RESEARCH & DEVELOPMENT

Analysis and Validation of Historical Transportation Investments:

Draft Final Report

NCDOT Project 2017-22

September 18th, 2018

Brittany V. Gaustad, MPP

John Murray, Graduate Research Assistant

Eleni Bardaka, PhD, Principal Investigator

Daniel Findley, PhD,

Russell Smith, Graduate Research Assistant

James B. Martin, PE

Institute for Transportation Research & Education

North Carolina State University

Research IV, 909 Capability Dr.

Raleigh, NC 27606

1. Report No.	2. Government Accession No. … …	3. Recipient's Catalog No. … …
4. Title and Subtitle Analysis and Validation of Historical Transportation Investments		5. Report Date *September 18th, 2018* 6. Performing Organization Code … …
7. Author(s) Brittany V. Gaustad, MPP John Murray Eleni Bardaka, PhD, Principal Investigator Daniel Findley, PhD Russell Smith James B. Martin, PE		8. Performing Organization Report No. … …
9. Performing Organization Name and Address Institute for Transportation Research & Education North Carolina State University Centennial Campus, Box 8601 Raleigh, NC 27695-8601		10. Work Unit No. (TRAIS) … … 11. Contract or Grant No. … …
12. Sponsoring Agency Name and Address Research and Development Unit 104 Fayetteville St. Raleigh, NC 27601		13. Type of Report and Period Covered Report *August 1, 2016 – July 31, 2018*
Supplementary Notes: … …		

16. Abstract

The purpose of this mixed-methods research is to enhance current economic analysis practices of NCDOT projects by using empirical data to quantify economic impacts of major highway expansion projects. In coordination with the NCDOT, the research team selected and developed case studies for ten highway projects located throughout North Carolina. The chosen projects, which cover a wide range of various characteristics (e.g. urban/rural, east/central/west North Carolina, and bypass/widening/beltway) to provide a broad reference set to inform future investment decisions, are the following: (1) I-540 Northern Wake Expressway (R-2000 & R-2641), (2) US-64 Widening (R-2548), (3) Jacksonville Bypass (U-2107), (4) US-70 Clayton Bypass (R-2552), (5) Greensboro Southwest Loop (I-2402 & U-2524), (6) I-485 Charlotte Outer Loop (R-2248), (7) I-140 Wilmington Bypass (R-2633), (8) U-15/US-501 (R-942), (9) US-1 Cameron/Vass Bypass (R-210), and (10) US-421 Widening (R-2120, R-2239 & R-2240). In order to obtain relevant information on the ten projects, project documents, news articles, US Census data, among other data sources, were gathered for analysis. Ultimately, 182 semi-structured telephone interviews were completed for the ten case studies – in-depth interviews with local officials considered knowledgeable about the project(s), as well as brief interviews with area businesses to determine which ones moved to the area because of the project. Quantitative economic data was mapped and presented in line graphs, and the ten case studies were compared based on the data sources as well as the type of project. In summary, a comparison of economic impact measures across all ten case studies suggests all projects likely have some impact on business growth, residential development, and property price in the study area. However, beltways tend to have a greater impact on business growth while bypasses tend to have a greater impact on residential development and property price and widenings appear to have an even impact across all these measures.

17. Key Words *Economic analysis, transportation, infrastructure, mixed methods, economic impacts, roadways, bypass, loop, beltway, widening*	18. Distribution Statement … …

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages *…fill in…*	22. Price … …

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

DISCLAIMER

The contents of this report reflect the views of the author(s) and not necessarily the views of the University. The author(s) are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the North Carolina Department of Transportation or North Carolina license plate agencies. This report does not constitute a standard, specification, or regulation.

Acknowledgements

The research team would like to thank everyone who contributed to this report, including the participation of local governmental and economic development officials, as well as businesses, in telephone interviews. Additionally, we would like to thank the consultants at Louis Berger (Leigh Lane, Adrienne Heller, and Joshua Schnabel) that helped with report review and qualitative data collection. The research team appreciates Shalini Ghosh's hard work in helping to complete qualitative data collection and analysis in a tight timeframe. Also thank you to engineering students Lily Cloud and Joe Dial that helped with the report. Michelle Carroll, with the NCDOT Environmental Analysis Unit, and Sebastian Montagne (NCDOT Strategic Planner), were instrumental in helping to gather project documents and relevant data, and their help is greatly appreciated.

Table of Contents

Table of Figures

Table of Tables

Executive Summary

This research project aims to enhance current economic analysis practices of NCDOT projects by using empirical data to quantify long-term, direct economic impacts of major highway expansion projects. In coordination with NCDOT, our team selected and developed case studies for ten highway projects located throughout North Carolina. The chosen projects, which cover a wide range of various characteristics (urban/rural, east/central/west North Carolina, and bypass/widening/beltway) to provide a broad reference set to inform future investment decisions, are the following: 1) I-540 Northern Wake Expressway (R-2000 & R-2641), 2) US-64 Widening (R-2548), 3) Jacksonville Bypass (U-2107), 4) US-70 Clayton Bypass (R-2552), 5) Greensboro Southwest Loop (I-2402 & U-2524), 6) I-485 Charlotte Outer Loop (R-2248), 7) I-140 Wilmington Bypass (R-2633), 8) U-15/US-501 Widening (R-942), 9) US-1 Cameron/Vass Bypass (R-210), 10) US-421 Widening (R-2120, R-2239 & R-2240).

The quantitative analysis compares time trends between metrics within the study area, surrounding area, and the state of North Carolina. The following six metrics comprise the core analysis profile this study uses to quantify possible direct economic impacts: jobs and unemployment rate, income, number of businesses, population, property values, and capital investment. The qualitative analysis for each case study consisted of in-depth interviews with local governmental officials, economic development experts, local business owners, local community members, and NCDOT officials who were involved in the project as well as brief interviews with local businesses located near the project. The interviews were used to identify area context, specific impacts related to the transportation projects, and businesses that had located in the area because of the transportation project. Additionally, the interviews provided context and support to the quantitative results and provided a causal argument for any observed economic impacts.

An overall comparison of the qualitative and quantitative results across all ten case studies revealed key, high-level insights; for example, beltway projects appear to have the most substantial effect on business development compared to the other project types. At the same time, the beltway projects showed very high yearly increases in population, but no substantial impact on housing prices. These results suggest beltway projects make the area most attractive to businesses and stimulate economic growth. Conversely, bypass projects appear to substantially improve residential property value, but are generally not associated with extensive business growth. This indicates the access and mobility a bypass project brings to an area is most attractive to residential developers. Finally, the widening project results are mixed. One shows outstanding economic impacts in all measures while the other shows improved median house values, but minimal changes otherwise. We believe the outlier (US-15/501 widening) is due to scale. This project has the lowest cost and the smallest footprint. Additionally, the study area included very few other roadway segments compared to the other nine projects. This suggests the US-15/501 widening analysis contained significantly fewer confounding factors, which is why we observe clear economic impacts in every category. The other widening (US-421) involved over 40 miles of roadway and showed signs of both residential and business development, but the magnitude observed is much lower. The widening projects provide an important insight that extends to the other projects in our study; there is variability associated with larger scale projects that likely dilutes observable impacts.

In summary, a comparison of economic impact measures across all ten case studies suggests all projects likely have some impact on business growth, residential development, and property values in the study area. However, beltways tend to have a greater impact on business growth, bypasses tend to have a greater impact on residential development and property price, and widening projects appear to have an even impact across all these measures. Future research could include a larger selection of projects that would improve the reliability of these economic results.

1 Literature Review

1.1 Introduction

Like many other states, North Carolina's Department of Transportation (NCDOT) uses economic competitiveness as one of the criteria for prioritizing transportation projects. This gives rise to the need for structured research to document and quantify the long-term economic impact of major highway expansion projects derived from projects completed as part of the 1989 Highway Trust Fund Act. Such a study will not only provide NCDOT with evidenced-based economic impact case studies associated with past Highway Trust Fund projects but also with a better insight into economic impact assessment tools (such as TREDIS) that can improve the quality of future decision-making about highway improvement investments. These evidence-based case studies will help to inform future transportation proposals that will facilitate dialogue between NCDOT staff and stakeholders, as well as to contribute to the EconWorks case study database to inform transportation decisions and analysis nationally.

