within the freight sector.

2.4 Forecast Modeling Framework

This prospective analysis estimates the budgetary impacts of reducing transportation sector petroleum dependence under a Baseline oil price trajectory from 2013 to 2040. It then estimates the impacts assuming higher or more volatile oil price trajectories.

2.4.1 ALTERNATIVE OIL CONSUMPTION SCENARIOS

The focus of this part of the analysis is to measure how different future oil consumption trajectories would affect key economic and budgetary outcomes. In particular, the analysis features different deployment levels of alternative light-duty and freight vehicle technologies through 2040. The *Baseline Scenario* represents business-as-usual petroleum consumption from these vehicles. Alternatively, a *Low Petroleum Use Scenario* assumes that light-duty vehicles (cars and light trucks) and freight trucks (medium- and heavy-duty trucks) decrease their petroleum dependence by more than half compared to the Baseline by 2040. Specific assumptions regarding fuel economy and alternative fuel vehicle penetration for these scenarios are listed below.

Baseline Scenario

Baseline petroleum consumption for transportation reflects the assumptions included in the Reference Case of the EIA's 2013 Annual Energy Outlook (AEO):

- Fuel economy standards remain level after 2025 for new light-duty vehicles, and after 2017 for new medium- and heavy-duty trucks.

- Battery electric and plug-in hybrid electric vehicles represent just 3% of light-duty vehicle sales by 2040.
- Natural gas vehicles (both LNG and CNG) represent 12% of medium- and heavy-duty vehicle sales by 2040.

Low Petroleum Use Scenario

This scenario assumes new measures to simulate substantial, yet plausible, reductions in vehicle petroleum fuel use. Three strategies are assumed: CAFE standard extensions, light-duty vehicle electrification, and increased natural gas vehicle use among medium and heavy-duty trucks. Together, these actions cut petroleum use by those vehicles in half by 2040. To simulate these, the following modifications to the Reference Case assumptions were made:

- The model assumed that conventional light-duty vehicles continued to make the fuel economy improvements beyond 2025 as shown in Figure 12.[68]
- The share of battery electric and plug-in hybrid electric vehicle sales is assumed to grow linearly through 2030 so that they represent 60% of light duty vehicle sales in 2030 and thereafter.
- The share of LNG and CNG vehicle sales are assumed to grow linearly through 2030 so that they represent 60% of medium- and heavy-duty truck sales in 2030 and thereafter.

This scenario illustrates some of the many potential pathways to lowering the oil dependence of the economy. Similar reductions could be achieved using technologies and fuels that are not simulated in this study or different deployment trajectories of the technologies included here.

2.4.2 ALTERNATIVE OIL PRICE TRAJECTORIES

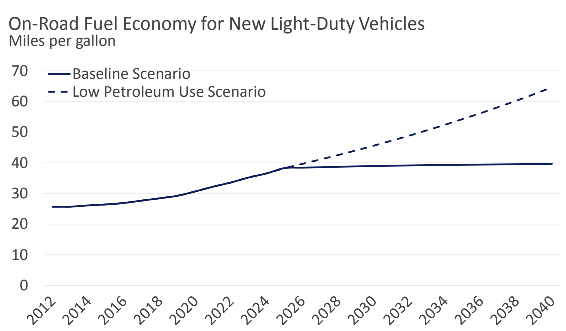
The *Baseline* and *Low Petroleum Use* scenarios were first developed using the 2013 Annual Energy Outlook Reference Case oil price projections. However, in order to examine how economic and budget effects might be different if oil prices rise more quickly or are highly volatile, both scenarios were also simulated using two additional oil price trajectories:

- Persistent High Oil Price Trajectory: Oil prices rise significantly faster over the next decade than projected in the AEO. Specifically, oil prices are assumed to experience a price increase from 2013-2023 that is similar in magnitude to the increase experienced over the 2002-2012 period. After 2023, prices are assumed to rise annually at the same pace – in percentage terms – as the Baseline Oil Prices.
- Volatile Oil Prices Trajectory: Oil prices follow the 2013 AEO Reference Case trajectory in most years, but experience temporary oil price shocks beginning 10 and 20 years from today. These shocks are assumed to result in doubling of oil prices in one year, similar to the jump experienced in 2007-2008. Prices are assumed to return to Baseline oil prices four years after each spike.

2.4.3 MODELS

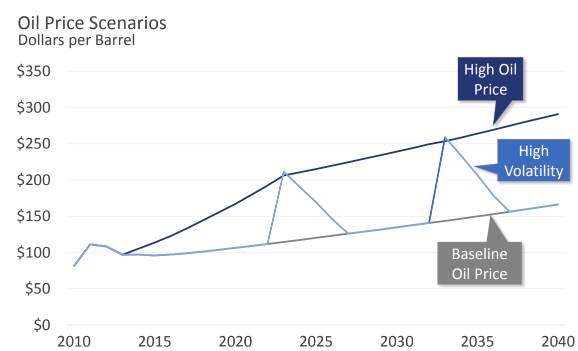
To simulate these scenarios, three vehicle stock turnover models were used in conjunction with the LIFT

Figure 12. Fuel Economy Assumptions



Source: U.S. Energy Information Administration (2013). Annual Energy Outlook, Tables 49 and 52.

Figure 13. Oil Price Scenarios



macroeconomic model. These models capture the extent to which older, less efficient cars are replaced by newer vehicles. The Excel-based stock turnover models were developed to provide a customizable illustration of how different alternative fuel vehicle sales trajectories would affect fuel consumption in the *Low Petroleum Use Scenario*.

LIFT

The main model used to estimate the economic and budgetary impacts in this analysis was the University of Maryland's Inforum LIFT model, which is described in detail in Appendix A and also discussed in Part One of this study. As mentioned above, the *Baseline Scenario* was modeled after the 2013 AEO Reference Case. This means that the LIFT model was calibrated to reflect the values of key input and output variables produced by the National Energy Modeling System (NEMS) – the model used by the EIA – for the AEO Reference Case. These variables include high-level macroeconomic outcomes such as gross domestic product but also industry-specific variables such as the demand for coal from the electric power industry.

The LIFT model, however, does not include the same energy sector detail as NEMS and some assumptions, such as the annual sales of natural gas vehicles to the trucking industry, are not variables that can be adjusted directly in LIFT. Instead, the variables that can be adjusted in the LIFT framework include, for example, diesel fuel consumption by the trucking industry and household expenditures on new vehicles. Changes in alternative fuel vehicle sales assumptions are connected to fuel and automotive expenditure assumptions via the detailed vehicle stock turnover models.

Stock Turnover Models

Three vehicle stock turnover models – one for each vehicle class (light-, medium-, and heavy-duty vehicles) – were developed. Each one estimates the incremental impact of changes to the composition of vehicle sales on fuel consumption and vehicle expenditures by households and by key industries. These stock turnover models used a three-step process to estimate the impact of alternative fuel vehicle sales projections on fuel consumption by type.

- **Step 1: Estimate the impact on the vehicle stock.** The models use the same historic vehicle sales data, vehicle scrappage/survival rates, and new sales volume projections that the EIA used to produce the 2013 AEO Reference Scenario in order to estimate the composition of the vehicle stock by vintage and vehicle type (e.g., conventional cars including non-plugin hybrids, battery electric vehicles, plug-in hybrid electric vehicles).

- **Step 2: Estimate vehicle miles traveled (VMT) by vintage and vehicle type.** The models use the same historic data on VMT per vehicle by vintage that the EIA uses in their Reference case and multiplies those estimates by the vehicle stock data in order to calculate total VMT by vintage and type. As is done for the AEO, these estimates are then multiplied by annual factors that adjust the total VMT for all vintages and types to account for cross-cutting economic factors.

- **Step 3: Estimate fuel consumption by vintage, vehicle type, and fuel type.** The models use the historic fuel economy by vintage data and projections for fuel economy by vintage, vehicle type, and fuel type to calculate total annual fuel consumption by fuel type.

Most of the underlying data and assumptions used for this model were provided by the EIA via special request. In addition, the EIA also publishes many of their findings online, including stock, VMT, fuel economy, and fuel consumption by vehicle type and year. These data were compared with the data being calculated by the vehicle stock model for the *Baseline Scenario* to ensure that the model was operating correctly. At each step, the data model outputs were almost exactly the same, varying at most 0.1% from the calculations being made by NEMS. This validation provided confidence that the models were also appropriately estimating fuel consumption in the *Low Petroleum Use Scenario*.

