The Economic Impact of New Pipeline Infrastructure

North Carolina

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Executive Summary

The purpose of this study is to estimate the economic impact that a new, hypothetical, refined petroleum products pipeline could have on the state of North Carolina. This analysis will include both the impacts resulting from pipeline construction and ongoing operations. Although the source of the petroleum products for the hypothetical pipeline was left undefined and conservative assumptions regarding the length of the pipeline route were made, the estimates in this study nevertheless provide a foundation upon which to evaluate the impact of any future pipeline infrastructure in North Carolina, with longer or shorter routes having proportionately larger or smaller impacts.

Also examined are the economic losses North Carolina experienced due to recent supply disruptions and the potential implications of cost savings to North Carolina consumers that could result from additional pipeline infrastructure in the Southeastern United States. Estimates of cost savings again serve as a foundation to evaluate future pipeline infrastructure, as actual cost savings would depend on many factors, including the exact source of supply, pipeline route, and nature of the disruption.

Although each set of estimates documented in this report reflects the impact of a hypothetical pipeline constructed in North Carolina, any new pipeline construction that occurs in neighboring states also has the potential to generate additional positive economic gains for North Carolina. These economic gains would consist of any new purchasing activity on the part of businesses or individual workers that occurred in North Carolina as a direct result of the construction and/or operations of a new pipeline in a neighboring state. These impacts are captured in our report *"The Economic Impact of Pipeline Infrastructure in the Southeast*."

The key findings of this study are as follows:

- *A new, hypothetical, refined petroleum products pipeline constructed in North Carolina of comparable size and scope to the existing Colonial and Plantation pipelines would likely measure 27 inches in diameter and span, at minimum, approximately 260 miles across the state.*

- *The economic impact of the construction of such a pipeline on North Carolina is estimated to add $111.6 million to Gross State Product. This figure reflects the dollar value of all final goods and services produced in North Carolina that would be the result of (either directly or indirectly) the construction of the pipeline.*

- *Based on the timeline of other similar projects across the United States, the construction phase of this new North Carolina pipeline would be anticipated to last between eight and twelve months. This study estimates that 1,159 construction and construction-related workers would be employed during the construction phase.*

- *Additional rounds of economic activity due to non-labor expenditures associated with pipeline construction and the local spending of workers would generate an additional 665 jobs during the construction phase. Thus, a total of 1,824 temporary jobs across North Carolina would likely be supported during the construction of the new pipeline. This impact corresponds to over $73 million in labor income.*

- *Upon completion of the pipeline, the ongoing activities that would be required to sustain all operations and maintenance are estimated to generate a permanent increase in statewide economic activity of approximately $27 million per year. This impact is associated with 237 new, permanent jobs and $16.4 million in annual labor income.*

- *To put the economic impact of supply disruptions in context, consider that there have been at least three major weather events to cause significant disruptions to the supply of refined petroleum products to North Carolina since 2005. These consist of Hurricane Katrina (August 2005), Hurricane Harvey (August 2017), and Hurricane Irma (September 2017). During the aftermath of Hurricane Katrina, a temporary supply constraint contributed to gasoline prices in North Carolina and the Southeast increasing by 12 cents per gallon relative to the national average. During the aftermath of Hurricanes Harvey and Irma, a similar temporary price increase of approximately 16 cents per gallon occurred. Price increases resulting from future supply disruptions could potentially be avoided or lessened with additional pipeline infrastructure (e.g. a pipeline connected to a different supply source than Colonial and Plantation).*

- *The temporary price increase due to petroleum supply constraints following Hurricane Katrina in 2005 lasted for approximately two months. During this period, the price increase is estimated to have generated nearly $40 million in total economic losses for the state of North Carolina. These include both the direct losses to consumers as well as all losses arising from economic multiplier effects associated with decreased in-state demand resulting from a lower volume of consumer spending activity.*

- *Similarly, the temporary price increase due to petroleum supply constraints following Hurricanes Harvey and Irma in 2017 lasted approximately nine weeks. During this period, the price increase is estimated to have generated approximately $136 million in total economic losses for the state of North Carolina. As with Hurricane Katrina, these include direct losses to consumers and those arising from decreased overall in-state demand resulting from a lower volume of consumer spending activity.*

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Section I – Introduction and Background

North Carolina has experienced significant population growth due to in-migration over the past 27 years. Between 1990 and 2015, the state experienced a net gain of approximately 2.4 million residents as a direct result of in-migration. This is part of a wider demographic trend of Americans moving both South and West in search of employment and a lower cost of living. In 2017 Lending Tree analyzed mortgage requests across the nation and found a definitive southern tilt in preferences for out-of-state homebuyers. The states of South Carolina, Florida, Delaware, North Carolina, and Georgia all scored highly on their Moving Popularity Score Index.

In addition to significant population growth, North Carolina has also been one of the fastest growing states in terms of Gross Domestic Product between 2012 and 2016. Over that time period, the state grew 8.2 percent, which was faster than the national average and ranked 8th overall.

Because of these trends, North Carolina is likely to experience a significant increase in the demand for petroleum products over time that will both outpace the United States average and eventually require an increase in supply of pipeline infrastructure to serve. At the national level, the U.S. Energy Information Administration (EIA) projects that total energy consumption will increase at an average annual rate of approximately 0.3 percent through the year 2050.[1]

Not only does maintaining an appropriate level of pipeline infrastructure help to meet increases in petroleum demand, it also has the potential to generate significant economic gains for the state by creating jobs and incomes for North Carolinians and by minimizing supply disruptions – that is – by allowing the state to more easily accommodate either an increase in demand or a temporary disruption in existing supply without a significant accompanying increase in price for the average North Carolina consumer. For example, consider the recent petroleum supply disruptions