As stated above, this research project aims to enhance current economic analyses at NCDOT with regards to quantifying the long-term economic impact of major highway expansion projects specifically those authorized as part of the 1989 Trust Fund Act. An initial review of journal articles, industry papers, economic white papers, reports commissioned by other state departments of transportation, and web documents demonstrates that structured and evidence-based economic methods are becoming more widely used in decision-making with respect to funding transportation projects. As economic rationale has become

a more integral component of project prioritization, the validity of economic models has been called into question.

1.2 Ex-post Economic Analysis Methods and Performance Measures

Utah's Department of Transportation commissioned a study (Schultz et al., 2010) to evaluate how forecasted economic impacts from transportation projects compared to actual economic impacts. In the Utah study, both pre- and post-construction data were collected and used to compare the trends of sales tax revenue, employment creation, and vehicle miles traveled (VMT) around transportation projects in Utah over the last 10 years. Using projects where sufficient data were available over a 10-year period, the results indicated that although there is variability in the data, a positive trend was observed on average between transportation improvement projects and sales tax revenues, employment, and VMT. A similar process of using pre- and post-construction data for North Carolina's 1989 Trust Fund Act projects could be used to evaluate the trend of forecasted and actual economic impacts of transportation projects in North Carolina.
Prior research has supported the incorporation of reliability and accessibility measures into studies on the economic impacts of transportation infrastructure. The Transportation Research Board (TRB) (2013) constructed spreadsheets that can be utilized to include measures of accessibility, connectivity, and reliability in economic analyses of transportation projects. Cambridge Systematics (2012) also emphasized the importance of including measures of predictability and reliability in economic analyses of transportation projects. Including these measures incorporates impacts that can lead to more widespread benefits, including the productivity of businesses in the area (TRB, 2013). Transportation projects whose primary purpose is to mitigate traffic congestion may also lead to greater reliability; for example, the length and likelihood of traffic accidents, as well as delays associated with such incidents, may be reduced (TRB, 2013). Other examples of increased reliability as it relates to transportation projects include fewer late deliveries and lower incidences of employee lateness (i.e. supply chain logistics benefits and labor productivity benefits, respectively) (TRB, 2013).

Intermodal connectivity refers to shorter travel times between departure locations and destinations (TRB, 2013). Market accessibility refers to time savings made in same-day product deliveries as well as commuter access, both of which can help to expand the effective size of the market (TRB, 2013). However, the similarity in these measures indicates that they should be used with caution so as not to double count anticipated economic benefits resulting from a transportation project. These considerations will be incorporated into the current study.

The type of transportation investment is also useful to incorporate into economic analyses. Eberts (n.d.) wrote that there are two main types of investments in transportation: capital enhancement and capital expansion; while capital expansion involves constructing additional highways, railroads, air capacity and other forms of transportation using traditional technologies, capital enhancement includes the installation of modern technologies used to improve the efficiency of existing transportation infrastructure. Increasingly, investments in transportation are becoming subtler and difficult to measure, since transportation infrastructure is already in place (Eberts, n.d.); this can be partially explained by the law of diminishing returns. Eberts recommends incorporating measures of the flow of goods and services into economic analyses of transportation infrastructure, as well as spatial analyses. Eberts also recommends including measures such as changes in income, employment, and changes in business operations (e.g. whether businesses open or close in conjunction with new transportation investments, all of which are measures incorporated into the Econ-Works database.

Econometric modeling as well as simulation studies have been used to analyze the economic impacts of investments in transportation infrastructure. Oster, Rubin and Strong (1997) compared econometric modeling to input-output analysis of transportation projects and stated that "input-output analysis is good

at reflecting the ripple effects of changes in employment of an existing facility, or even of most new facilities in a metropolitan area, where the changes do not affect the basic structure of the regional economy" ("Summary and Conclusions," para. 2).

One type of transportation project to be included in the current study is bypasses. Wisconsin Department of Transportation (WIDOT) (1998) completed a study of the economic impacts of bypasses on communities and found that there is little adverse economic impact on community economic activity, although the potential adverse economic impacts have the potential to be greater for small communities. In addition, it was found that bypass communities generally exhibited economic growth that exceeded that of the communities in the control group (WIDOT, 1998). This research will be used to contextualize the findings of the current study.

1.3 Review of Existing Economic Impact Analysis Models switch

The Connecticut Department of Transportation commissioned a study to evaluate 18 economic models used to analyze the economic impacts of transportation projects (Konduri et al., 2013). TREDIS, REMI, IMPLAN and RIMS-II performed best under six overarching research criteria (Konduri et al., 2013). The study determined that IMPLAN and RIMS-II possessed limitations that could be overcome with TREDIS and REMI models. Though both of TREDIS and REMI have adequate capabilities, research undertaken by AKRF, Inc. (2013) found that the REMI's platform is complex and many of its features "amount to overkill for most non-academic and non-policy-oriented analyses." Furthermore, "the complexity of the [REMI] model makes it more difficult to explain the modeling process and outline basic assumptions." In contrast, TREDIS is cost-effective, user-friendly, and used by transportation agencies in 27 states (EDRG, 2015).

1.4 Transportation Investments and Disinvestments

Diaz et al. (2016) found in their system dynamics simulation study that transportation infrastructure investments typically lead to increased income and job creation; the increased usage of the transportation infrastructure and population increase associated with these economic impacts then lead to traffic congestion. This traffic congestion is associated with a decline in the gross regional product as well as regional attractiveness. Diaz et al. (2016) suggested that transportation infrastructure investments typically follow this cyclical pattern which involves only a short-term increase in economic growth. As is shown in Diaz et al. (2016), there are a variety of analytical methods that can be utilized to assess the economic impacts associated with investments in transportation infrastructure.

Not only has prior research been completed on investment in transportation infrastructure, but studies have also focused on disinvestment in transportation systems. Duncan and Weisbrod (2015) completed research on the impacts of disinvestment in existing transportation infrastructure, which is a factor that could be incorporated into an opportunity cost analysis of choosing to fund new transportation projects. As stated by Duncan and Weisbrod (2015), "decisions to overinvest in one part of a system... can result in passive disinvestment elsewhere, because of limited funding" (p. 3).

1.5 Review of Existing Methodologies and Economic Impact Measures

Prior research and associated case studies have defined general methodologies and measures to use in ex-post analysis of highway investments. The Economic Development Research Group (EDRG) completed

research in 2001 and 2012 on the use of empirical information to measure the economic impact of highway investments and identified the following impact measures:

- Jobs
- Wages and total income
- Number of businesses
- Business volume and sales
- Population
- Capital investment
- Property values
- Economic distress (unemployment rate)
- Tax revenue
- Average annual daily traffic (AADT)

A more general report regarding economic impact analysis published by the Environmental Protection Agency in 2010 discusses important impact measures based on what entities a change (highway project in our case) affects. The report suggests relevant economic impact measures for a highway investment would include: population, property values, household income, unemployment rate, and total employment. Thompson et al. (2008) discussed benefit/cost and economic impact analysis as predictive tools in evaluating highway investments also provided some insight on key economic impact measures. The report explicitly identifies levels or growth of jobs, population, and income as pertinent measures in economic analysis. Inclusion of this report is important because it shows consistency between variables in both pre- and post-economic impact analysis, which both validates the impact measures used in these case studies and supports ideas presented in the future research section including using ex-post analysis to evaluate or enhance predictive analysis. EDRG (2001a) and EPA (2012) both discuss potential data sources for economic impact measure. The economic impact measures and their potential data sources found in EDRG (2001a) and EPA (2012) are shown in Table 1.