2.4.4 OTHER KEY ASSUMPTIONS

Alternative Fuel Vehicle Costs

The AEO provides cost estimates for every light-duty vehicle type by year for its reference case. These were simply multiplied by the sales data for each vehicle type in order to calculate the total cost of light duty vehicles in the different scenarios. The percent change in total vehicle costs between the *Baseline* and *Low Petroleum Use* scenarios for each year was then calculated.

The process for natural gas vehicles was slightly different. The EIA provides incremental cost estimates of natural gas engines and fuel tanks for medium- and heavy-duty trucks relative to their conventional counterparts, but does not provide cost estimates for those conventional trucks. The modeling team, therefore, did independent research to estimate base truck prices for conventional vehicles by class.[69] With the base and incremental cost estimates, the overall cost of trucks could be calculated for both scenarios. The percentage increase between the *Baseline* and *Low Petroleum Use* scenarios for each year was then calculated. The percentage increases in vehicle costs for light-, medium-, and heavy-duty vehicles were then incorporated into the LIFT model by adjusting the expenditures for new vehicles by households, government, and industries.

Energy Consumption (Fuel Efficiency, VMT)

Just as the EIA does in its Reference Case, this simulation assumes that alternative fuel vehicles of a given vintage and class drive the same amount in a year as their conventional counterparts. This means total VMT are approximately equal across *Baseline* and the *Low Petroleum Use* scenarios. In contrast, VMT does in essence vary across the different oil price simulations. The LIFT model does this by responding to changes in oil prices and economic growth through changes in fuel consumption that reflect changes in travel (VMT) demand. The price-induced effects on fuel consumption are quite small, however, relative to those caused by changes in the use of alternative fuel vehicles and fuel economy.

The model assumes that natural gas trucks achieve the same fuel economy as the diesel trucks that they replace on an energy-equivalent basis. This means that reductions in diesel fuel consumption are offset by equal increases in energy-equivalent natural gas consumption. There is an assumed efficiency gain for light-duty battery electric and plugin electric hybrid vehicles over conventional vehicles. The assumed fuel economy of these vehicles, as well as the percentage of miles driven by plugin hybrids using gasoline versus electricity, are the same as those assumed in the AEO Reference Case.

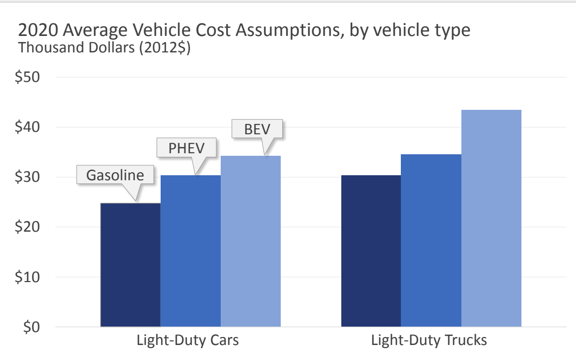
Energy Production (Additional Natural Gas & Electricity, Reduced Oil)

Additional electricity demand, created by the increased use of battery electric and plug-in electric hybrid vehicles in the *Low Petroleum Use Scenario*, was assumed to be met by additional natural-gas power plants, meaning that increased electric vehicles sales decrease petroleum consumption and increase both electricity and natural gas consumption.

Natural gas consumption is further boosted in this scenario because of heavier use in the trucking industry. The increased natural gas demand from both the trucking and electric power industries pushes the price of natural gas higher in this scenario, which is assumed in turn to drive increased domestic production to meet that demand.

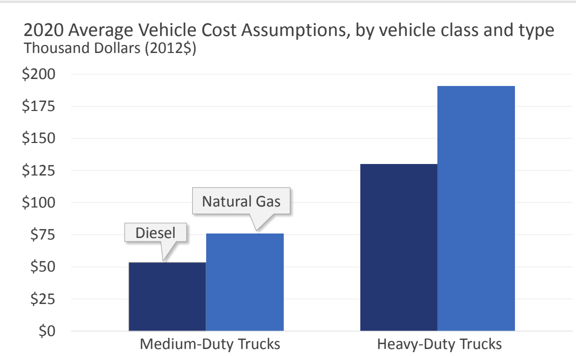
Finally, because real oil prices were assumed to be equal in the *Baseline* and *Low Petroleum Use* scenarios, it was assumed that oil production would be the same across scenarios. Reductions in oil demand in the *Low Petroleum Use Scenario* were therefore assumed to reduce oil imports, but not domestic production.

Figure 14. Light-Duty Vehicle Cost Assumptions



Source: U.S. Energy Information Administration (2013). Annual Energy Outlook, Tables 52.

Figure 15. Medium/Heavy-Duty Vehicle Cost Assumptions



Source: U.S. Energy Information Administration (2013). Annual Energy Outlook, Tables 49.

2.5 Results

2.5.1 RESULTS SUMMARY

Improvements in fuel economy and the increased use of alternative fuel vehicles in the transportation sector are projected to significantly improve the country's economic and budgetary outlooks. In particular, the study finds that in the *Low Petroleum Use Scenario*, as compared to the *Baseline Scenario*:

- The federal budget deficit is $492 billion lower in 2040.
- The federal government accumulates $5.0 trillion less debt over the 2014-2040 period.
- The federal debt-to-GDP ratio is 10.3 percentage points lower in 2040.

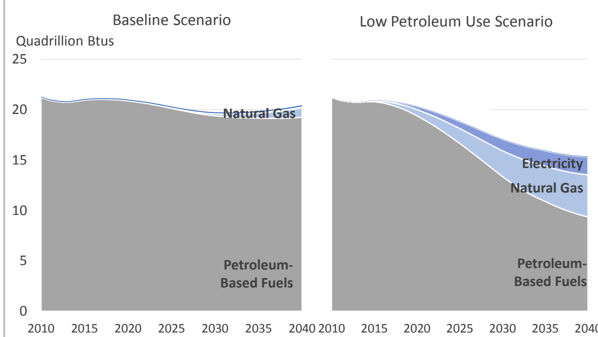
These improved budget outcomes are almost entirely due to indirect impacts on the budget through moderately increased inflation and slightly higher economic growth. Under alternative oil price assumptions, the differences in inflation between scenarios change significantly, but the direction of the impacts on the federal budget and other key economic indicators stay the same.

2.5.2 IMPACTS ON FUEL CONSUMPTION

The key driver of the differences between the *Baseline* and *Low Petroleum Use* scenarios is the different fuel mix used by light-duty vehicles and medium- and heavy-duty freight trucks. As discussed above, the assumptions input to the stock turnover models for the *Low Petroleum Use Scenario* include much higher sales of electric and natural gas vehicles in these two markets than in the *Baseline Scenario*. As the number of these alternative fuel vehicles on U.S. roads grows, the demand for natural gas and electricity from those segments of the transportation sector does too.

Figure 16 shows the fuel use trajectories projected by the stock turnover models for combined light-duty and freight vehicles. In the *Low Petroleum Use Scenario*, these vehicles use just under half of the diesel and gasoline fuels as in the *Baseline Scenario* in 2040. This helps to reduce total transportation sector petroleum usage by 39% and economy-wide petroleum usage by 30% or 9.9 mbd.

Figure 16. Light-duty and Freight Vehicle Fuel Use



Note: "Petroleum-Based Fuels" includes Biofuel Liquids
Source: Calculated by Stock Turnover Models

In contrast, the transportation and electric power sectors use an additional 7.2 quadrillion Btus of natural gas, increasing economy-wide natural gas use by 30% and putting upward pressure on natural gas prices. Indeed, the LIFT model estimates the real natural gas price to be 12% higher in the *Low Petroleum Use Scenario* than in the *Baseline Scenario* in 2040.