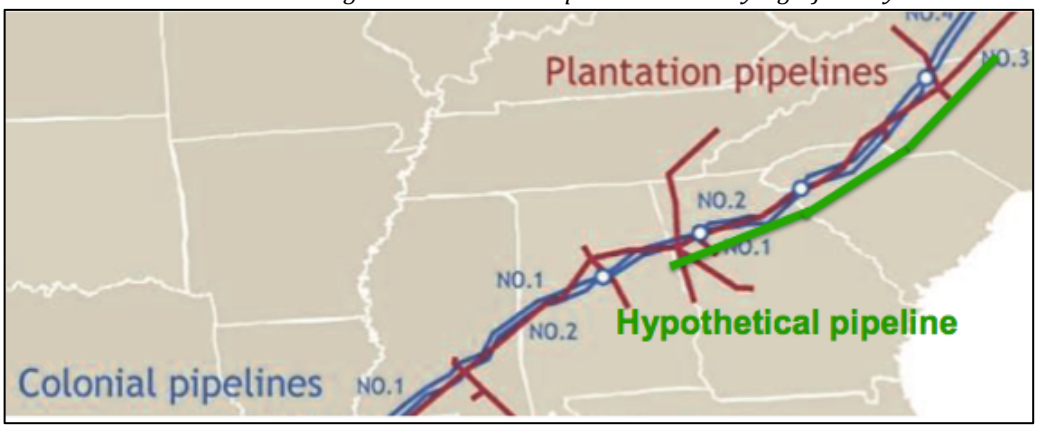
[1] Source: U.S. Energy Information Administration, Annual Energy Outlook 2017

in North Carolina due to Hurricanes Harvey and Irma that resulted in a short-run increase in gasoline prices of between 30 and 50 cents per gallon. This price increase may have potentially been avoided or minimized if additional pipeline capacity following a different route or sourced from a different location had been available.

The purpose of this research effort is to conduct an analysis that estimates the economic impact on North Carolina that would result from a new, hypothetical, refined petroleum products pipeline that would traverse the state but not necessarily have any in-state terminals. Such a pipeline would augment the existing Colonial and Plantation pipeline supply and likely follow a similar route, as denoted in Figure 1.

Figure 1 – Hypothetical Pipeline Route: Georgia, South Carolina, and North Carolina

Note: Actual origin and destination points could vary significantly



The economic impacts resulting from the new, hypothetical pipeline documented in this report include: (1) estimates of all economic activity generated as a result of the *construction* and *ongoing operations* of the new pipeline and (2) estimates of all economic activity *preserved* as a result of additional pipeline capacity that would have the potential to reduce price increases in the event of any major supply constraint (e.g. a natural disaster). This report is organized as follows: Section II highlights the economic impact methodology used to quantify all estimates in this report; Section III specifically documents the economic impact of pipeline construction – including all impacts resulting from the economic multiplier effect;

Section IV focuses on the economic impacts of ongoing pipeline operations and maintenance; Section V examines the impact that additional pipeline infrastructure can have on minimizing supply disruptions; finally, Section VI offers a brief conclusion.

Section II – Economic Impact Methodology

Estimating the economic impact of any new business activity starts by examining all direct procurement that occurs within the state, which includes both labor and non-labor expenditures. The construction and operations of a refined petroleum products pipeline would both employ a large workforce and also support in-state suppliers through various non-labor expenditures.[2] Expenditures made with local businesses and through wages and salaries paid to employees introduce new spending activity at a statewide level that would not exist otherwise and thus represent a net increase in total economic activity for the state.

Yet these activities do not provide a complete picture of the impact of a new, refined petroleum products pipeline to North Carolina's economy. The expenditures outlined above only represent direct economic activity within the state. However, these expenditures also lead to additional job creation and economic activity throughout North Carolina by way of the economic multiplier effect (or economic ripple effect).

Economic multiplier effects can be divided into *direct, indirect,* and *induced* impacts. The direct effect represents the initial change in economic activity. This includes, for example, the initial dollars that are injected into the economy of North Carolina directly through the construction and maintenance activity of the pipeline. This would include any employee wages and benefits, pipeline materials purchased, transportation equipment, or other overhead and administrative costs. This

[2] These expenditures would likely include building infrastructure and a variety of purchases from professional service providers. It should also be noted that many pipeline-related manufactured goods would likely be purchased out-of-state and thus would not be part of the in-state supply chain.

spending increases demand for goods and services and leads to the creation of new jobs and more income for employees and suppliers of any construction maintenance firms that are hired.

The indirect effect reflects all of the additional economic impacts resulting from inter-industry linkages between other local businesses in North Carolina. For example, consider an in-state purchase that is made to replace existing pipeline infrastructure as part of standard maintenance. In this situation, the equipment provider would, as a result of this purchase, experience an increase in demand. This would require this equipment provider to purchase additional raw materials to accommodate the new increase in demand and to potentially hire additional employees if the increase in demand were high enough. Any in-state vendors of the equipment providers would then experience an increase in demand and have to purchase additional inputs as well, and so on. These indirect effects ripple through the economy of North Carolina.

The induced effect reflects additional economic activity that results from increases in the spending of household income. For example, when the aforementioned equipment provider hires new workers to satisfy an increase in demand, these workers will earn incomes. They will then spend part of this new income locally on, for example, food, entertainment, or housing. These industries will then see an increase in demand for their goods and services, which will lead to higher incomes for some of their employees, part of which will also be spent locally.

These successive rounds of indirect and induced spending do not go on forever, which is why a specific value can be calculated for each of them. In each round, money is "leaked out" for a variety of reasons. For example, firms may purchase some of their supplies from vendors located outside of the local area. In addition, employees will save part of their income or spend part of it with firms located outside of North Carolina. In order to determine the total economic impact that will result from an initial direct impact, economic multipliers are used. An economic

multiplier can be used to determine the total impact (direct, indirect, and induced) that results from an initial change in economic activity (the direct impact). Multipliers are different in each sector of the economy and are largely determined by the size of the local supplier network as well as the particular region being examined. In addition, economic multipliers are available to calculate not just the total impact, but also the total employment and income levels associated with the total impact. To estimate the economic impacts in this study, a detailed structural model (known as an input-output model) of North Carolina that contains specific information on economic linkages between all industries within the state was used. The input-output modeling software *IMPLAN* was used to calculate all estimates.