1.6 EconWorks Case Studies

The EDRG (2001a, 2001b, 2012) reports define a substantial portion of this report's overall methodology including study area criteria, data analysis, data interpretation, and narrative construction. EDRG (2001b) outlines a set of prototype study areas that fit depending on type of project and defined scope of "direct" economic effects. The corridor study area type fits this set of case studies as the goal is to measure the economic growth in the area adjacent to the highway investment compared to the surrounding area. The comparison is drawn via observed differences in growth rates of various measure over pre- and post- project periods. The report mentions using trend analysis for this comparison helps develop a case for causality between a highway investment and the observed economic measures. The report goes on to state causality can be further supported or fully established via interviews conducted with area experts or businesses post-construction.

EDRG (2012) elaborates on the use of trend analysis stating that both point, and multi-year trend analysis can support economic impacts of the project, but multi-year analysis is encouraged as it can capture anticipation and post-project effects separately. Both EDRG reports mention the importance of choosing pre- and post-construction dates that fully encompass the effects of a project. Accurate time-based analysis requires at least four measurements, "...1) at least one before project construction, 2) at the time of project completion, 3) within a year after project completion to capture short-term effects, and 4) between five and 10 years after project completion to capture longer-term effects." In the case that post- construction data does not extend at least 5 years past construction, the EDRG reports defined an order in which project impacts generally occur (bulleted list is verbatim from EDRG report):

- Change in land prices/valuation (as demand grows for some locations);

• Change in property sales volume and prices (land is sold for new or more intensive uses);
• Change in construction spending (building investment is made for new or more intensive uses);
• Change in employment, associated wages, and business sales (as building are occupied); and
• Change in public-sector tax revenues (as business activity occurs in the new buildings).

The Transportation Research Board (TRB) (2012) compiled 100 Transportation Project Impact Case Studies (T-PICS) to inform future transportation planning efforts, particularly in the initial stages of planning, to provide a database of transportation projects and their economic impacts. These case studies are displayed on the EconWorks website and as new case studies are completed, the database is added to. TRB (2012) also completed a meta-analysis which indicated that the project setting, and type of project are more significant indicators of long-term economic than the dollar amount put into a transportation project. The findings from the 10 case studies of focus in the current study were written to facilitate their submission to EconWorks to be included in their database.

1.6.1 Case Study Narrative Outline

EDRG (2012) suggests the following structure for the submission of highway investment economic impact case studies (bulleted list is verbatim from EDRG report):

- **Synopsis**. A one-paragraph summary of the project history and its outcomes. The summary should include a description of the project, its location, dates of construction, project cost, and impacts in terms of jobs or types of businesses attracted.
- **Background**. Describe the local project context. The backgrounder should include a brief economic history of the region, population and employment trends, description of major transportation routes and facilities that serve the area, travel time to the nearest commercial airport, and other transportation features.
- **Project description and motives**. Describe the project (type, cost, etc.) and why it was built.
- **Transportation impacts**. Discuss the implications of the project on local transportation, such as changes in average annual daily trips, travel time savings, or other factors.
- **Demographic, economic, and land use impacts**. Discuss pre-construction and post- construction data and impacts attributed to the project, such as new firms attracted and retained and changes in employment, land use, and land development.
- **Non-transportation factors**. Discuss other factors that influenced project outcomes (e.g., supportive policies and incentives). If several factors combined with the transportation investment to create a climate for economic growth, then transportation investments can only be attributed a portion of that growth. The allocation of causality for each project should be discussed with interview participants.
- **Resources and citations**. Compile a list of studies and links to websites used in the case study.
- **Interviews**. Compile a list of organizations participating in the interview process.

Data interpretation based on project type, study area, and available data is discussed in detail in the following section.

1.6.2 EconWorks Definitions

Each case study in this report reports direct, indirect, induced, and total economic effects of the project. These values are generated using EconWorks. The EconWorks User's Guide was reviewed with the other literature and descriptions of its primary and secondary project factors are delineated below for clarity.

- **Region** – Based on the US Department of Commerce's eight Bureau of Economic Analysis (BEA) regions: Far West, Rocky Mountain, Southwest, Plains, Great Lakes, Southeast, Mideast, and New England. Note that the following pairs are combined in EconWorks: Far West & Rocky Mountain, Great Lakes & Plains, Mideast & New England.
- **Urban/Rural Class** – Based on US Census Metropolitan Classification (metro, mixed, rural)
- **Population Density** – Population per square mile.
- **Economic Distress** – Unemployment rate (ratio to national rate)
- **Economic Growth Trend** – Percent change in employment comparing the pre-project date to the post-project date.
- **Transportation and Market Access** – Area within a 40-minute travel time of the project; the area buffer is centered around midpoint of the project.
- **Topography** – Aggregate county land surface rating as per the US Geological Survey, beginning at 1 [flat] and reaching 21 [very mountainous]).

1.7 Review of Completed Case Studies

The methodologies and results from post ex-facto case studies from various sources were analyzed for application to the North Carolina case studies. The FHWA published detailed economic studies on several major corridors across the country; I-26 in South Carolina, I-86 in New York, I-68 in Maryland, and State Highway 29 in Wisconsin. Missouri Department of Transportation published a study that included eight case studies of projects across the state. On behalf of the Kansas Department of Transportation (KDOT), High Street Consulting Group compiled five economic case studies. Case studies on connector, widening, beltway, and bypass were queried from the EconWorks database and the data compiled.

A study area was established for each case study; the analysis depends on the scope the area in which data is collected. For each study, data were collected for several spatial areas varying in scope and location. A regional area is defined to incorporate data from a wider radius from the subject facility to compare to data within the study area. Additionally, a no-build comparison location is established to compare the study area with a location with similar demographic and economic characteristics without a new highway project.

1.7.1 FHWA Case Studies

The FHWA SR 29 study adopted a comparison route through adjacent counties of roughly the same length. SR 10, the comparison route, is only a two-lane facility, however, the adjacent counties are close enough for a valid comparison. The I-86 FHWA study cites the central part of the NY North Country as a valid comparison to the study corridor. Adjacent counties are designated as comparison areas for the other FHWA case studies. KDOT utilized smaller-scale projects like interchanges and small widening projects, therefore the study and comparison areas were zip code(s). MODOT varied the size of the study/comparison areas based on the project. For the James River Freeway case study, the downtown district and another freeway corridor were selected as a comparison area. The neighboring town of Centralia, Mo. was selected as the comparison areas for the Avenue of the Saints project in Bowling Green, Mo.

The temporal aspect of the economic analysis depends on the methodology used for the case studies. The FHWA studies incorporate several decades into the study going back to 1960. Percent change calculations were performed for several smaller durations to account for changes to the facilities including widening and the opening of new roadway segments. EconWorks case studies typically compare metrics during a pre-construction period, usually several years before construction begins, and post-construction window at least a year after construction is completed. Missouri and Kansas only included the project open date. Some metrics are only available in the decennial census; therefore, the pre-project data is collected for the census

years closest to the pre-construction and post-construction study period. Economic impacts are observed over a period and some impacts take several years to develop (EDRG, 2012).

Many of the case studies presented qualitative data on capital investments due to an apparent lack of quantitative data. The case study narratives detail specific examples of new businesses or relocations to the study area. New industrial and manufacturing facilities are also included in the case study narrative as referenced by the jobs created and sq. ft. of buildings constructed.

1.7.2 State DOT Case Studies

In St. Louis, a new business park along the Highway 370 corridor attracted a new Coca-Cola bottling facility, a new aviation parts manufacturer, and an entertainment complex complete with a movie theater, amusement park, and an ice rink. The widening of the Grindstone Parkway in Columbia, Missouri into a four-lane access-controlled highway resulted in the opening of a Kohl's retail store and Wal-Mart opened a new location. Avenue of the Saints in Bowling Green, Mo. attracted a new Walmart supercenter and a manufacturing facility that employs about 175 people.