2.5.3 THE ECONOMIC AND BUDGETARY IMPACTS OF REDUCED PETROLEUM USE

Indirect Budget Impacts Due to Inflation

As discussed above, petroleum products have played a major role in determining the level of inflation over the past decade. The same is true, though to a lesser extent, of natural gas prices. In Part Two of this analysis, the *Baseline* and *Low Petroleum Use* scenarios differ in the relative importance that oil and natural gas prices have on inflation. By 2040, for example, the relative weight of oil prices in determining GDP inflation is roughly 30% lower in the *Low Petroleum Use Scenario* than in the *Baseline Scenario*, because oil consumption is approximately 30% lower. In contrast, natural gas prices will play a larger role in determining inflation in the *Low Petroleum Use Scenario* because natural gas consumption is higher and because natural gas prices are higher.

In the main scenarios of the prospective analysis – those that use the Baseline oil price trajectory from the 2013 AEO Reference Case – the differences in inflation between the two scenarios is minor. In both scenarios, the oil price increases at almost twice the rate of GDP inflation. While

Table 3: Summary of Part Two Modeling Analysis in 2040

Key Assumption for 2040			
Indicator	Baseline	Low Petroleum Use	Difference
Refiner's Acquisition Crude Price (2011$/barrel)	$166.2	$166.2	-
Henry Hub Natural Gas Price (2011$/tcf)	$7.7	$8.7	+ $1.0
Transportation Petroleum Consumption (Quadrillion Btus)	19.2	9.3	- 9.9
Transportation Electricity Consumption (Quadrillion Btus)	0.04	1.8	+ 1.7
Transportation Natural Gas Consumption (Quadrillion Btus)	0.95	4.2	+ 3.2
Economic Impacts for 2040			
Indicator	Baseline	Low Petroleum Use	Difference
Real Gross Domestic Product (billions of 2011 dollars)	$31,251	$31,399	+ $148
Cumulative Change in GDP Deflator from 2012 to 2040	66.8%	68.9%	+ 2.1%
Total Employment (millions of jobs)	179.0	179.9	+ 0.9
Real Disposable Income (billions of 2011 dollars)	$22,271	$22,357	+ $86
Budget Impacts for 2040			
Indicator	Baseline	Low Petroleum Use	Difference
Federal Revenue Receipts (billions of current dollars)	$13,442	$13,819	+ $378
Federal Expenditures (billions of current dollars)	$13,275	$13,162	- $113
Net Federal Savings (billions of current dollars)	$221	$713	+ $492
Federal Debt in Hands of Public (billions of current dollars)	$33,213	$28,217	- $4,966
Federal Debt-to-GDP Ratio (percent)	62.9%	52.6%	- 10.3%

the impact of this is muted in the *Low Petroleum Use Scenario*, the impact of higher natural gas consumption and higher natural gas prices entirely offsets this to make average annual inflation slightly higher – 0.05% higher – in the *Low Petroleum Use* scenario. Although this difference is minor, accumulated inflation from 2013 to 2040 generates an additional 2% rise in the price level, which in turn causes some significant indirect economic and budgetary outcomes discussed below.

Economic Growth

Increased reliance on alternative fuels and improved fuel economy in the transportation sector is estimated to result

in higher real GDP in the *Low Petroleum Use Scenario* than in the *Baseline Scenario* throughout the projection period.

By 2040, real GDP is estimated to be $148 billion or 0.5% higher in the *Low Petroleum Use Scenario*. Along with higher economic growth, the economy in the *Low Petroleum Use Scenario* is estimated employ 930,000 more Americans by 2040, reducing the unemployment rate by 0.5% as compared to the *Baseline Scenario* economy. One benefit for the federal budget over that period is that unemployment insurance payments are reduced by $6.2 billion in 2040 and $92 billion over the 2014-2040 period.

Government Consumption and Transfer Payments

Aside from reduced unemployment insurance payments and government expenditures on fuel, reduced petroleum usage and the higher economic growth that it brings do not do much else to lower government consumption and transfer payments. Government consumption expenditures in the *Low Petroleum Use Scenario* are $10 billion higher in 2040 and $80 billion higher over the entire period. Total transfer payments from the federal government are estimated to be $84 billion higher in 2040 and $582 billion higher over the entire period. In inflation adjusted terms, these expenditures are estimated to be lower than in the *Baseline Scenario*, indicating that the higher level in nominal terms reflects higher inflation.

Federal Revenues

The most significant impact on the overall federal budget balance is the impact of higher real economic growth and higher inflation in the *Low Petroleum Use Scenario* on revenues. Both forces work in the same direction to boost federal revenues by $378 billion in 2040 and by $4.1 trillion over the entire period. This impact dominates all of the impacts on the spending side of the ledger.

Net Savings and Debt

In sum, the shift to alternative fuel vehicles in the *Low Petroleum Use Scenario* increases government revenues much more than it increases government consumption. The net effect is that government deficits are significantly smaller in that scenario than in the *Baseline Scenario*. By 2040, federal net savings (i.e., the budget balance) are $492 billion higher than in the *Baseline Scenario* and $5.1 trillion higher over the study period. This is mostly due to the addition $4.1 trillion in revenues but also reflects lower overall expenditures thanks to $1.7 trillion of avoided interest payments, which more than offset the inflation-induced government consumption and transfer payment increases. By 2040, the debt is $5.0 trillion lower – $3.2 trillion in today's dollars – and the debt-to-GDP ratio is 10.3 percentage points lower in the *Low Petroleum Use Scenario*.

2.5.4 DIFFERENTIAL IMPACTS UNDER ALTERNATIVE OIL PRICE TRAJECTORIES

The findings are considerably different when these scenarios are modeled under different oil price trajectories. In particular, the impacts on inflation change the results dramatically.

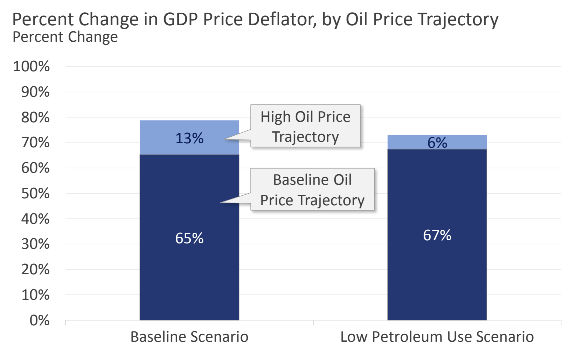
Budget Impacts Under the High Oil Price Trajectory

In the historical analysis above, it was found that lower oil prices would have significantly reduced federal deficits and the accumulation of debt that occurred over the last decade. Similarly, in the simulations that assume higher oil prices in the future, projected deficits are higher – both in the *Baseline Scenario* and the *Low Petroleum Use Scenario*. Interestingly, these simulations find that deleterious effects of higher oil prices on the federal budget are actually worse in the *Low Petroleum Use Scenario* than in the *Baseline Scenario*.

This is because oil prices drive larger increases in inflation in the *Baseline Scenario* (13.4%) than in the in the *Low Petroleum Use Scenario* (5.6%). This means that the effect of reducing the relative size of the debt – "inflating the debt away" – is larger in the *Baseline Scenario* than in the *Low Petroleum Use Scenario*. Despite this, the 2040 debt-to-GDP ratio is still far lower in the *Low Petroleum Use Scenario* (60.4%) than in the *Baseline Scenario* (68.4%).

Additionally, even though the higher oil prices mute the benefit of the reduced petroleum use on the debt-to-GDP ratio – an 8.0 percentage point difference as compared to 10.3 percentage points when the Baseline oil price trajectory is used – the benefit to the overall economy of reduced petroleum fuel usage is enhanced. Real GDP is estimated to be $250 billion (or 0.8%) higher in the *Low Petroleum Use Scenario* than in the *Baseline Scenario* when the higher oil price trajectory is used, as compared to $150 billion (0.5%) when the Baseline oil price trajectory was used. Reduced petroleum usage and stronger economic growth are also estimated to result in 1.18 million more

Figure 17. Cumulative GDP Inflation (2013-2040)



jobs by 2040 when higher oil prices are assumed, as compared to 930,000 jobs when lower prices are used.

Budget Impacts Under the Volatile Oil Price Trajectory

The *Baseline* and *Low Petroleum Use* scenarios were also simulated using a more volatile oil price trajectory in which oil prices are primarily equivalent to Baseline oil prices except for dramatic but temporary oil price shocks in 2023 and 2033. This volatility increases the federal government's long-term debt in 2040 in both scenarios relative to the scenarios using Baseline oil prices, but the added volatility only increases the debt-to-GDP ratio in the *Baseline Scenario*.