Although each set of estimates documented in this report reflects the impact of a hypothetical pipeline construction in North Carolina, any new pipeline construction that occurs in neighboring states also has the potential to generate additional positive economic gains for North Carolina. These economic gains would consist of any new purchasing activity on the part of businesses or individual workers that occurred in North Carolina as a direct result of the construction and/or operations of a new pipeline in a neighboring state. Thus, the construction of a new pipeline in a neighboring state cannot necessarily be assumed to have no impact on North Carolina's economy.

Section III – Economic Impact: Pipeline Construction

The first set of economic impacts to be documented in this report are those resulting from all construction activities associated with building new pipeline infrastructure in North Carolina. Any economic impacts that arise from construction activities will be the result of dollars invested within the state through purchases of various construction-related materials/services and through direct purchases of labor (e.g., employee wages).

Modeling Assumptions

Because the pipeline project being analyzed in this study is hypothetical in nature, specific assumptions had to be made regarding the pipeline's dimensions (length and diameter) and its route through North Carolina. Although neither the exact dimensions nor the exact route of any new pipeline is currently known, the economic impacts described in this report would likely be approximately scalable to any actual pipeline that is constructed.

There is a wide range of possible sizes for a new petroleum pipeline in North Carolina, with most current pipelines in the United States being between 12 and 36 inches in diameter. Using the current diameters of the Colonial and Plantation pipelines running through North Carolina as a baseline reference, this study made the assumption that a likely diameter for any new petroleum pipeline constructed in North Carolina would be 27 inches.[3]

The length of the new pipeline was assumed to be 260 miles in North Carolina, which is the approximate distance from Charlotte, NC to Murfreesboro, NC. A route between these two cities would roughly parallel that of the Colonial and Plantation pipelines. This 260-mile estimate represents a conservative projection of length, implying that the final route of any new pipeline may be considerably longer. A longer pipeline route, in turn, would also increase the final economic impact to North Carolina.

To determine the number of workers required for a 27-inch pipeline built across 260 miles, employment data were obtained from a 2014 report issued by the U.S. Department of State that estimated the economic impact of the Keystone XL Project on the United States.[4] Among other things, the report estimated that the 875-mile Keystone XL pipeline would support approximately 3,900 annual average jobs

[3] This assumption was provided to the DOR by the American Petroleum Institute (API) and reflects the expert opinions of personnel regularly involved in examining and overseeing pipeline projects across the United States.

[4] https://keystonepipeline-xl.state.gov/finalseis/

within the 4-state region in which the pipeline was to be constructed.[5] Using this job/pipeline-mile construction ratio, this implies that about 1,159 average annual (direct) jobs would be supported from a new 260-mile pipeline in North Carolina during the construction period. In order to estimate the construction costs associated with building this new pipeline, data were obtained from API documenting the current average cost parameters for pipeline infrastructure in the United States along with the relative distribution of purchase activities.[6]

Primary Results

The structural input-output model used to estimate all impacts in this report generates economic impacts in terms of three specific measures: gross state product, employment, and labor income. Gross state product is defined as the dollar value of the final goods and services purchased that can be attributed (directly or indirectly) to all construction activity that results from the construction of the new pipeline. It can also be thought of as an all-inclusive measure of the impact on total economic activity. Employment measures the impact on jobs in terms of the total number of average annual positions. Labor income represents total employee compensation, including wages, salaries, and benefits.

As described above, this report assumes that a hypothetical 27-inch, 260-mile pipeline in North Carolina would require approximately 1,159 average annual jobs to build. These direct economic impacts also lead to indirect and induced impacts through increases in demand for goods and services in other related industries and through increases in household spending activity – all of which are estimated using economic multipliers. Each impact is reported in Table 1, along with the

[5] This estimate reflects all jobs needed in construction and construction-related contractor services. An "annual average job" is defined as the total number of construction-related positions multiplied by the average number of weeks per construction period (19.5) divided by the total number of weeks in a year (52). See *U.S. Dept. of State Supplemental Environmental Impact Statement for the Keystone XL Project* for more details at https://keystonepipeline-xl.state.gov/finalseis/

[6] Source: *Feasibility and Impacts of Domestic Content Requirements for U.S. Oil and Gas;* ICF Report submitted to API on May 16, 2017

accompanying totals. These totals represent the overall impact of the construction phase of the new hypothetical pipeline on North Carolina.[7]

Table 1 – Total Economic Impact of Pipeline Construction in N.C.[8]

	Direct Impact	Indirect Effect	Induced Effect	Total Impact
Employment	1,159	290	375	1,824
Labor Income	$42.3M	$15.4M	$15.8M	$73.5M
Gross State Product (GSP)	$56.9M	$25.3M	$29.4M	$111.6M

The 1,159 average annual jobs that would likely be created (along with all associated non-labor expenditures) generate approximately $56.9 million in annual state GDP. This level of direct economic activity leads to indirect and induced effects totaling approximately $54.7 million in state GDP and 665 jobs. These estimates reflect the increased demand for goods and services of local suppliers resulting from in-state expenditures as well economic activity in North Carolina generated across all industries resulting from increases in household spending. The combination of the direct, indirect, and induced effects leads to a total economic impact of approximately $111.6 million, which is associated with 1,824 jobs across North Carolina. These results can also be broken down by major industry sector as denoted in Table 2.

Table 2 – Total Economic Impact of Pipeline Construction in North Carolina
Top Industrial Sectors

Industry Sector	Total Employment	Total Labor Income	Total Gross State Product
Construction	1,216	$45.2M	$65.7M
Wholesale and Retail Trade	180	$7.6M	$12.5M
Prof. Svs. & Mgmt. of Companies	65	$4.8M	$5.0M

[7] To estimate the results in Table 1, the analysis-by-parts (ABP) method was used to ensure that the construction sector was sufficiently disaggregated to accurately capture the purchasing effects that differentiate oil and gas pipeline construction (NAICS code 237120) from the more aggregated construction sector (two-digit NAICS code 23) that is incorporated into the default *IMPLAN* model software settings.