In Kansas, a storage tank manufacturing company opened an 80,000-sq. ft. plant with 300 employees opened along the US 400 Parson Bypass. The K-96 Northeast Bypass in Wichita, Kansas attracted a business park with a FedEx facility, manufacturing plants, and a distribution center. The interchange improvement project at I-435 and Nall Ave was cited as a key reason for retaining the corporate headquarters of the merged Sprint-Nextel corporation in Overland Park, Kansas. In addition to retaining the corporate headquarters, a 237,000-sq. ft. Overland Park Convention Center was constructed as part of a 412-room Sheraton Hotel.

In addition to capital investment, case study narratives detail qualitative economic trends and impacts. The FHWA study of SR 29 in Wisconsin noted that the decrease in travel time attracted workers from the adjacent urban metro areas. The result of this shift was an increase in business openings near the newly constructed interchanges and some decrease in businesses along the downtown thoroughfare. In addition, 43 manufacturing plants either opened or expanded near the corridor.

Along the I-68 corridor in Maryland, the traditional manufacturing economy shifted to tourism aided by easier access to east coast cities and interstate routes such as I-95. According to the study, travel time to the BWI or IAD airports decreased by about 50%, which encouraged several call centers to locate in the region and still be within a day's drive of Baltimore and Washington D.C. In the middle of the 20th century, this rural part of Maryland was originally served by rail lines but was left out by the shift to freight by truck. Interstate access has led to some growth in manufacturing, including a 250,000-sq. ft. cabinet assembly factory with 330 employees.

Case study narratives also include non-transportation policies that can impact the economic effects of a new roadway facility. In Maryland, a statewide policy to limit "sprawl" by focusing funds in areas already developed. According to economic development leaders in the I-68 corridor, this statewide policy may have hindered the economic benefits of completing I-68.

1.7.3 Comparison of Data Analysis and Interpretation Practices

Each case study reviewed included employment data in several forms. The Kansas case studies report employment change on an average annual basis, while the other studies record change in employment from the pre-construction year to the post construction year. The change in employment is measured for the

regional, comparison, and project study area for the Kansas and Missouri case studies. EconWorks case studies include state, county, and local study areas, however, some projects in rural areas lack data at the local level. KDOT case studies also reported the average number of jobs added annually. Each Kansas project added an average of 1,210 jobs per year.

Data from each case study reviewed were used to compare the projects by case study source, project type, and project location. The EconWorks database of case studies was queried for all beltway, bypass, connector, and widening projects. 44 total case studies were returned by the database and each study was reviewed and data recorded. 11 case studies (6 beltways, 2 bypasses, 1 connector, and 2 widening projects) were removed from the data set because reported metrics weren't annualized and/or the period for which each data was collected. Seven beltways, ten bypasses, nine connectors, and seven widening projects were included in the analysis dataset. The project type, project length, project costs/mile (in 2013 millions of dollars), average annual daily traffic (AADT), population density (persons/square mile), population growth rate, and employment growth rate were reported for each project in the data set. Table 2 contains this data for each of the 33 case studies for which annualized data was available. Averages of project cost/mile, AADT, population density, population growth rate, and employment were calculated for each project type (beltway, bypass, connector, and widening) and the total dataset.

The FHWA economic development post-facto case studies were reviewed, and all relevant data collected. For consistency, only the interstate corridor case studies were included in our dataset for more specific comparison. Unlike the other case studies, the FHWA studies are compiled over a 50-year time horizon (1960's to 2000's) during various stages of project completion. In some cases, construction of the entire corridor occurred over three decades While the data has been annualized for comparison purposes, it is likely that other non-transportation factors are influencing the data. The data for these studies should only be compared with the other FHWA case studies. Cost data was only reported in a few case studies, therefore that metric was not included. Additionally, inflation of project costs in year of expense data would distort the cost value. Table 3 lists project information for each case study including project area, project length, comparison area, study time, and completion year. Table 4 shows the average annual growth rate in employment and population for the project area, comparison area, and state.

In contrast to the FHWA studies, the Missouri DOT and Kansas DOT case studies focused on a very specific project area and time horizon. Several case studies were on interchange improvement projects driven by economic growth and the longest project was the 14-mile James River Freeway in Springfield, Mo. Additionally, a port improvement project was studied by MDOT and the surface street improvements were only a part of the multi-modal improvements made as part of the project. Some interchange projects included adjacent widening of surface streets and/or the mainline interstate, however, this widening was usually of a negligible length. Table 5 lists the pertinent details of each case study from MDOT and KDOT. Due to the inclusion of interchange projects, project costs could not be compared on a per mile basis. Costs were assumed to be in year of expenditure dollars and the opening year was assumed to the year of expenditure for all projects. The year of expenditure costs were converted into 2013 dollars using the Consumer Price Index (CPI). Missouri DOT presented employment data in total percent change over the study period, therefore, the reported data was divided by the number of years in the study period to determine an annual average. Kansas DOT reported employment data in average annual percent change, so no additional modifications were required. Table 6 provides the study period, project cost, and average annual employment growth rate at the project, comparison, and regional spatial levels.

1.8 Conclusion of Literature Review

Former studies and existing methodology provide a solid base to begin building an index of ex-post facto economic impact studies for NCDOT. Trend analysis of pertinent economic impact factors will provide an

overall picture of how the project affected key economic factors within the study area. Additionally, utilizing existing economic impact models (i.e. TREDIS and IMPLAN), we can report dollar estimates for direct and indirect economic impacts for each project. Further, we can support the causality of the quantitative effects observed via a qualitative analysis based on interviews with businesses and local area experts. This review helped identify approaches to each of the tasks outlined above and will allow us to apply the most relevant and relevant methods to the ten North Carolina case studies.

1.9 Tables

Table 1. Economic impact measures.

Impact Category	Economic Measure	Highest Spatial Resolution	Data Sources
Real Estate Market	Property Values	Select ZIP codes, County	Decennial Census, American Community Survey (ACS)
	Transaction Data	Select metropolitan areas	Proprietary residential sales data
Private Investment	Capital Investment	Select local, county and statewide data	Economic Census
	Building Permits/ Construction Activity	County	Census Bureau: Residential Building Permit Data Series
Business Growth	Wages	Select metropolitan areas, county	Bureau of Labor Statistics (BLS) Employment Security (ES) 202 Covered Employment and Wages, County Business Patterns
	Jobs	Local	BLS: ES 202, County Business Patterns
	Number of Businesses	Local	BLS: ES 202, County Business Patterns
	Business Output	Local	Dun & Bradstreet: Prospecting Records or Economic Census
Overall Growth	Population	Block	Decennial Census
	Income	Block group	Decennial Census, Bureau of Economic Analysis (BEA): REIS Personal Income Series
Overall Growth	Economic Distress Ratio (local to national unemployment rate)	Select metropolitan areas, county	BLS: Local Area Unemployment Statistics
	Annual Average Daily Traffic	Local	NCDOT: Traffic Survey Group
	Tax Revenues	State	Census Bureau: Quarterly Summary of State & Local Tax Revenue

Table 2. Summary data from EconWorks case study dataset.