In that scenario, federal deficits temporarily surge during oil-price induced recessions in 2023 and 2033. This fall in real GDP dramatically reduces the growth of government tax revenues from 2022 to 2023 — in real terms, revenues fall by 1.9% over this period. At the same time, the recession increases government expenditures in nominal terms. In real terms, expenditures still grow by 2.7% that year, which is average for the study period.

In the years after recessions, oil prices fall back toward baseline prices and federal revenues surge as the economy experiences booming recoveries while the growth in expenditures retreats. In the *Baseline Scenario*, however, this recovery is not enough to offset the increased deficits during the recessions, which leads to increased interest payments and by 2040 a somewhat higher (0.5%) debt-to-GDP ratio than the ratio estimated using Baseline oil prices. In the *Low Petroleum Use* Scenario, the impacts of oil price volatility are similar, except the net impacts of the recessions and recoveries offset each other enough to eliminate the impact of the oil price volatility on the debt-to-GDP ratio, showing that reduced petroleum use helps insulate the federal budget against oil price shocks.

When comparing the net fiscal outcomes of the *Baseline* and *Low Petroleum Use* scenarios under this volatile oil price trajectory, the differences in the budget impacts are very similar to those estimated using the Baseline oil price trajectory. By 2040, the accumulated federal debt is $4.7 trillion ($3.4 trillion in 2011$) lower in the *Low Petroleum Use Scenario* than in the *Baseline Scenario*. As a result, the debt-to-GDP ratio is 10.9 percentage points lower in the *Low Petroleum Use Scenario* (52.5%) than in the Baseline scenario (63.4%).

Discussion

Economic researchers commonly identify reduced economic growth, current account deficits, weakened national security, and environmental harm as negative consequences of the nation's oil dependence. Missed in these discussions, however, is the relationship between oil prices, U.S. oil dependence, and the U.S. federal budget. The results of the analyses in this report identify oil prices and dependence as meaningful contributors to both the current fiscal imbalance and the worrisome federal budget outlook.

The results of Part One indicate that U.S. dependence on oil played a significant role in the doubling of government debt as a percentage of GDP. This comes about through the direct and indirect impacts of the quadrupling of oil prices over the past decade. While the impact of and policy responses to the Great Recession of 2008-2009 were the salient fiscal drivers over this time, the impact of rising oil prices are estimated to account for $1.2 trillion of the increased debt stock. As such, this analysis suggests that had oil prices not increased faster than the prices of other goods and services in the period of 2002-12, the current debt-to-GDP ratio would have been about 6.6 percentage points lower than it was at the end of 2012.

The results of Part Two suggest that reducing the United States' oil dependence in the future would improve the federal budget outlook. The analysis finds that greater use of alternative fuel vehicles and improved fuel economy would reduce future federal deficits, resulting in a reduced debt burden in 2040 of $5.0 trillion ($3.2 trillion in $2011) when using the Baseline oil price trajectory. This lowers the debt-to-GDP ratio in 2040 by 10.3 percentage points.

With the federal government reaching a debt ceiling of $16.7 trillion on May 19, 2013 and a forecast by the Congressional Budget Office that the federal debt will reach $31.4 trillion (in $2011) in 2040 under current policy, it is clear that oil prices and oil dependence are not the primary drivers of this debt.[70] However, the fiscal impacts of oil prices and dependence are significant, and would smartly be considered in policy decisions regarding strategies to reduce the nation's debt. For example, the estimated contribution of oil prices to the current debt is larger than the combined projected deficits for the next two fiscal years, FY2014 and FY2015 ($0.9 trillion); and the reduction in projected debts from 2014 to 2040 due to increased use of alternative fuel vehicles and improved fuel economy is similar in magnitude to eliminating projected deficits for FY2014 to FY2019 (a total of $2.9 trillion).[71]

In coming years, high oil prices will be one of the factors that continue to encourage a larger market share for electric and natural gas vehicles. Higher oil prices will also spur the development and use of other technologies that provide alternatives to petroleum fuels. However, most of these technologies still face hurdles that can impede them from gaining wider use. Public policies can play a constructive role in removing or reducing those hurdles and moving the United States toward an economy that is less dependent on petroleum. In addition to the immediate fiscal costs and other economic, environmental, and security impacts of petroleum dependence, policymakers should consider the potential short-and long-term fiscal benefits of reducing petroleum use in their decisions.

Appendix

APPENDIX A: THE INFORUM LIFT MODEL OF THE U.S. ECONOMY

The Inforum LIFT (Long-term Interindustry Forecasting Tool) model is unique among large-scale models of the U.S. economy. Combining an interindustry (input-output) formulation with extensive use of regression analysis, it employs a "bottom-up" approach to macroeconomic modeling. For example, aggregate investment, total exports, and employment are not determined directly, but are computed by the sum of their parts: investment by industry, exports by commodity, and employment by industry. Indeed, LIFT contains full demand and supply accounting for 97 productive sectors.

In short, the demand/production block of LIFT uses econometric equations to predict the behavior of real final demand (consumption, investment, imports, exports, government) at a detailed level. Then, the detailed predictions for demand are used in input-output production identity to generate gross output (total revenue adjusted for inflation). LIFT's approach to projecting industry prices is similar. Behavioral equations estimate each value-added component (e.g., compensation, profits, interest, rent, indirect taxes) for each industry. Value added per unit of output is then combined with the prices of intermediate goods and services with the input-output price identity to form an indicator for industry prices. Prices by industry are also dependent on measures of slack in each industry, and, in some cases, international prices. Thus, income and prices are directly related and are consistent. In turn, relative price terms and income flows are included as independent variables in the regression equations for final demand, creating a simultaneity between final demand and value-added.

This bottom-up technique possesses several desirable properties for analyzing the economy. First, the model works like the actual economy, building the macroeconomic totals from details of industry activity, rather than distributing predetermined macroeconomic quantities among industries. Second, the model describes how changes in one industry, such as increasing productivity or changing international trade patterns, affect related sectors and the aggregate quantities. Third, parameters in the behavioral equations differ among products, reflecting differences in consumer preferences, price elasticities in foreign trade, and industrial structure. Fourth, the detailed level of disaggregation permits the modeling of prices by industry, allowing one to explore the causes and effects of relative price changes.

Despite its industry basis, LIFT is a full macroeconomic model, with more than 800 macroeconomic variables determined consistently with the underlying industry detail. This macroeconomic "superstructure" contains key functions for household savings behavior, interest rates, exchange rates, unemployment, taxes, government spending, and current account balances. Like in an aggregate macroeconomic model, this structure insures that LIFT exhibits "Keynesian" demand driven behavior over the short-run, but neoclassical growth characteristics over the longer term. For example, while monetary and fiscal policies and changes in exchange rates can affect the level of output in the short-to-intermediate term, in the long term, supply forces -- available labor, capital and technology -- will determine the level of output.

Another important feature of the LIFT model is the importance given to the dynamic determination of endogenous variables. For example, investment depends on a distributed lag in the output growth of investing industries and imports and exports depend on a distributed lag of foreign price changes. Therefore, LIFT model solutions are not static, but are fully capable of projecting a time path for the endogenous quantities.

Finally, the LIFT model is linked to other, similar models with the Inforum Bilateral Trade Model (BTM). Countries included in this system include the U.S., Japan, China, and the major European economies. Through this system, sectoral exports and imports of the U.S. economy respond to sectoral level demand and price variables projected by models of U.S. trading partners. In summary, the LIFT model is particularly suited for examining and assessing the macroeconomic and industry impacts of the changing

composition of consumption, production, foreign trade, and employment as the economy grows through time.

The current model is the fourth discrete version of a modeling framework that has been in continuing existence since 1967. Since its inception, LIFT has continued to develop and change. We have learned more about the properties of the model through working with clients, and in doing our own simulation tests. We have learned about the behavior of the general Inforum type of model, from work with our partners in other countries. Finally, through many experiments, we have learned that many principles of economics, while attractive theoretically, are difficult to implement practically. We will continue to experiment, and share ideas, and bring the models closer to our vision of what they should be. A detailed description of the LIFT model can be found at: http://inforumweb.umd.edu/services/models/lift.html.