[8] The economic impact of this hypothetical pipeline on the United States would be significantly larger than the estimates reflected in Table 1. This study, however, focuses exclusively on the impacts to North Carolina. Estimates reflect average annual impacts for the entirety of the pipeline construction period. API estimates that a 260-mile pipeline would likely require four spreads working for 8 to 12 months.

Industry Sector	Total Employment	Total Labor Income	Total Gross State Product
Administrative and Waste Services	64	$2.1M	$2.4M
Health and Social Services	61	$3.5M	$3.8M
Accommodations and Food Svs.	60	$1.3M	$1.8M
Other Services	51	$2.0M	$2.1M
Real Estate and Rental	42	$1.4M	$9.8M
Manufacturing	36	$2.4M	$3.8M
Finance and Insurance	33	$2.0M	$2.7M

Section IV – Economic Impact: Operations and Maintenance

The second set of economic impacts to be documented in this report are those that would result from the ongoing operations and maintenance of the hypothetical pipeline. These include (1) regular spending on construction maintenance that will be required for proper upkeep of the new pipeline infrastructure over time and (2) the property tax revenue that will be collected as a result of the pipeline construction and then re-spent in the state's economy – thereby increasing demand across a variety of industrial sectors.[9]

Modeling Assumptions

The required costs to regularly maintain pipeline infrastructure in the United States have been recently estimated at the national level by IHS Economics.[10] These cost estimates reflect the direct economic activity associated with pipeline maintenance. Specifically, IHS Economics estimates that among 6,805 miles of newly built oil transmissions lines in the United States in 2016, the required operations and maintenance (O&M) spending generated approximately 2,156 jobs. As Table 3 highlights, this translates into a ratio of 0.3 jobs per mile. This ratio can then be applied to the 260-mile hypothetical pipeline in North Carolina to determine the

[9] This study does not take a position regarding the appropriate use of new property tax dollars collected in the state of North Carolina. The assumption that new property tax dollars collected as a result of the ongoing operations of a new pipeline would be spent was made for the sake of simplicity.

[10] This report, entitled *The Economic Impact of Crude Oil Pipeline Construction and Operation* was released by IHS Economics in February 2016; see page 8 of this report for more details of how these estimates were derived.

number of permanent annual direct jobs that are likely to result from its ongoing maintenance.

Table 3 – Annual Direct O&M Employment Impact of Newly Built Crude Oil Transmission Lines in 2016

Economic Metric	Direct Impact
Direct Employment	2,156
Total Pipeline-Miles	6,805
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Direct Employment per Mile	***0.3***

In addition to the permanent increase in economic activity resulting from ongoing O&M associated with the pipeline, there will also be a permanent increase in spending that results from increased tax revenue that is collected and then re-spent within the local economy. For the purposes of this study, it was assumed that any hypothetical pipeline would be taxed at a rate of 0.84 percent – the average effective property tax rate for the state of North Carolina.[11]

Primary Results

Combining the economic activities associated with ongoing O&M and property tax dollars that are collected and then re-spent locally yields a permanent total increase in economic activity of $26.6 million in annual state GDP, which is associated with 237 jobs and approximately $16.4 million in annual labor income. Table 4 highlights these results in detail.[12]

Table 4 – Annual Total Permanent Economic Impact of Pipeline O&M

	Direct Impact	Indirect Effect	Induced Effect	Total Impact
Employment	80	73	84	237
Labor Income	$9.4M	$3.5M	$3.5M	$16.4M
Gross State Product (GSP)	$15.2M	$4.8M	$6.6M	$26.6M

A comparison of the construction and O&M impacts in Tables 1 and 4 shows that the latter generates fewer jobs, but relatively more labor income. This is consistent with

[11] Source: http://smartasset.com

[12] The results in Table 4 were calculated under the assumption that O&M direct employment figures primarily reflect NAICS sector 486910.

the findings of IHS Economics that suggest that the annual wage levels of workers operating and maintaining pipelines is higher than for workers building them. These results are broken down by major industry sector in Table 5.

Table 5 – Total Economic Impact of Pipeline O&M in North Carolina
Top Industrial Sectors

Industry Sector	Total Employment	Total Labor Income	Total Gross State Product
Transportation and Warehousing	86	$9.8M	$17.2M
Administrative and Waste Services	22	$0.8M	$0.9M
Prof. Svs. & Mgmt. of Companies	22	$1.5M	$1.4M
Wholesale and Retail Trade	20	$0.8M	$1.3M
Construction	14	$0.7M	$0.9M
Health and Social Services	12	$0.7M	$0.8M
Accommodations and Food Svs.	12	$0.3M	$0.4M
Other Services	10	$0.4M	$0.4M
Finance and Insurance	8	$0.5M	$0.6M
Real Estate and Rental	8	$0.2M	$1.7M

Section V – Economic Impact: Minimizing Supply Disruptions

One of the major long-run economic benefits that can arise from maintaining adequate pipeline infrastructure is represented by the losses that could be *avoided* during periodic supply constraints resulting from major pipeline disruptions that lead to gasoline price increases. For example, Hurricanes Katrina (2005), Harvey (2017), and Irma (2017) all created supply disruptions involving the existing pipeline infrastructure that led to temporary decreases in the availability of petroleum products in North Carolina. The decrease in supply led to a sizable increase in the price of petroleum products, which in turn generated a net economic loss for North Carolina resulting from a net reduction in consumer purchases due to higher prices.