Project Name:	Project Type:	Project Length (mi):	Project Costs/Mi: 2013 $ (In Millions)	AADT:	Pop. Density (ppl/sq. mi)	Pop. Growth Rate (%)	Jobs Growth Rate %
I-476 Blue Route	Beltway	15.7	$62.14	106,000	3,006	0.04%	0.57%
E470 Denver	Beltway	47	$42.54	160,818	425	1.25%	0.55%
Beltway 8 Houston segments	Beltway	2.68	$54.91	190,107	2242	2.14%	1.42%
Danville, VA I-785 Bypass	Beltway	25	$12.06	20,100	2468	-0.58%	-0.60%
Fort Wayne, Indiana, I-469 Bypass	Beltway	30	$10.59	20,352	527	0.66%	0.46%
Appleton, Wisconsin, Route 441 Bypass	Beltway	10.9	$18.82	58,000	270	0.75%	1.11%
Richmond, VA I-295 Bypass	Beltway	52.75	$16.38	70,000	525	1.73%	1.81%
Bennington Bypass, VT 279	Bypass	4.2	$7.41	3,700	54	-0.18%	0.97%
Mercer Co. KY, US-127 Bypass	Bypass	4.9	$4.77	22,294	86	0.75%	0.78%
US-400 Parsons Bypass	Bypass	10.9	$3.02	19,572	34	-0.43%	-0.15%
Sonora & East Sonora SR49 & SR108	Bypass	2.2	$38.91	55,000	25	0.36%	2.19%
Hollister SR156	Bypass	5.5	$4.31	10,000	39	-0.06%	1.00%
Wichita Northeast Bypass	Bypass	10.5	$15.54	60,700	470	1.32%	0.84%
Stonewall Bypass	Bypass	10	$1.07	4,000	50	0.53%	2.84%
Verona Bypass	Bypass	2.7	$15.70	47,010	391	1.49%	2.00%
Fort Atkinson Bypass	Bypass	26	$1.14	8,700	143	0.53%	0.68%
Eastern Washington - SR 195 Bypass	Bypass	3.6	$5.34	19,774	19	0.44%	1.46%
Highway 141: Page-Olive Connector	Connector	2	$27.91	28,243	1954	-0.14%	-0.32%
US 25 Kentucky	Connector	2.2	$6.13	5,800	95	1.41%	0.48%
US 460	Connector	10	$23.38	12,275	268	0.58%	1.25%
Topsham Bypass/Connector	Connector	2.7	$21.53	21,545	285	0.49%	1.07%
Ted Williams Freeway	Connector	9.7	$25.85	110,146	702	0.54%	1.25%
Southern Connector	Connector	16	$14.44	7,200	527	1.52%	1.14%

Branson W (Ozark Mt. Highroad)	Connector	7.5	$14.40	2,970	69	1.75%	2.85%
I-705 Connector in Washington	Connector	1.5	$136.47	62,200	716	1.14%	1.97%
US Hwy 281, San Antonio (Extension)	Connector	8	$22.05	147,000	1247	1.90%	1.91%
I-394 Minnesota	Widening	10	$5.29	145,000	2028	0.06%	0.33%
US 75 North Central Expressway, Dallas	Widening	8.55	$50.12	242,000	2658	0.64%	-0.14%
Corridor Q, Appalachia	Widening	163.6	$12.60	24,000	114	0.03%	0.83%
Corridor J, Appalachia	Widening	243.5	$1.29	21,218	74	0.84%	0.73%
I-15 Reconstruction - Salt Lake City	Widening	17	$115.55	77,588	1343	1.60%	1.82%
I-86 NY Southern Tier	Widening	185	$9.71	13,023	75	-0.51%	-0.27%
Corridor D	Widening	70	$17.03	23,722	111	-0.13%	0.75%
Beltway Average:			$18.82[1]	89,340	1,352	0.86%	0.76%
Bypass Average:			$5.34[1]	25,075	131.1	0.48%	1.26%
Connector: Average:			$22.05[1]	44,153	651.44	1.02%	1.29%
Widening Average:			$12.60[1]	78,079	914.71	0.36%	0.58%
OVERALL AVERAGE:			$15.54	55,153	698	0.68%	1.02%

[1] Median Project Cost Per Mile

Table 3. Project information for FHWA economic development post-facto case studies.

Project Name:	Project length (mi):	Project Area:	Comp Area:	Study Period	Open Date:
I-86, New York	185	Allegany, Cattaraugus, and Chautauqua counties --> "Southern Tier West Region"	Central North Country region; St. Lawrence and Franklin Counties	1990 - present	1999
I-68, "The National Freeway"	82	Link between Washington-Baltimore and the Midwest, from Hancock, MD to I-79 near Morgantown, WV	State of Maryland	1969-2011	1991
I-81 in Pennsylvania	234	Harrisburg, PA (state capital) and Wilkes-Barre/Scranton metro; connectivity to Syracuse, NY and Hagerstown, MD	State of Pennsylvania	1969-2011	1969
I-16 in Georgia	167	Savannah to Macon, GA; Port access in Savannah, cross-roads with I-95 and terminates at I-75	Non-metro Georgia	1969-2002	1978
I-29 in Iowa	152	MO, IA, SD, ND; in IA, Kansas City, Council Bluffs, Omaha, Sioux City, IA	Non-metro Iowa	1696-2002	1973
I-26 in South Carolina	221	Connects SC, NC, and TN; in SC, Charleston, Columbia, Greenville, and Spartanburg	State of SC	1969-2011	1969
I-27 in Texas	124	North-south route between Amarillo and Lubbock in northwest Texas	Non-Metro TX	1969-2002	1992
I-81 in Virginia	325	I-81 connects the northeast with the deep south; in VA it passes through Bristol, Roanoke, Harrisonburg, and Winchester	Non-Metro, VA	1969-2002	1971
I-43 in Wisconsin[2]	120	North-south interstate between Milwaukee and Green Bay, WI	State of Wisconsin	1960-2000	1981

Table 4. Annualized employment and population data for FHWA economic development case studies.

Project Name:	Average annual % change in employment			Average annual % change in population		
	Project	Comp.	Statewide	Project	Comp.	Statewide
I-86, New York	0.05%	0.03%	0.13%	-0.11%	0.29%	0.55%
I-68, "The National Freeway"	0.84%	N/A	1.36%	0.44%	N/A	0.94%
I-81 in Pennsylvania	0.78%	N/A	0.65%	0.33%	N/A	0.25%
I-16 in Georgia	1.73%	1.77%	2.73%	0.87%	1.03%	1.90%
I-29 in Iowa	1.03%	0.80%	1.30%	0.10%	-0.17%	0.10%
I-26 in South Carolina	1.78%	N/A	1.60%	1.46%	N/A	1.34%
I-27 in Texas	2.50%	1.50%	3.13%	0.77%	1.03%	2.10%
I-81 in Virginia	1.47%	0.93%	2.00%	1.27%	0.73%	1.43%
I-43 in Wisconsin[2]	2.00%	N/A	1.67%	0.25%	N/A	0.83%
FHWA Averages:	1.35%	1.01%	1.62%	0.60%	0.58%	1.05%

Table 5. Project information for Missouri DOT and Kansas DOT.

Project Name:	Project Description:	Length (mi):	Project Area:	Project Type:
I-70 Interchange at Little Blue Parkway – Independence, Mo.	Arterial widening (Little Blue Parkway), new interchange with I-70	N/A	SE corner of Independence, MO; Urban	Interchange
Highway 370 – St. Louis, Mo.	New 12-mile 6-lane limited access highway; eight interchanges, crosses the Missouri River	12	St. Charles and St. Louis Counties, Urban	New Highway
James River Freeway – Springfield, Mo.	14-mile freeway along southern border of city, interchanges with north-south arterials; US 65 and I-44	14	Springfield, Mo.; Urban	New Highway
East 32nd Street (Mo. Route FF) – Joplin	Widening of an arterial, new interchange with I-49; located in region hit by a bad tornado	2	Joplin, Mo., Urban	Widening
Riverside Road (Missouri Route AC) – St. Joseph	Extended an arterial to connect with US 169 to St. Joseph	2	North of Kansas City	Extension
The Port at New Madrid, Mo.	2.1 mile widening into a 4-lane access-controlled highway; Port of New Madrid; near St. Jude Industrial Park	N/A	North of City of New Madrid, east of I-55	Port improvements; paving, railway construction
Economic Impact of Grindstone Parkway (Route AC) – Columbia, Mo.	2.1 mile widening into a 4-lane access-controlled highway,	2.1	South of Columbia, Mo. Urban	Connector