APPENDIX B: DATA TABLES

Table B.1: Part 1 *Baseline* and *Low Oil Price Alternative* Scenarios

Line 1 (grey): Value in Baseline Scenario

Line 2 (white): Change in Low Oil Price Scenario

Description	Units	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ENERGY PRICES												
Crude Oil Price	$/barrel	25	30.2	39.5	53.6	63.4	70.5	99.7	60.2	78.9	99.5	99.5
			23.2	24.8	28.5	29.4	29.1	37.2	20.6	25	29.4	27.7
Natural Gas Price	$/tcf	3.4	5.6	6.2	8.4	7.3	7.1	9.1	4.2	4.8	4.4	2.9
			5.6	6.2	8.4	7.3	7.1	9	4.1	4.7	4.3	2.8
ECONOMIC IMPACTS (Percent Change)												
GDP	billion 2005$	11,543	11,836	12,247	12,623	12,959	13,206	13,162	12,758	13,063	13,299	13,589
			0.2	0.4	0.6	0.7	0.8	0.9	0.9	1	11	11
GDP Deflator	index	92.2	94.1	96.8	100	103	106	109	110	111	113	116
			-0.1	-0.3	-0.5	-0.8	-11	-14	-17	-2	-2.3	-2.6
Personal Consumption Expenditures	billion 2005$	8,018	8,245	8,516	8,804	9,055	9,263	9,212	9,033	9,196	9,429	9,604
			0.3	0.6	0.7	0.9	1	12	13	14	15	16
PCE Deflator	index	92.8	94.7	97.1	100	103	106	109	109	111	114	116
			-0.3	-0.7	-11	-15	-19	-2.4	-2.8	-3.2	-3.6	-4
Trade Balance	billion 2005$	-427	-504	-619	-723	-769	-713	-710	-389	-512	-568	-568
			22	49	85	121	155	188	156	202	242	263
Disposable Income	billion 2005$	8,633	8,851	9,153	9,277	9,653	9,880	10,120	9,837	10,017	10,150	10,416
			0.3	0.6	0.9	11	13	15	17	18	2	2.1
Employment	million jobs	144	144	146	148	151	152	151	145	144	145	148
			0.1	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.8	0.9
NET BUDGET IMPACTS												
Net Federal Lending	billion 2005$	-278	-422	-27	-353	-247	-315	-756	-1,457	-1,490	-1,394	-1,178
			16.2	37	59.7	81.6	104	122	150	187	212	235
Federal Public Debt	billion 2005$	-452	-516	-625	-741	-798	-716	-679	-382	-449	-466	-480
			22.2	47.3	88.3	136	181	220	189	238	282	309
Debt-to-GDP Ratio	percent	33.3	35.1	36.2	36.4	36.1	35.9	40.6	54	62.2	67.2	71.6
			-0.2	-0.5	-0.9	-14	-2	-2.7	-3.7	-4.7	-5.7	-6.6
FEDERAL REVENUES & EXPENDITURES												
Total Receipts	billion dollars	1,859	1,885	2,014	2,290	2,525	2,655	2,502	2,226	2,395	2,520	2,699
			9.3	18.8	29.6	36.1	37.9	33	26.2	32.6	36.8	45.9
Current tax receipts	billion dollars	1,074	1,070	1,154	1,384	1,558	1,638	1,448	1,164	1,310	1,503	1,716
			8.4	16.5	27	34	36.9	33.1	28	36.2	42.1	52.8
Personal current taxes	billion dollars	829	774	799	932	1,050	1,166	1,101	857	894	1,075	1,162
			3.7	7.7	12.3	16.6	21.2	22.8	19.6	22.3	28.8	33.2
Taxes on production & imports	billion dollars	87	89	94	99	99	95	94	91	95	107	113
			-0.2	-0.3	-0.7	-11	-14	-17	-2.1	-2.6	-3.3	-3.9
Taxes on corporate income	billion dollars	151	198	250	341	395	363	234	200	305	304	424
			4.8	9.2	15.4	18.6	17.3	12.4	10.8	16.9	17.1	24.1
Contributions for social insurance	billion dollars	739	763	808	853	905	945	973	949	970	906	872
			0.9	2.4	2.8	2.3	14	0.4	-11	-2.8	-4.3	-5.9
Total Expenditures	billion dollars	2,112	2,262	2,393	2,573	2,728	2,900	3,116	3,456	3,703	3,757	3,767
			-6.7	-17.7	-29.8	-44.7	-65.5	-87.9	-122	-152	-173	-187
National defense	billion dollars	381	435	481	515	544	575	633	664	703	712	713
			-17	-3.9	-6.4	-9.2	-12.2	-15.7	-18.9	-22.5	-25.4	-28
National non-defense	billion dollars	210	225	240	251	267	274	299	323	353	349	355
			-0.1	-0.3	-0.6	-1	-16	-2.3	-3.2	-4.4	-5.2	-6.1
Transfer payments	billion dollars	1,252	1,339	1,405	1,491	1,587	1,690	1,842	2,157	2,311	2,309	2,334
			-4.4	-10.6	-16.2	-23.1	-32.1	-45.4	-73.1	-90	-95.9	-103
Old age benefits	billion dollars	447	464	486	513	544	576	606	665	690	713	760
			-0.9	-2.1	-3.8	-6	-8.7	-11.7	-15.7	-19.2	-22.9	-27.6
Unemployment benefits	billion dollars	54	53	36	32	30	33	51	131	139	108	85
			-14	-2.9	-3.1	-3	-3.6	-6.7	-19.3	-22.4	-18.6	-15.6
Interest Payments	billion dollars	229	213	221	255	279	313	292	253	281	325	304
			-0.5	-2.7	-6.1	-11.2	-18.9	-23.8	-25.7	-34	-45.5	-48.5

Table B.2: Part 2 Scenario Comparison – Baseline Oil Price Trajectory
Line 1 (grey): Value in Baseline Scenario
Line 2 (white): Change in Low Oil Price Scenario