Although it cannot be known for certain whether additional pipeline infrastructure would have definitively prevented the supply constraints associated with these three specific hurricane events, maintaining an adequate pipeline infrastructure in North Carolina would nevertheless have the potential to help similar future supply

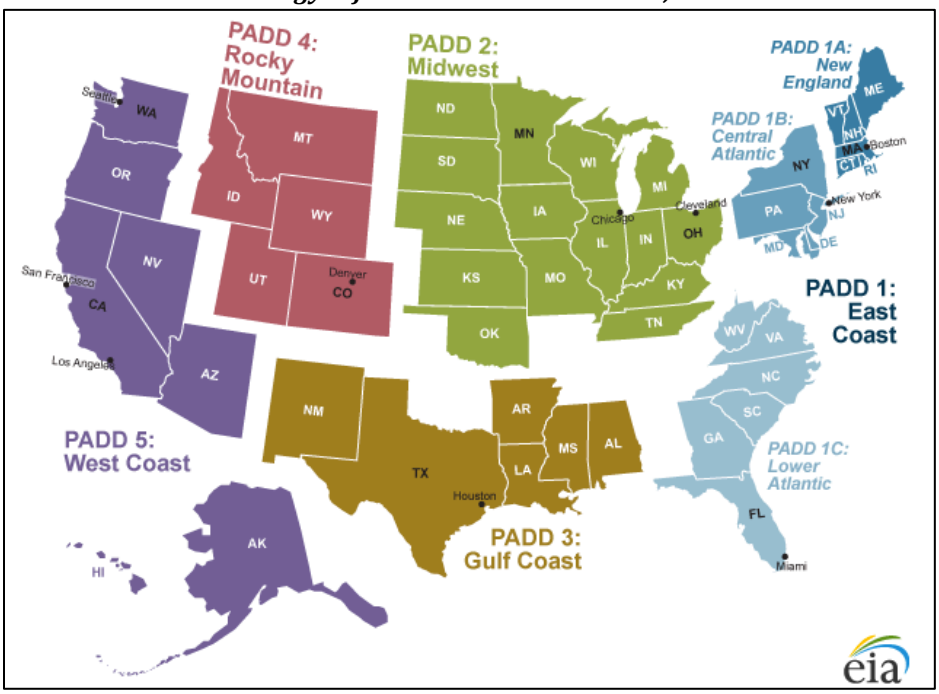
disruptions from generating such large negative effects on the state's economy. The economic losses that could possibly be avoided as a result of maintaining pipeline infrastructure needs is the third set of economic impacts to be documented in this report. This section specifically estimates the economic losses that may have been avoided in 2005 and 2017 if the petroleum supply to North Carolina had not been affected by Hurricanes Katrina, Harvey, and Irma.

Modeling Assumptions

In order to estimate the economic impacts on North Carolina resulting from a major supply disruption, historical data were first collected from the EIA on regional and national retail gasoline prices. Regional and national gasoline prices reflect the average price as reported by the EIA for the Lower Atlantic PADD 1C and for the U.S. as a whole, respectively. Figure 2 shows the states covered by each PADD (Petroleum Administration for Defense Districts) region.

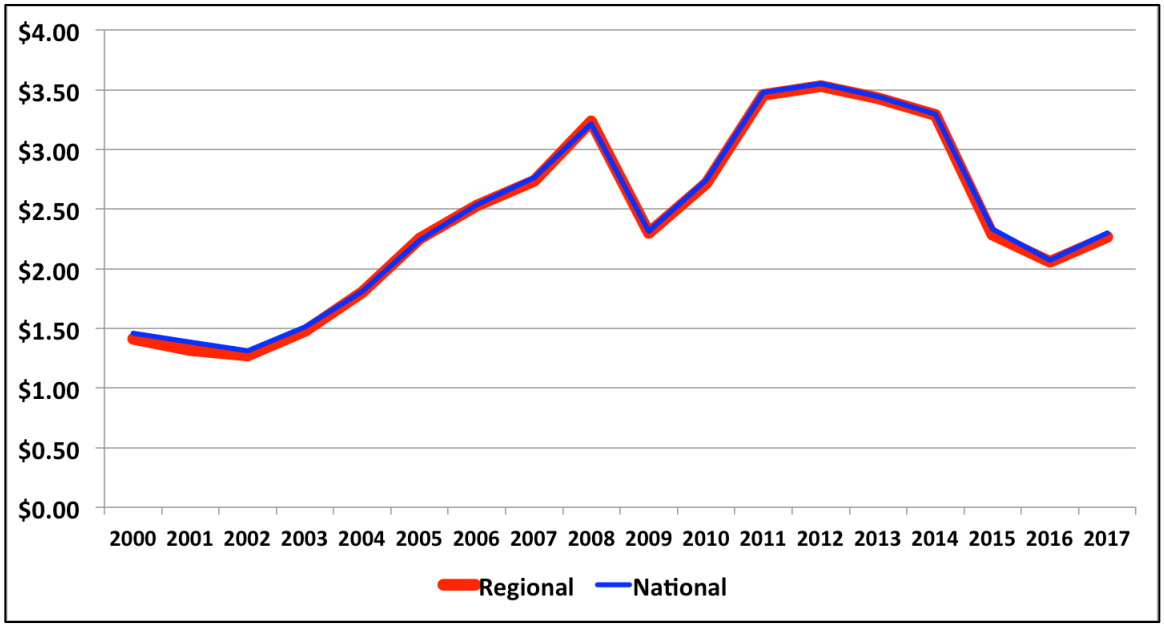
Figure 2 – States by PADD for Retail Motor Gasoline

Source: U.S. Energy Information Administration, Form EIA-878



Trends in Lower Atlantic regional gasoline prices closely align to those of national gas prices, with regional prices averaging approximately two cents lower per gallon over the past 17 years. As Figure 3 displays, gasoline prices in the U.S. have risen from an average price of $1.46 per gallon in 2000 to $2.30 per gallon by September 2017.

Figure 3 – Lower Atlantic and National Gasoline Prices: 2000-2017
Source: U.S. Energy Information Administration



Because of the close parallels between national and regional price trends, this study estimates the effects of a regional supply disruption by examining the extent to which the difference between regional and national gasoline prices change. In other words, is there evidence that the difference between regional and national gasoline prices change during an event that causes a major disruption in supply? As outlined above, two case studies are examined: pricing changes following supply disruptions due to Hurricane Katrina in August 2005 and pricing changes following supply disruptions due to Hurricanes Harvey and Irma in August 2017.