[2] Original section from Milwaukee to Green Bay

Avenue of the Saints – Bowling Green, Mo.	Upgrading highway to four-lane cross-section, construction of two interchanges	N/A	Bowling Green, Mo.	Interchange
US 400 Parson Bypass, Labette County, KS	Upgraded to "Super Two" configuration, four lanes near Wichita, access controlled, higher design speed	10.5	Parsons, KS	Bypass
K-96 Northeast Bypass, Wichita, KS	New highway linking the northeastern Wichita suburbs; I-135 to west, Kansas Turnpike/US-54 to east; four-lane access-controlled	10.5	NE Wichita, KS,	Beltway/Bypass
I-70 & 110th St. Interchange, Wyandotte County, KS	Interchange modification with adjacent arterial improvements	N/A	W of Kansas City	Interchange
I-435 and Nall/Roe Interchange – Overland Park, KS	New interchange I-435 & Nall Ave; existing overpass; concurrently I-485 was widened to 8 lanes from 6 lanes, Nall Avenue was widened to six lanes; Sprint paid for $4.5 million in road improvements [turn lanes]	N/A	Kansas City metro (Johnson County, Kansas)	Interchange
Commerce Parkway Interchange, Hays, Ellis County, KS	New diamond interchange with Commerce Parkway, Commerce Parkway originally a gravel access road to Hays Airport Industrial Park, paved as port of the project.	N/A	On I-70 west of Kansas City	Interchange, road improvement

Table 6. Study period and average annual job growth rate for Missouri DOT and Kansas DOT case studies.

Project Name	Study Period	Project Cost (in 2013 million of $)	Average Annual Job Growth Rate		
			Project	Comparison	Region
I-70 Interchange at Little Blue Parkway - Independence, Mo.	2000-2010	$112.66	-1.04%	-1.22%	0.87%
Highway 370 - St. Louis, Mo.	1995-2010	$2,564.29	0.53%	0.48%	0.96%
James River Freeway - Springfield, Mo.	1995-2010	$834.40	1.04%	1.10%	1.57%
East 32nd Street (Mo. Route FF) - Joplin	1997-2010	$121.18	1.20%	0.04%	4.55%
Riverside Road (Missouri Route AC) - St. Joseph	2006-2010	$125.44	-1.23%	-2.20%	0.60%
The Port at New Madrid, Mo.	2008-2010	$28.08	0.00%	N/A	8.55%
Economic Impact of Grindstone Parkway (Route AC) - Columbia, Mo.	2004-2010	$188.40	0.32%	0.48%	1.83%
Avenue of the Saints - Bowling Green, Mo.	1998-2010	$239.40	-0.21%	-2.01%	4.93%
Missouri Average:		$526.73	0.08%	-0.48%	2.98%
US 400 Parson Bypass, Labette County, KS	2004-2006	$338.25	0.98%	3.91%	5.76%
K-96 Northeast Bypass, Wichita, KS	1994 - 2006	$1,671.84	1.50%	0.20%	7.30%
I-70 & 110th St. Interchange, Wyandotte County, KS	2001-2006	$651.07	0.20%	5.80%	17.20%
I-435 and Nall/Roe Interchange - Overland Park, KS	1998 - 2006	$706.64	1.00%	-0.80%	9.60%
Commerce Parkway Interchange, Hays, Ellis County, KS	1995 - 2006	$51.26	1.52%	-0.65%	2.52%
Kansas Average:		$683.81	1.04%	1.69%	8.48%
TOTAL Average:		$587.15	0.45%	0.43%	5.10%

1.10 References

Cambridge Systematics. (2012). *Assessing the economic benefit of transportation infrastructure investment in a mature surface transportation system*. Cambridge Systematics: Bethesda, MD.

Cambridge Systematics et al. (2008). *Economic impact study of completing the Appalachian development highway system*. Prepared for the Appalachian Regional Commission.

Cervero, R. & Aschauer, D. (1998). *TCRP report 35: Economic impact analysis of transit investments: Guidebook for practitioners*. Transportation Research Board, National Academy Press: Washington, D.C.

Chester, M.V., Nahlik, M.J., Fraser, A.M., Kimball, M.A., & Garikapati, V.M. (2013). Integrating life-cycle environmental and economic assessment with transportation and land use planning. *Environmental Science Technology, 47*, 12020-12028. doi:10.1021/es402985g

Diaz, R., Behr, J.G., & Ng, M.W. (2016). Quantifying the economic and demographic impact of transportation infrastructure investments: A simulation study. *Simulation: Transactions of the Society for Modeling and Simulation International, 92*(4), 377-393. doi:10.1177/0037549716632343

Duncan, C., Landau, S., Cutler, D., Alstadt, B., & Petraglia, L. (2012). Integrating transportation and economic models to assess impact of infrastructure investment. *Transportation Research Record: Journal of the Transportation Research Board, 2297*, 145-153. Transportation Research Board of the National Academies: Washington, D.C. 145–153. doi:10.3141/2297-18

Duncan, C. & Weisbrod, G. (2015). *NCHRP Synthesis 480: Economic and development implications of transportation disinvestment*. Transportation Research Board: Washington, D.C.

Eberts, R. (n.d.). *Understanding the impact of transportation on economic development*. Minnesota Department of Transportation Committee on Transportation and Economic Development: St. Paul, MN.

Economic Development Research Group, Inc. (2011). SHRP2 C03: Interactions between transportation capacity, economic systems, and land use DTFH6 I -06-H-00009 Phase I1, Tasks 4 – 9 Transportation Project Impact Case Studies (TPICS): Case Study Design.

Economic Development Research Group. (2015). *Assessing Productivity Impacts of Transportation Investments: Guidebook, NCHRP Project 02-24*. National Cooperative Highway Research Program: Transportation Research Board (forthcoming, 2014).

Economic Development Research Group (EDR Group) & Cambridge Systematics (2001a). *Using empirical information to measure the economic impact of highway investments, Volume I: review of literature, data sources, and agency needs*. Federal Highway Administration.

Economic Development Research Group (EDR Group) & Cambridge Systematics (2001b). *Using empirical information to measure the economic impact of highway investments, Volume II: guidelines for data collection and analysis*. Federal Highway Administration.

Economic Development Research Group (EDR Group) & Cambridge Systematics (2015). *EconWorks user's guide*. American Association of State and Highway Transportation Officials (AASHTO).

EPA: US Environmental Protection Agency (2010). *Guidelines for preparing economic analyses*. updated in 2014.

FHWA: Federal Highway Administration (2003). *Economic impact study of the I-86 corridor*. US DOT.

FHWA: Federal Highway Administration (2002). *Economic and land use impacts study of state trunk highway 29: phase I Chippewa Falls to Abbotsford, Wisconsin*. US DOT.

FHWA: Federal Highway Administration (2013). *Economic development history of I-81 corridor*. US DOT.

FHWA: Federal Highway Administration (2013). *Economic development history of interstate 68 in Maryland*. US DOT.

FHWA: Federal Highway Administration (2013). *Economic development history of interstate 26 in South Carolina*. US DOT.

FHWA: Federal Highway Administration (2005). *Economic effects of selected rural interstates at the county level*. US DOT.

HSC: High Street Consulting Group. *Transportation infrastructure investments and economic growth: Five Kansas case studies*. Kansas Department of Transportation.

Konduri, K., Lownes, N.E., Angueira, J., Shannon, D., DeJonge, A.K., Ford, C., Strauss, R.H., Clark, T., & Bertini, A.G. (2013). *Analyzing the Economic Impacts of Transportation Projects*. Connecticut Academy of Science and Engineering.

Lorenz, J. (2011). Building support for new transportation funding and financing program: Linking investments to stakeholder priorities through collaboration and economic impact analysis. *Transportation Research Record: Journal of the Transportation Research Board, 2245*. Transportation Research Board of the National Academies: Washington, D.C. 8–16. doi:10.3141/2245-02

Mikesell, J.L., Wang, J.Q., Zhao, Z.J., & He, Y. (2015). Impact of transportation investment on economic growth in China. *Transportation Research Record: Journal of the Transportation Research Board, 2531*, 9-16. Transportation Research Board: Washington, D.C. doi:10.3141/2531-02

MODOT: Missouri Department of Transportation (2013). *Missouri long range transportation plan*. MODOT.