Description	Units	2010	2015	2020	2025	2030	2035	2040
ENERGY PRICES								
Crude Oil Price	$/barrel	81.5	96.0	106.3	120.2	134.7	149.8	166.2
		-	-	-	-	-	-	-
Natural Gas Price	$/tcf	4.84	3.56	4.54	5.18	5.62	6.46	7.69
		0.01	-0.02	0.12	0.39	0.64	0.83	0.95
TRANSPORTATION SECTOR ENERGY CONSUMPTION								
Petroleum Liquid Fuels	Quadrillion	26.78	26.36	26.41	25.84	25.17	24.97	25.15
		-	-0.25	-1.75	-3.72	-6.10	-8.03	-9.26
Electricity	Quadrillion	0.02	0.02	0.03	0.04	0.04	0.05	0.06
		-	0.02	0.30	0.68	1.12	1.48	1.73
Natural Gas (Direct Use)	Quadrillion	0.04	0.06	0.08	0.12	0.26	0.60	1.05
		-	0.00	0.52	1.30	2.23	2.80	2.94
Natural Gas (Indirect Use via	Quadrillion	0.05	0.06	0.07	0.08	0.10	0.12	0.15
		-	0.06	0.79	1.79	2.78	3.67	4.27
ECONOMIC IMPACTS								
GDP	billion	14,871	16,701	19,157	21,687	24,072	27,166	31,251
			13.4	16.7	77.8	88.1	112.7	147.7
GDP Deflator	index	97.7	104.8	113.8	124.6	136.7	151.7	169
			-0.1	0	0.3	1	1.5	2
Trade Balance	billion	-479	-420	-21	438	839	1,227	2,153
			-6.7	-10.1	-24.4	-29	-26.6	-40.5
Disposable Income	billion	11,433	12,434	14,106	15,848	17,440	19,588	22,272
			9.3	-4.5	64.8	67.7	77.5	86
Employment	million jobs	139.1	147.6	155.5	160.5	165	171.6	179
			0.2	0.2	0.7	0.7	0.8	0.9
NET BUDGET IMPACTS								
Net Federal Lending	billion	-1,274	-803	-659	-500	-318	-128	221
			20.7	52	120.4	204.5	326.8	491.8
Federal Public Debt	billion	9,233	14,247	17,281	19,216	20,321	20,342	19,653
			-33	-208	-605	-1258	-2108	-3152
Debt-to-GDP Ratio	percent	62.1	85.3	90.2	88.6	84.4	74.9	62.9
			-0.3	-1.2	-3.1	-5.5	-8	-10.3
FEDERAL REVENUES & EXPENDITURES								
Total Receipts	billion	2,408	3,503	4,834	6,441	8,362	10,596	13,442
			15.7	39.7	97	172.8	266.2	377.7
Current tax receipts	billion	1,341	2,184	3,164	4,358	5,795	7,421	9,428
			13.8	37.4	80.9	144	222	314
Personal current taxes	billion	896	1,592	2,473	3,502	4,777	6,140	7,792
			14.2	38.2	87.3	149	224	316
Taxes on production & imports	billion	102	127	163	213	265	343	453
			0	0.6	2.2	4.4	7.2	10.5
Taxes on corporate income	billion	330	448	507	617	720	896	1,130
			-0.4	-1.3	-8.6	-8.6	-9.1	-12.1
Contributions for social	billion	966	1,198	1,526	1,914	2,366	2,935	3,727
			1.8	2.3	16.1	28.4	44.4	63.7
Total Expenditures	billion	3,703	4,332	5,521	6,973	8,716	10,764	13,275
			-5	-12.2	-23	-31.6	-60.4	-113
Government Consumption	billion	1,054	1,098	1,207	1,336	1,492	1,675	1,887
			-0.9	-0.5	0	3.8	7.6	10.3
Transfer payments	billion	2,314	2,526	3,311	4,427	5,847	7,552	9,716
			-3.2	-3.2	3.2	25	52.4	84.9
Old age benefits	billion	690	904	1,218	1,635	2,142	2,686	3,262
			-1.2	-2.2	-3.8	0	3.5	5.8
Unemployment benefits	billion	139	45	41	43	54	66	80
			-0.8	-0.8	-3.7	-3.9	-4.7	-6.2
Interest Payments	billion	280	643	928	1,124	1,276	1,419	1,534
			-0.9	-8.4	-26	-60.4	-121	-209

Table B.3: Part 2 Scenario Comparison – High Oil Price Trajectory
Line 1 (grey): Value in Baseline Scenario
Line 2 (white): Change in Low Oil Price Scenario

Description	Units	2010	2015	2020	2025	2030	2035	2040
ENERGY PRICES								
Crude Oil Price	$/barrel	81.5	113.5	167.1	215.2	239.1	264.2	291.0
		-	-	-	-	-	-	-
Natural Gas Price	$/tcf	4.84	3.54	4.41	4.90	5.27	6.02	7.11
		0.01	0.01	0.25	0.63	0.88	1.08	1.25
TRANSPORTATION SECTOR ENERGY CONSUMPTION								
Petroleum Liquid Fuels	Quadrillion	26.8	26.2	25.9	25.1	24.5	24.3	24.4
		-	-0.06	-1.26	-2.99	-5.43	-7.36	-8.57
Electricity	Quadrillion	0.02	0.02	0.03	0.04	0.04	0.05	0.06
		-		0.29	0.68	1.12	1.48	1.72
Natural Gas (Direct Use)	Quadrillion	0.04	0.06	0.07	0.12	0.25	0.58	1.03
		-	0.01	0.51	1.31	2.23	2.79	2.93
Natural Gas (Indirect Use via	Quadrillion	0.05	0.06	0.07	0.08	0.10	0.12	0.14
		-	0.00	0.78	1.80	2.77	3.57	4.26
ECONOMIC IMPACTS								
GDP	billion	14,871	16,637	19,129	21,449	23,897	27,026	31,125
			80.4	67.8	299	252.9	279.7	317.6
GDP Deflator	index	97.7	106	117	132	146	163	183
			-0.8	-3.4	-5.9	-5.5	-5.3	-6.1
Trade Balance	billion	-479	-405	-55	370	704	1,026	1,867
			-18.8	32.9	65.2	122	190	263
Disposable Income	billion	11,434	12,367	14,129	15,714	17,384	19,638	22,423
			74.4	-34.7	132	78.2	30.9	-37.2
Employment	million jobs	139	147	156	159	164	171	179
			0.8	0.3	2.1	1.6	1.3	1.3
NET BUDGET IMPACTS								
Net Federal Lending	billion	-1,274	-835	-729	-708	-542	-417	-165
			37.6	68.5	194.5	210	294.6	400
Federal Public Debt	billion	9,233	14,220	17,070	19,057	20,605	21,238	21,291
			39.5	188.6	-19	-694.2	-1,489.90	-2,304.50
Debt-to-GDP Ratio	percent	62.1	85.5	89.2	88.9	86.2	78.6	68.4
			-0.2	0.7	-1.3	-3.8	-6.3	-8
FEDERAL REVENUES & EXPENDITURES								
Total Receipts	billion	2,408	3,495	4,917	6,632	8,702	11,098	14,173
			10.1	-71.3	-115	-141	-138	-193
Current tax receipts	billion	1,341	2,179	3,222	4,495	6,043	7,786	9,959
			5.4	-51.7	-90.6	-113	-113	-160
Personal current taxes	billion	896	1,586	2,522	3,623	4,986	6,455	8,258
			7.2	-44.9	-76.8	-87.7	-92.6	-141
Taxes on production & imports	billion	102	128	170	226	284	372	494
			-0.1	-2.3	-2.5	-1.1	1.2	2.7
Taxes on corporate income	billion	330	448	508	620	740	918	1,154
			-1.7	-4.5	-11.4	-23.9	-21.7	-21.4
Contributions for social	billion	966	1,195	1,552	1,967	2,458	3,071	3,927
			4.7	-19.6	-25.1	-29	-25.6	-33.8
Total Expenditures	billion	3,703	4,356	5,674	7,372	9,281	11,556	14,392
			-27.4	-140	-310	-351	-433	-593
Government Consumption	billion	1,054	1,104	1,238	1,403	1,578	1,783	2,022
			-7	-32.7	-63.5	-72.1	-81.9	-101
Transfer payments	billion	2,314	2,540	3,393	4,673	6,202	8,047	10,420
			-15.8	-75.7	-188	-197	-207	-258
Old age benefits	billion	690	911	1,250	1,730	2,275	2,861	3,490
			-7.1	-28.1	-69.5	-73.1	-75	-88
Unemployment benefits	billion	139	48	42	53	62	72	86
			-3.5	-2.5	-12.6	-10.8	-10.4	-11.4
Interest Payments	billion	280	647	966	1,205	1,393	1,600	1,802
			-4.1	-29.8	-54.7	-78.9	-141	-230

Table B.4: Part 2 Scenario Comparison – Volatile Oil Price Trajectory
Line 1 (grey): Value in Baseline Scenario
Line 2 (white): Change in Low Oil Price Scenario