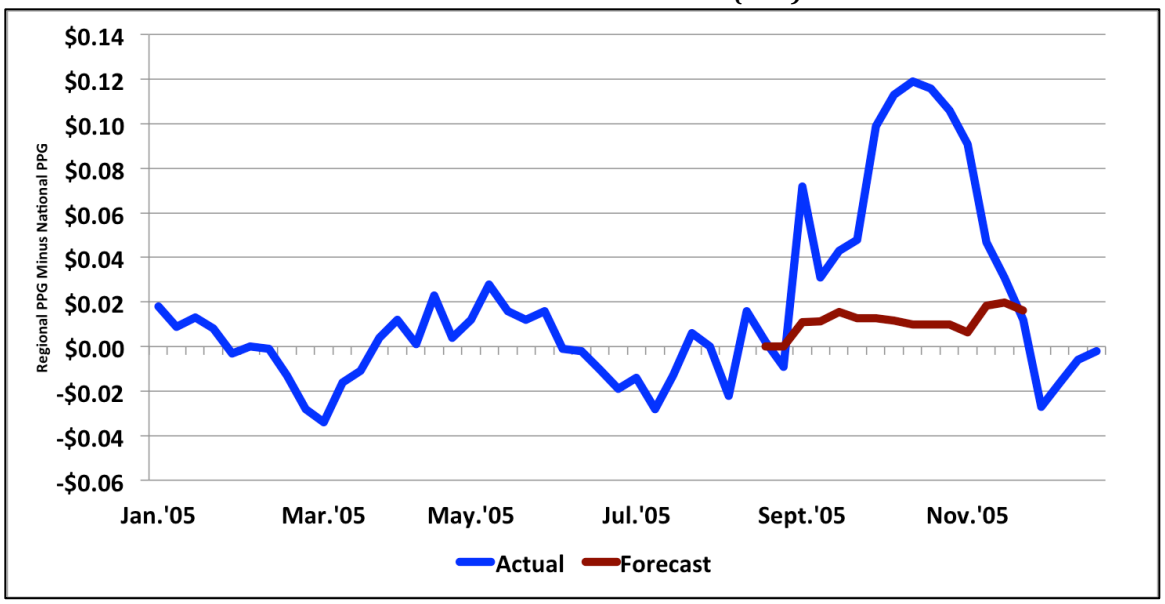
Case Study 1: Hurricane Katrina

After originating in the Bahamas on August 23, 2005, Katrina strengthened to a category 5 hurricane and subsequently caused severe destruction along the Gulf Coast from central Florida to Texas over the course of approximately one week. One

of the many effects of this storm was to disrupt the petroleum supply to the east coast of the United States, including to North Carolina and the entire Lower Atlantic region covered by PADD 1C. This supply constraint, in turn, generated a significant short-run price increase that can be observed in Figure 4. Specifically, Figure 4 illustrates both the actual difference between regional and national gasoline prices during 2005 as well as forecasted values for the difference between regional and national prices from August 30, 2005 through December 31, 2005. These forecasted values are based upon historical data and thus estimate the likely price differences that would have emerged during the final four months of 2005 if Hurricane Katrina had never existed.[13]

Figure 4 – Regional vs. National Gasoline Prices: Jan.'05– Dec.'05

Note: Shown as Price Per Gallon (PPG)



A review of Figure 4 clearly shows the sizable increase in relative prices from September to November of 2005 in the aftermath of Hurricane Katrina. The average price per gallon of gasoline in the Lower Atlantic region averaged one cent less than that of the U.S. in August, but climbed to eleven cents higher than that of the U.S. by October (totaling a twelve cent price swing) before falling again to the national average by December. Table 6 summarizes these monthly changes and then

[13] Forecasted values are based upon an autoregressive integrated moving average (ARIMA) model with seasonal controls using k-fold cross validation (k=10) to optimize model specification.

compares them to the forecasted values. Although there is some variation in relative gasoline prices every year, the twelve-cent price spike is highly unusual and thus is more likely attributable to Hurricane Katrina.

Table 6 – Gasoline Price Differentials in 2005: Regional Less National

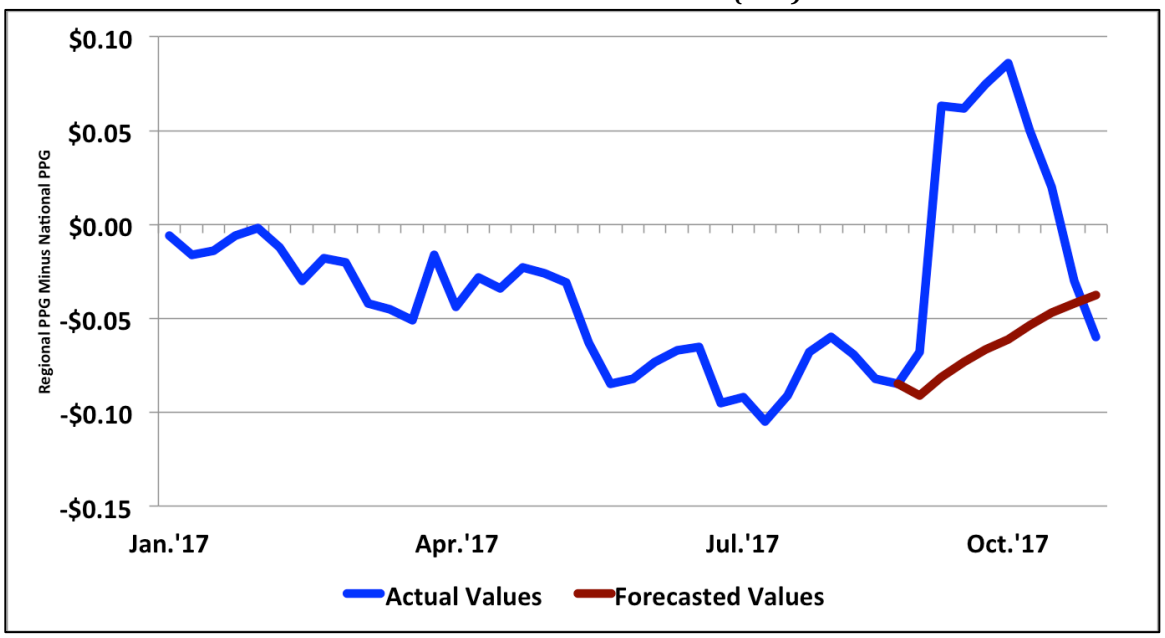
Date (Month)	Price Differential (Actual)	Price Differential (Forecast)	Net Price Impact
Aug. 2005	-$0.01	+$0.00	-$0.01
Sept. 2005	+$0.05	+$0.01	+$0.04
Oct. 2005	+$0.11	+$0.01	+$0.10
Nov. 2005	+$0.01	+$0.02	-$0.01
Dec. 2005	+$0.00	+$0.03	-$0.03