Morris, J.R., McGuire, T.J., Alexander, J., Dupor, W.D., Eberts, R.W., Epstein, R.L., Haughwout, A., Jones, B.F., Richardson, N.J., & Shambaugh, J.C. (2014). *Special report 312: Transportation investments in response to economic downturns*. Transportation Research Board: Washington, D.C.

NC Legislature. (1989). *North Carolina Highway Trust Fund Act*. General Statutes §136, Article 13, 175-186.

Oster, C.V., Rubin, B.M., & Strong, J.S. (1997). Economic impacts of transportation investments: The case of Federal Express. *Transportation Journal, 37*(2).

Schultz, G.G., Searle, J.E., & Saito, M. (2010). *Understanding the Economics of Transportation in Utah*. Utah Department of Transportation.

Thompson, Eric et al (2008). *Evaluating roads as investments: A primer on benefit-cost and economic-impact analyses*. University of Nebraska, Bureau of Business Research Publications, No. 5.

Transportation Research Board (2012). *SHRP 2 Report S2-C03-RR-1: Interactions between transportation capacity, economic systems, and land use*. National Academy of Sciences.

Transportation Research Board (2012). *New Tool for estimating economic impacts of transportation projects: Transportation Project Impact Case Studies (T-PICS)*. Transportation Research Board: Washington, D.C.

Transportation Research Board of the National Academies. (2013). *Development of tools for assessing wider economic benefits of transportation*. National Academy of Sciences: Washington, D.C.

Weisbrod, G. & Weisbrod, B. (1997). Assessing the economic impact of transportation projects: How to choose the appropriate technique for your project. *Transportation Research Circular, 477*.

Wisconsin Department of Transportation. (1998). *The Economic Impacts of Highway Bypasses on Communities*. Wisconsin Department of Transportation: Madison, WI.

2 Methodology

A review of previous literature and ex-post facto analyses of transportation projects formed the basis for the analytical methodology applied to the case studies included in this report. EconWorks, an economic analysis platform created from the second Strategic Highway Research Program (SHRP2) and maintained by AASHTO, includes several analytical methods to derive the economic impacts of a proposed transportation improvement. To support the development of these tools, 100 post-facto case studies were compiled for projects of diverse types around the country. After the initial effort was completed, another 25 case studies were added to the database. The case studies within this report will be submitted for inclusion into the EconWorks database, therefore our methodology follows the general process utilized in previous studies included in the database.

2.1 Project Selection and Data Retrieval

The research team, in consultation with the NCDOT, compiled a list of 21 projects from across the state to consider for evaluation and analysis. From that list, 10 projects were selected based on project cost, year of completion, project type, and data availability. The projects were chosen to create a sample that represent both urban and rural areas across western, central, and eastern regions of North Carolina. The types of projects included were narrowed down to the following: widening, bypass, beltway, and connector projects in the west, central, and eastern regions of North Carolina.

For this study, the NCDOT provided all project data including the initial environmental/planning documents (project breakdown maps, Environmental Analyses (EA), Findings of No Significant Impact (FONSI), Environmental Impact Statements (EIS), construction timeline, and project cost information. The alignment of each project was provided in an ESRI shapefile for spatial analysis (i.e. GIS).

The following ten transportation projects were chosen for analysis: 1. I-540 Northern Wake Expressway (R-2000 & R-2641) 2. US-64 Widening (R-2548) 3. Jacksonville Bypass (U-2107) 4. US-70 Clayton Bypass (R-2552) 5. Greensboro Southwest Loop (I-2402 & U-2524) 6. I-485 Charlotte Outer Loop (R-2248) 7. I-140 Wilmington Bypass (R-2633) 8. U-15/US-501 (R-942) 9. US-1 Cameron/Vass Bypass (R-210) 10. US-421 Widening (R-2120, R-2239 & R-2240)

2.2 Project Area Identification

A five-mile buffer was created around each project segment to identify spatial areas. This buffer area was used to identify all sub-county geographic areas, including block groups, census tracts, and zip code boundaries. Census Bureau statistical area definitions were applied to the buffer area of each project and any relevant micropolitan, metropolitan, and combined statistical areas identified. Projects not located within a Census Bureau statistical area were classified as rural for analysis purposes. County and municipal boundaries were identified from GIS shapefiles provided by NCDOT. Relevant geographic data were included on the regional and vicinity maps produced for each project.

2.3 Spatial Comparison Areas

Spatial comparison areas were established to compare project data with adjacent areas like the project area. The geographic extent of the comparison area was determined by the metric compared and the urban/rural

nature of the project. Metrics reported at sub-county spatial regions were typically compared to the rest of the project counties. County-level data was typically compared to data from adjacent counties with the number of counties comprising the comparison area determined by the relative size and scope of the subject project. Data was also collected at various spatial extents including county, regional, and statewide data. Analysis of wider spatial areas can identify variation between project-level trends and wide-area trends, possibly indicating a project impact.

2.4 Quantitative Analysis

Temporal analysis varies on a per project basis, typically starting the year before construction and ending at the shorter of five years or the most recent year with data available. Economic impacts tend to develop over time, therefore, sufficient time should have passed before completing an ex-post facto analysis. Decennial Census Bureau data was collected in 1990, 2000, and 2010. If project construction starts before 2000, 1990 data is used for the beginning of the temporal region, otherwise 2000 data is used for pre-construction data. 2010 data was used for post-construction values for all projects, even if construction was not complete in 2010. For other census data sources, an analysis of time-based effects required at least four data points. The following time periods were chosen:

1. Before project construction
2. At the time of project completion
3. Within a year after project completion (short-term effects)
4. Between five and ten years after project completion (long-term effects)

2.4.1 Selection of Economic Impact Measures

The six impact measures analyzed for each case study include the following: jobs and unemployment rate, income, number of businesses, population, property values, and capital investment. These measures comprise the core analysis profile to quantify possible economic impacts and are supplemented by relevant data specific to each project. All measures except capital investment are included in the quantitative data analysis. Capital investment is analyzed qualitatively via interviews with various project stakeholders in which specific examples of business growth due to the transportation project of focus are identified. The table below summarizes the data metrics and data sources for the economic impact measures featured in the case studies.

Table 7. Six impact measures of focus in the case studies.

Impact Category	Economic Impact Measure	Data Source
Property Demand	Property values	Decennial Census and ACS
	Income	Decennial Census and ACS
Business Growth	Jobs	County Business Patterns
	Number of businesses	County Business Patterns
	Population	Decennial Census
Overall Growth	Economic distress (area unemployment rate relative to national)	BLS: Local Area Unemployment Statistics

In the case when the data point five-years post-construction is not available, the following order of effects was consulted (EDRG, 2012) to determine whether the early indicators of economic growth are present within the study area:

- Change in land prices/valuation (as demand grows for some locations)
- Change in property sales volume and prices (as land is purchased for new or more intensive uses)
- Change in amount of construction spending (as building investment is made for new or more intensive uses)
- Change in employment, income, and total business sales (as buildings are occupied)
- Change in public-sector tax revenues

For example, if a project is completed in 2014 we do not have 2019 data. However, if we see an increase in median house value and property sales, but no significant changes in income or employment a year after construction it still suggests economic growth is occurring post-project completion.

2.4.2 Economic Impact Measure Definitions

3.4.2.1 Economic distress

Economic distress (i.e. the ratio of the local/regional unemployment rate to the national unemployment rate) is reported in EconWorks case studies and provides a comparison of local unemployment rates to statewide and national economic conditions.