Description	Units	2010	2015	2020	2025	2030	2035	2040
ENERGY PRICES								
Crude Oil Price	$/barrel	81.5	96.0	106.3	168.0	134.7	204.3	166.2
		-	-	-	-	-	-	-
Natural Gas Price	$/tcf	4.84	3.55	4.54	5.06	5.57	6.28	7.61
		0.00	-0.01	0.12	0.35	0.62	0.76	0.92
TRANSPORTATION SECTOR ENERGY CONSUMPTION								
Petroleum Liquid Fuels	Quadrillion	26.8	26.3	26.4	25.6	25.2	24.7	25.2
		-	-0.23	-1.74	-3.74	-6.13	-8.02	-9.31
Electricity	Quadrillion	0.02	0.02	0.03	0.04	0.04	0.05	0.06
		-		0.30	0.69	1.11	1.48	1.73
Natural Gas (Direct Use)	Quadrillion	0.04	0.06	0.08	0.12	0.26	0.60	1.05
		-	0.00	0.52	1.32	2.23	2.79	2.93
Natural Gas (Indirect Use via	Quadrillion	0.05	0.06	0.07	0.08	0.10	0.12	0.15
		-	0.00	0.80	1.81	2.93	3.88	4.56
ECONOMIC IMPACTS								
GDP	billion	14,874	16,699	19,165	21,959	24,065	27,414	31,234
			13.6	11.0	102	43.9	5.8	86.8
GDP Deflator	index	97.7	105	114	128	138	156	171
			-0.2	0	1.1	1.4	2.7	2.6
Trade Balance	billion	-479	-419	-22	284	810	1,029	2,107
			-5.9	-7.6	-48	-26.2	-22.7	-39.7
Disposable Income	billion	11,436	12,432	14,114	16,174	17,444	19,931	22,285
			7.4	-13.4	151	30	74.6	46.3
Employment	million jobs	139	148	156	164	165	175	179
			0.2	0.2	1.3	0.5	0.3	0.7
NET BUDGET IMPACTS								
Net Federal Lending	billion	-1,274	-806	-660	-432	-330	-45	199
			22.6	53.1	132	209	299	512
Federal Public Debt	billion	9,235	14,243	17,279	18,850	20,333	20,010	19,790
			-25.5	-203.6	-736.7	-1,336.00	-2,296.80	-3,358.40
Debt-to-GDP Ratio	percent	62.1	85.3	90.2	85.8	84.5	73.0	63.4
			-0.2	-1.1	-3.7	-5.7	-8.4	-10.9
FEDERAL REVENUES & EXPENDITURES								
Total Receipts	billion	2,408	3,505	4,839	6,696	8,417	11,017	13,550
			13.6	35.8	156	180	300	395
Current tax receipts	billion	1,341	2,186	3,168	4,535	5,826	7,723	9,496
			12.2	34.8	120	150	244	329
Personal current taxes	billion	896	1,593	2,476	3,691	4,812	6,469	7,856
			12.6	35.5	138	150	262	325
Taxes on production & imports	billion	102	127	164	222	267	357	457
			-0.1	0.5	3.4	4.6	7.5	10.8
Taxes on corporate income	billion	330	448	507	596	714	854	1,131
			-0.3	-1.1	-21.5	-4.9	-25.2	-6.5
Contributions for social	billion	966	1,199	1,528	1,990	2,390	3,054	3,767
			1.3	1	36.3	30.2	55.8	65.9
Total Expenditures	billion	3,703	4,336	5,528	7,163	8,784	11,109	13,405
			-9	-17.2	26.1	-28.7	1.5	-116
Government Consumption	billion	1,054	1,099	1,209	1,368	1,508	1,723	1,913
			-1.9	-2.6	4.8	1.3	10.3	2.5
Transfer payments	billion	2,314	2,529	3,315	4,523	5,915	7,765	9,834
			-5.7	-5.9	37.5	38.1	121	103
Old age benefits	billion	690	905	1,219	1,668	2,160	2,749	3,291
			-2	-2.8	3.9	5.2	18.3	13.2
Unemployment benefits	billion	139	46	41	28	55	49	81
			-1	-0.8	-6.4	-2.5	-1.8	-4.6
Interest Payments	billion	280	644	929	1,184	1,260	1,500	1,519
			-1.2	-8.5	-16.4	-68.4	-131	-223

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Endnotes

[1] Haver Analytics. Accessed 9/16/13.
[2] See, e.g., U.S. Department of Energy, Annual Energy Outlook 2013, Table A.11.
[3] Congressional Budget Office (August 2013). Historical Budget Data. Table 1. Available at https://www.cbo.gov/publication/44507.
[4] Congressional Budget Office (August 2013). Historical Budget Data. Table 1. Available at https://www.cbo.gov/publication/44507.
[5] Congressional Budget Office (August 2013). Historical Budget Data. Table 1. Available at https://www.cbo.gov/publication/44507.
[6] Congressional Budget Office (August 2013). Historical Budget Data. Table 1. Available at https://www.cbo.gov/publication/44507.
[7] Congressional Budget Office (September 2013). The 2013 Long-Term Budget Outlook. Table 1. Available at http://www.cbo.gov/publication/44521.
[8] Congressional Budget Office (September 2013). The 2013 Long-Term Budget Outlook. Table 1. Available at http://www.cbo.gov/publication/44521.
[9] U.S. Energy Information Administration. Petroleum & Other Liquids Data, Product Supplied. Available at http://www.eia.gov/dnav/pet/pet_cons_psup_dc_nus_mbblpd_a.htm.
[10] U.S. Energy Information Administration (August 2013). Monthly Energy Review, Table 3.1. Available at http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf.
[11] U.S. Energy Information Administration (August 2013). Monthly Energy Review, Table 3.1. Available at http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf.
[12] U.S. Energy Information Administration (2013). Petroleum & Other Liquids Data, Cushing, OK WTI Spot Price FOB. Available at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rwtc&f=a; Census Bureau. U.S. International Trade in Goods and Services, Exhibit 9. Available at http://www.census.gov/foreign-trade/Press-Release/current_press_release/#ft900.
[13]. Census Bureau. Historical Statistics, U.S. Imports of Crude Oil. Available at http://www.census.gov/foreign-trade/statistics/historical/petr.pdf.
[14] Consumption includes all liquid fuels. Production includes all liquid sources other than biofuels because 2002 data were not available. U.S. Energy Information Administration (August 2013). Monthly Energy Review, Table 3.1. Available at http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_3.pdf.
[15] U.S. Energy Information Administration (2013). Annual Energy Outlook., Table 1. Available at http://www.eia.gov/forecasts/aeo/data.cfm#summary.
[16] U.S. Energy Information Administration (2013). Annual Energy Outlook, Table 2. Available at http://www.eia.gov/forecasts/aeo/data.cfm#summary.
[17] Hamilton, James D. "Historical Oil Shocks." Prepared for the *Handbook of Major Events in Economic History.* Available at http://dss.ucsd.edu/~jhamilto/oil_history.pdf.
[18] Census Bureau. U.S. Trade in Goods and Services (FT900), Exhibit 9. Available at http://www.census.gov/foreign-trade/Press-Release/current_press_release/ft900.pdf
[19] U.S. Department of Energy (2013). Available at http://www.fueleconomy.gov/feg/bifueltech.shtml#3.
[20] Non-Defense federal petroleum consumption is obtained from: U.S. Energy Information Administration (2012). 2012 Annual Energy Review. Table 1.12; Non-defense petroleum spending assumes average annual price: U.S. Energy Information Administration (2013). Petroleum and Other Liquids Spot Prices. Available at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=A.
Defense spending estimates: Defense Logistics Agency Energy (2012). Fact Book. P.32. Available at http://www.energy.dla.mil/library/Documents/Fact%20Book%20Fiscal%20Year%202012.pdf; Congressional Research Service (September 2009). Department of Defense Spending, Supply, Acquisition, and Policy. Table 1. Available at http://www.fas.org/sgp/crs/natsec/R40459.pdf.
[21] U.S. Energy Information Administration (2012). 2012 Annual Energy Review. Table 1.12.
[22] U.S. Energy Information Administration (2012). 2012 Annual Energy Review. Table 1.12.

23 Third Way (February 2013). Fuel Costs Squeeze Defense Budget. Available at http://content.thirdway.org/publications/530/Third_Way_Digest_-_Fuel_Costs_Squeeze_Defense_Budget.pdf.

24 Id.

25 U.S. Energy Information Administration (2013). Table: Cushing, OK WTI Spot Price FOB. Available at http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rwtc&f=a.

26 Office of Natural Resources Revenue. Statistical Information. Available at http://statistics.onrr.gov/ReportTool.aspx

27 Bureau of Economic Analysis (August 2013). National Income and Product Accounts Tables. Tables 6.18D & 6.19D. See http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&903=251.

28 FHWA (2011). Available at http://www.fhwa.dot.gov/policyinformation/pubs/hf/pl11028/chapter6.cfm.

29 Bureau of Labor Statistics (August 2013). Consumer Price Index – July 2013. Table 1. Available at http://www.bls.gov/news.release/pdf/cpi.pdf.

30 Bureau of Labor Statistics (2013). Urban Wage Earners and Clerical Workers (current series). Series IDs CWSR0000SA0LE and CWSR0000SA0. Available at http://www.bls.gov/cpi/#data.