Case Study 2: Hurricanes Harvey and Irma

Harvey and Irma were two category 4 hurricanes that both struck the eastern United States within the span of approximately two weeks during late August and early September of 2017. As with Katrina in 2005, one of the effects of Harvey and Irma was to disrupt the petroleum supply to the east coast of the United States, generating a significant short-run price increase. Figure 5 highlights the actual difference between regional and national gasoline prices during 2017 as well as forecasted values for the differences between regional national prices from August 21, 2017 to October 23, 2017. Once again, these forecasted values are based upon historical data and thus should be interpreted as the likely price differences that would have emerged between August and October of 2017 if Hurricanes Harvey and Irma had never existed.

Figure 5 – Regional vs. National Gasoline Prices: Jan.'17 – Oct.'17

Note: Shown as Price Per Gallon (PPG)



Just as Figure 4 shows a clear relative price increase following Hurricane Katrina in 2005, so too does Figure 5 show a relative price increase following Hurricanes Harvey and Irma in August and September of 2017. The average price per gallon of gasoline in the Lower Atlantic region averaged seven cents less than that of the U.S. on August 28, but climbed to nine cents higher than that of the U.S. by September 25 (totaling a sixteen cent price swing). As of October 23, region prices had returned to six cents less than that of the U.S. average. Table 7 summarizes these monthly changes and then compares them to the forecasted values. As with Hurricane Katrina, examining data from August to October reveals a unique price increase in 2017 that is likely attributable to Hurricanes Harvey and Irma.

Table 7 – Gasoline Price Differentials in 2017: Regional Less National

Date (Week)	Price Differential (Actual)	Price Differential (Forecast)	Net Price Impact
8/28/17	-$0.07	-$0.07	$0.00
9/4/17	+$0.06	-$0.08	+$0.14
9/11/17	+$0.06	-$0.07	+$0.13
9/18/17	+$0.08	-$0.07	+$0.15
9/25/17	+$0.09	-$0.05	+$0.13

Date (Week)	Price Differential (Actual)	Price Differential (Forecast)	Net Price Impact
10/2/17	+$0.05	-$0.05	+$0.10
10/9/17	+$0.02	-$0.05	+$0.07
10/16/17	-$0.03	-$0.04	+$0.01
10/23/17	-$0.06	-$0.04	-$0.02

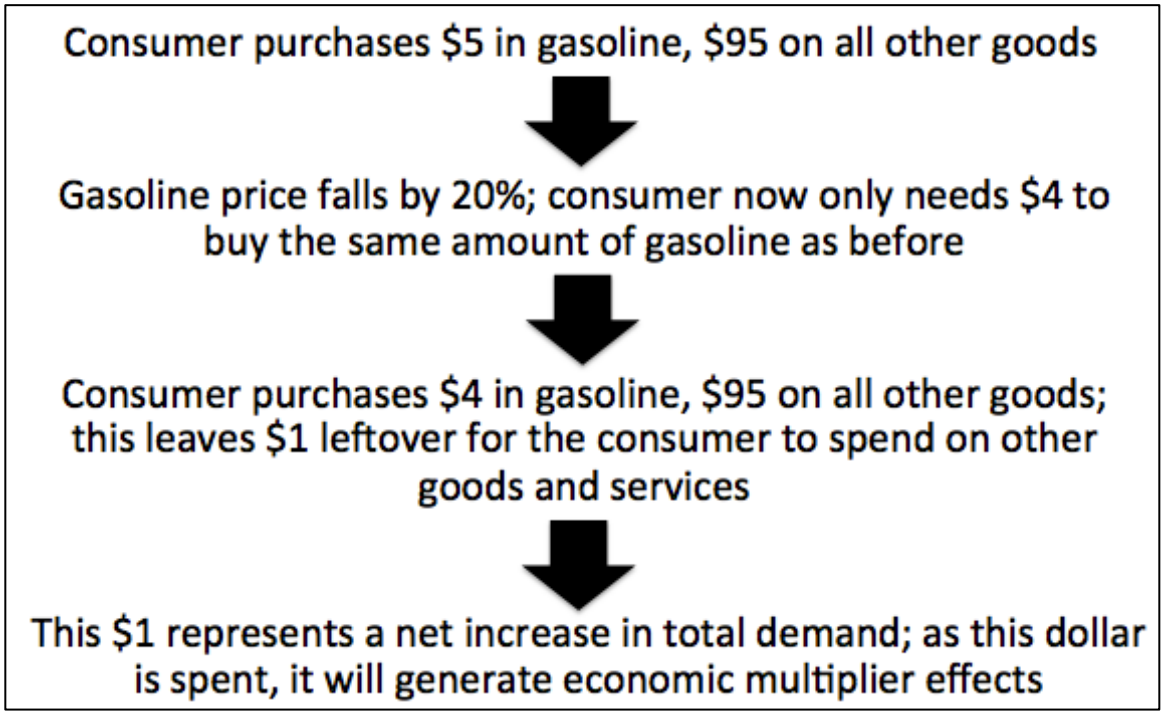
Primary Results

For each case study, Figures 4 and 5 highlight both the actual price differentials during the aftermath of the petroleum supply disruption as well as the forecasted price differentials that are assumed to have been the most likely alternatives in the event that the aforementioned hurricanes had not struck the U.S. In order to determine the total economic losses that could have possibly been avoided without a gasoline supply constraint, data on daily total gasoline consumption in North Carolina was first obtained from the EIA. The difference between the actual price per gallon and the forecasted price per gallon during each month of the supply disruption (denoted "Net Price Impact" in Tables 6 and 7) was then applied to each month's consumption volume during the hurricane aftermath in each case study to estimate the potential savings to consumers that would have occurred if there had been no supply constraint. These savings to consumers represent the *direct effect* resulting from minimizing supply disruptions.