31 Greene et al. (2013). OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010. P.8. The Baker Center for Public Policy. Available at http://bakercenter.utk.edu/wp-content/uploads/2013/02/OilDependenceCosts2010-New-Cover021413.pdf

32 Greene et al. (2013). OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010. P.1. The Baker Center for Public Policy. Available at http://bakercenter.utk.edu/wp-content/uploads/2013/02/OilDependenceCosts2010-New-Cover021413.pdf

33 CBO (May 2012). "Energy Security in the United States." P. 4. Available at http://www.cbo.gov/sites/default/files/cbofiles/attachments/05-09-EnergySecurity.pdf

34 The Atlantic (2012). "The $110 Effect: What Higher Gas Prices Could Really do to the Economy." Available at http://www.theatlantic.com/business/archive/2012/03/the-110-effect-what-higher-gas-prices-could-really-do-to-the-economy/254386/; Oil Prices and the U.S. Economy: Some Rules of Thumb. Available at http://www.ihs.com/products/global-insight/industry-economic-report.aspx?id=1065929077; "Macroeconomic and Industrial Effects of Higher Oil and Natural Gas Prices." Available at http://www.esa.doc.gov/sites/default/files/reports/documents/energy_report_web_version3.pdf (Note: This study models the combined effects of increased oil and natural gas prices); The Joint Economic Committee (2008). "High Oil Prices have Significant Effects on Consumers and the U.S. Economy." Available at http://www.jec.senate.gov/archive/Documents/Reports/Oil%20Fact%20Sheet%2002%2027%2008.pdf, See also http://www.gao.gov/new.items/d06872.pdf, p. 58.

35 Hamilton, James D. (2005). Oil and the Macroeconomy. P. 1. Available at http://dss.ucsd.edu/~jhamilto/JDH_palgrave_oil.pdf.

36 Hamilton, James D. (2009). Causes and Consequences of the Oil Shock of 2007-08. P.1. Available at http://www.brookings.edu/~/media/files/programs/es/bpea/2009_spring_bpea_papers/2009a_bpea_hamilton.pdf.

37 As in an aggregate macroeconomic model, this structure ensures that LIFT exhibits "Keynesian," demand-driven behavior over the short run but neoclassical growth characteristics over the longer term.

38 A detailed description of the LIFT model can viewed at: www.inforum.umd.edu/papers/wp/wp/2001/wp01002.pdf.U5T

39 The model simulations use older data that estimated the debt to GDP ratio to be 71.6% rather thatn the current estimate of 70.1%.

40 U.S. Energy Information Administration (August 2013). Monthly Energy Review. Table 3.3a. Available at http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_7.pdf.

41 U.S. Energy Information Administration (September 2013). Short Term Energy Outlook. Table 4a. Available at http://www.eia.gov/forecasts/steo/

42 U.S. Energy Information Administration (August 2013). Monthly Energy Review. Table 3.5. Available at http://www.eia.gov/totalenergy/data/monthly/pdf/sec3_15.pdf.

43 U.S. Energy Information Administration (2013). Annual Energy Outlook. Figure 93.

44 U.S. Energy Information Administration (2013). Annual Energy Outlook. Figure 93.

45 U.S. Energy Information Administration (2013). Annual Energy Outlook. Table 37. Available at http://www.eia.gov/forecasts/aeo/data.cfm#summary

46 U.S. Energy Information Administration (2013). Annual Energy Outlook. Table 37. Available at http://www.eia.gov/forecasts/aeo/data.cfm#summary

47 Citi GPS (June 2013). Energy 2020: Trucks, Trains, & Automobiles. P.57. Available at https://ir.citi.com/ROzgbJktqIDIbvbbj8Kae%2BI%2F1te4V9Hh91ex5wFyG1wuStLT5EL8L%2BP7DiZLBZC%2FZIYJ%2BHi13iU%3D

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48 Bloomberg (March 2013). GE Races Caterpillar on LNG Trains to Curb Buffett Cost. Available at http://www.bloomberg.com/news/2013-03-06/ge-races-caterpillar-on-lng-trains-to-curb-buffett-cost.html

49 U.S. Energy Information Administration (2013). Annual Energy Outlook. Table 37. Available at http://www.eia.gov/forecasts/aeo/data.cfm#summary

50 Tennessee Valley Authority. Types of Electric Vehicles. Available at http://www.tva.gov/environment/technology/car_vehicles.htm.

51 The Edison Foundation - Innovation Electricity, Efficiency (April 2013). Forecast of On-Road Electric Transportation in the U.S. (2010-2035). Available at http://www.edisonfoundation.net/iee/Documents/IEE_OnRoadElectricTransportationForecast_0413_FINAL.pdf.

52 U.S. Department of Energy. Alternative Fuels Data Center. Available at http://www.afdc.energy.gov/vehicles/electric_emissions.php.

53 Christian Science Monitor (August 6, 2013). "Chevy Volt Price Slashed. An EV Price War?" Available at: http://www.csmonitor.com/Environment/Energy-Voices/2013/0806/Chevy-Volt-price-slashed.-An-EV-price-war

54 Autoblog (January 14, 2013). Nissan Leaf Becomes Least Expensive 5-Seat EV With Massive Price Drop." Available at http://www.autoblog.com/2013/01/14/nissan-leaf-becomes-least-expensive-5-seat-ev-with-massive-price/

55 U.S. Department of Energy. Alternate Fuels Data Center. Available at http://www.afdc.energy.gov/data/10332.

56 HybridCars.com dashboard.

57 Electrification Coalition (July 2013). "State of the Plug-in Electric Vehicle Market." Available at http://electrificationcoalition.org/sites/default/files/EC_State_of_PEV_Market_Final.pdf.

58 Id.

59 Id.

60 Citi GPS (June 2013). Energy 2020: Trucks, Trains, & Automobiles. P.28. Available at https://ir.citi.com/ROzgbJktqIDIbvbbj8Kae%2BI%2F1te4V9Hh91ex5wFyG1wuStLT5EL8L%2BP7DiZLBZC%2FZIYJ%2BHi13iU%3D.

61 Natural Gas Vehicles for America. About NGVs. Available at http://www.ngvc.org/about_ngv/; American Public Transportation Association (March 2013). "More than 35% of U.S. Public Transit Buses Use Alternative Fuels or Hybrid Technology. Available at http://www.apta.com/mediacenter/pressreleases/2013/Pages/130422_Earth-Day.aspx.

62 Natural Gas Vehicles for America. About NGVs. Available at http://www.ngvc.org/about_ngv/.

63 Resources for the Future (May 2011). Will Natural Gas Vehicles Be in Our Future? P.16. Available at http://www.rff.org/rff/documents/rff-ib-11-06.pdf.

64 Citi GPS (June 2013). Energy 2020: Trucks, Trains, & Automobiles. P.18. Available at https://ir.citi.com/ROzgbJktqIDIbvbbj8Kae%2BI%2F1te4V9Hh91ex5wFyG1wuStLT5EL8L%2BP7DiZLBZC%2FZIYJ%2BHi13iU%3D

65 New York Times (April 2013). "Trucking Industry is Set to Expand Its Use of Natural Gas." Available at http://www.nytimes.com/2013/04/23/business/energy-environment/natural-gas-use-in-long-haul-trucks-expected-to-rise.html?pagewanted=all&_r=0.

66 Bloomberg Businessweek (May 2, 2013). "Why Natural Gas-Powered Vehicles Are Catching On." Available at http://www.businessweek.com/articles/2013-05-02/why-natural-gas-powered-vehicles-are-catching-on#p2

67 Resources for the Future (May 2011). Will Natural Gas Vehicles Be in Our Future? P.11. Available at http://www.rff.org/rff/documents/rff-ib-11-06.pdf.

68 The modeling team assumed that fuel economy improvements in conventional vehicles continued to increase at the rate experienced over 2015-2025.

69 Truck prices were taken from searches on www.commercialtrucktrader.com. The average cost assumed for a new class 3 diesel truck was $50,000; for classes 4-6, $56000; and for classes 7-8, $130,000.

70 Congressional Budget Office (September 2013). The 2013 Long-Term Budget Outlook. Table 1. Available at http://www.cbo.gov/publication/44521.

71 Congressional Budget Office (September 2013). The 2013 Long-Term Budget Outlook. Tables 1 and 2. Available at http://www.cbo.gov/publication/44521.