These direct effects, in turn, lead to additional benefits that arise through the economic multiplier effect. When gasoline prices decrease, consumers have the ability to purchase the same volume of gasoline at a lower price. This means that they will have extra money that is now "leftover" and can be used to purchase other goods and services. For example, consider a consumer who typically spends $100 in the North Carolina economy - $5 of which is spent on gasoline. If the price of gasoline decreases such that only $4 is now needed to purchase the same amount of gasoline as before, the consumer will now have the ability to purchase the same $100 of goods and services in North Carolina for only $99. The extra $1 can then be

spent elsewhere, as Figure 6 illustrates. In this example, the extra $1 being spent in the local economy represents the *direct effect,* while any subsequent rounds of spending that result from this initial wave of economic activity represents the *multiplier effect.*

Figure 6 – How a Price Decrease in Gasoline Can Generate a Net Gain in Economic Activity



Tables 8 and 9 summarize all estimates on the total economic losses that were sustained during the aftermath of Hurricanes Katrina, Harvey, and Irma and could potentially have been avoided if there had been increased petroleum pipeline infrastructure in North Carolina. In the two months following Hurricane Katrina, gasoline consumption in North Carolina averaged 11.1 million gallons per day. The supply shortage during this period was estimated to have generated $46.9 million in losses to North Carolina consumers – that is – consumers spent $46.9 million more in gasoline because of the increased price per gallon that resulted from supply constraints. These direct losses, in turn, led to an approximately $39.8 million loss in

state GDP.[14] These estimates reflect the total economic losses to North Carolina that could likely have been prevented had additional pipeline infrastructure been in place during Hurricane Katrina.

Table 8 – Total Economic Impact of Minimizing Supply Disruptions: Hurricane Katrina

Metric	Estimate
Gasoline Consumption (9/2005-10/2005)	11.1M gallons/day
Total Gasoline Savings in North Carolina	$46.9M
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Gross State Product (GSP)	$39.8M

Similarly, the average gasoline consumption that occurred between August and October 2017 was approximately 13.1 million gallons per day. The supply shortage during this period resulting from Hurricanes Harvey and Irma was estimated to have generated $160.6 million in losses to North Carolina consumers – that is – consumers spent $160.6 million more in gasoline because of the increased price per gallon that resulted from supply constraints. These direct losses, in turn, led to an approximately $136.1 million loss in gross state product. These estimates reflect the total economic losses to North Carolina that could likely be avoided by having additional pipeline infrastructure in place during events like Hurricanes Harvey and Irma.

Table 9 – Total Economic Impact of Minimizing Supply Disruptions: Hurricanes Harvey & Irma

Metric	Estimate
Gasoline Consumption (8/2017-10/2017)	13.1M gallons/day
Total Gasoline Savings in North Carolina	$160.6M
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Gross State Product (GSP)	$136.1M

Section VI - Conclusion

This study has estimated the potential economic impacts that would likely emerge if a new, refined petroleum products pipeline were to be constructed and operated

[14] The estimated loss to state GDP is less than the total increase in consumer spending on gasoline because a portion of these consumer dollars would have otherwise been spent outside of North Carolina.

within North Carolina. These estimates include both the impacts of construction and operations as well as the implications of cost savings to consumers in the form of lower gasoline prices that could possibly result from a permanent increase in petroleum supply to the Southeastern United States.

Specifically, this study has found that the construction of a hypothetical pipeline that is comparable to the existing Colonial and Plantation pipelines in North Carolina would likely be 27 inches in length and span at least 260 miles across North Carolina. The construction of such a pipeline would, in turn, generate a total of $111.6 million in state GDP. Additionally, it would support a total of 1,824 temporary jobs during the construction phase, of which approximately 1,159 would be on-site construction and construction-related positions. These 1,824 jobs would be associated with over $73 million in new labor income that would not exist otherwise. Upon completion of the pipeline, the ongoing operations and maintenance would generate a permanent increase in state GDP of approximately $26.6 million annually, including 237 jobs and $16.4 million in labor income. To the extent that an actual pipeline route would be longer or shorter, benefits would be roughly proportional to the length.

Additional pipeline infrastructure also has the benefit of increasing the supply of petroleum to the Southeast and to North Carolina, thus helping to minimize supply disruptions – including those that occur during major weather events. Since 2005, for example, Hurricanes Katrina, Harvey, and Irma have each caused significant temporary disruptions to the supply of petroleum in North Carolina. In 2005, Hurricane Katrina helped to cause a temporary 12-cent per gallon increase in gasoline prices in North Carolina relative to the national average, while Hurricanes Harvey and Irma helped cause a temporary 16-cent per gallon increase in 2017.

This study estimates the size of the losses that could potentially be avoided through additional pipeline infrastructure. The aforementioned pricing disruptions are found to have generated a total of $40 million and $136 million in lost state GDP to

North Carolina in 2005 and 2017, respectively. These losses include both the direct losses to consumers as well as all losses arising from economic multiplier effects associated with decreased in-state demand resulting from a lower volume of consumer spending activity. Maintaining adequate pipeline infrastructure in North Carolina would help any future supply disruptions from generating such large negative effects on the state's economy.

As the demand for energy and for refined petroleum products continues to increase in North Carolina in the coming years, it will be important to consider the effects this increase will have on petroleum prices and on North Carolina consumers. Maintaining an appropriate level of pipeline infrastructure has the potential to help meet increases in petroleum demand while simultaneously generating significant gains for the state by creating jobs and incomes and by minimizing supply disruptions – that is – allowing the state to meet an increase in demand for energy without an accompanying increase in price for the average North Carolina consumer. This, in turn, will help to keep energy affordable in North Carolina for the foreseeable future as the state continues to help drive the nation's economic growth.