3.4.2.2 Unemployment rate

State, regional, and local unemployment rates are reported individually. Unemployment rates are the ratio of unemployed persons seeking employment to the labor force (persons employed or seeking employment) and are often cited by stakeholders (Lorenz, 2011). At smaller spatial regions, the unemployment rate can be influenced by persons dropping out of the labor force and seasonal employment. To supplement unemployment data, the total number of jobs (i.e. the total number of employed persons) was collected from County Business Patterns at the zip code (study area), county, and state levels. This metric is also used to calculate the number of jobs created in each study area/time.

3.4.2.3 Income and wages

According to the review of existing literature (EDRG, 2001a), wages are a more accurate measure of economic growth than median household income or personal per capita income. However, we were unable to obtain wage data with enough granularity to observe project effects for all ten case studies. Conversely, median household income data is available at the block group level for every case study, so we determined median household income is better for our purposes. Median household income was obtained from the 1990, 2000 decennial census and the American Community Survey (ACS) five-year estimate datasets. After the 2000 Census, median household income was removed from the Decennial Census and incorporated into the ACS. The ACS surveys about 3.5 million households per year, and data is averaged over several years to provide a more complete sample. County Business Patterns data were used to determine the number of businesses in the defined study area and surrounding area. Business output and revenue data were not available at the spatial resolution needed for analysis, therefore this data is not included in the case studies.

3.4.2.4 Population and population density

Total population and population density data was sourced from Decennial Census data in 1990, 2000, and 2010 at the block-group level. Changes in population between census years can indicate local and regional growth patterns. Population density also captures changes in the housing market by identifying the migration of the population over the decade interval between census years.

3.4.2.5 Median house value

Impacts to the real estate market are commonly cited to support or oppose transportation investments. Median house value was obtained from the 1990, 2000 decennial census and the American Community

Survey (ACS) five-year estimate datasets. After the 2000 Census, median house value was removed from the Decennial Census and incorporated into the ACS. The ACS surveys about 3.5 million households per year, and data is averaged over several years to provide a more complete sample.

3.4.2.6 Tax-assessed parcel data

To supplement real estate data from the Census and ACS, parcel data were obtained from NC OneMap, the geospatial data clearinghouse for data from county, state, and federal agencies. The statewide parcel data set displays the spatial boundaries of each parcel and contains a large attribute table providing data on the tax-assessed value of the parcel, the owner's information, the parcel identification number (PIN), parcel use classification, number of structures, year of structure construction or most recent improvement, and source documents. The data provided in the geospatial dataset are provided by the individual county and the availability of data for each attribute depends on the county. This data will be used to identify parcels with structures (e.g. houses, commercial, and industrial), and the year the structure(s) were built or most recently improved. This data shows construction activity and new development over the study period.

2.4.3 Estimating Economic Impacts

Based on the expected order of effects, we can estimate the extent of a project's impact. The results of each impact measure are presented as line graphs. Each project is analyzed in IMPLAN and TREDIS to estimate its net direct and indirect economic impacts. In addition, choropleth maps are created for wages and population density using the start and end dates of a project's construction, or the two census data points that correspond most closely with the start and end dates of the project's construction for population density. Based on the general timeline of effects outlined above, average annual growth rates were calculated for each economic impact measure. Comparing the growth rates within each impact measure provides an estimate of the project's effect on that economic measure. Trend analysis is preferred over actual magnitude analysis for each specific impact measure as the literature suggests trend analysis builds a stronger case for causation between a project's construction and observed changes in economic measures (EDRG, 2001a).
Capital investment is analyzed purely on a qualitative basis via interviews with area experts and local businesses. The decision to analyze capital investment qualitative is two-fold: 1) the literature review did not identify a consistent data source for quantitative analysis and 2) the literature indicates that interviews provide the strongest case to establish causation between economic growth and the construction of a project (EDRG, 2001a).

2.5 Qualitative Analysis

2.5.1 Interviews

Area context and specific impacts related to the transportation projects were identified through interviews with the following groups: local governmental officials, economic development experts, local business owners, local community members, and NCDOT officials that were involved in the project. For each case study, 5-8 interviews between 30-60 minutes in duration were completed. Interview participants were selected based on their physical proximity to the project, snowball sampling, and mentions in project planning documents (e.g. EIS, EA, etc.). Interview questions, as well the list of interview participants, were specific to each case study and are cited in the Appendix of each case study. Interviews were audio recorded, transcribed, and then their content was thematically analyzed. Interviews were open coded and then closed coded to quantify the themes identified during interviews.

2.5.2 Surveys

Brief telephone surveys were completed with a goal of at least 20 local business owners to identify examples of businesses that had located in the area in part because of the transportation project. Area businesses were identified based on their proximity to the transportation project of focus in each case study, a methodology supported by EconWorks. Interview questions, as well the list of interview participants, were specific to each case study and are in the respective Appendices of each case study.

2.5.3 Other Supporting Data

Other supporting qualitative data may be available and will be included in the case studies pending its availability as well as time and resources needed to adequately collect and analyze this data. One potential source of data includes community and agency letters and speakers recorded in the EIS, which could provide information on public concern and/or involvement. Another source of qualitative information was relevant newspaper articles, which were extracted from the LexisNexis database for project background information as well as area context relevant to area economic impacts.

2.6 Case Study Organization

The case study narrative was derived from EconWorks and reflects the following basic structure:

- **Synopsis** - A summary of the project history and its outcomes.
- **Background** - Describes the local project context including the area's economic history and the existing major transportation facilities.
- **Project Description and Motives** - Describes the project and why it was built.
- **Project impacts** - Discusses the accessibility, demographic, economic, and land use impacts of the project on the study area.
- **Non-transportation factors** - Discusses other factors that influenced project outcomes (e.g., supportive policies and incentives). Considers other factors present in the area which may have enhanced or diminished the impacts observed in the area. Based on the existence of other factors, only a portion of the positive or negative economic impacts can be attributed to the project. The final allocation of causality for each project is determined via the interviews.
- **References** – A list of case studies, journal articles, reports, and interviews used to develop the case studies.
- **Appendix** - Includes line graphs and maps used for trend analyses in the case study.

3 Case Summaries

3.1 Northern Wake Expressway

The Northern Wake Expressway (I-540) is a six-lane, median divided highway that connects the cities of Knightdale and Morrisville north of Raleigh. The main motivations cited for this project were congestion mitigation and facilitating economic growth in the area. Our qualitative analysis indicates the first of these goals was accomplished as an in-depth interview with a government official stated that the I-540 project helped alleviate congestion and improve travel time in the Northeast portion of Wake County, including travel to the Raleigh-Durham airport. In addition, this study revealed the Northern Wake Expressway likely contributed to employment and business growth within the study area. Between pre- and post-construction dates we observed increases in both employment (3.3% per year) and number of businesses (3.2% per year) within the study area. We also observed sharp increases in trends for both these measures around I-540 construction begin and end dates within the study area compared to the trends observed for the surrounding area and state. Further, in-depth interviews with knowledgeable local economic development experts and government officials indicate that the Northern Wake Expressway attracted a significant amount of business to the area, and specifically mention the proliferation of warehouses in the area near I-540. Additionally, brief interviews with businesses located near the project revealed that I-540 also facilitated growth in retail and service industry within the study area. These results all indicate I-540's construction achieved its second goal of facilitating economic growth in the area. The in-depth interviews also mention the Raleigh area population exploded during the same years the project was constructed, which coincides with the substantial increase we observed in population (7.3% per year) between beginning and end of construction. However, we did not observe an increase in house value mentioned in one of the in-depth interviews that often occurs along with heavy residential growth in an area. We believe the size of our study area limits our ability to observe effects on residential property value in close proximity to the highway; however, a more complex analysis looks at property prices for this project and is discussed in a separate section of our report. Finally, we observed a decrease in median household income between pre- and post-construction dates within the study area, but our trend analysis reveals that the surrounding area and state experienced nearly identical decreases. This indicates the economic climate during the time of construction is likely responsible for the decrease observed and suggests the Northern Wake Expressway did not heavily alter the job/wage composition within the study area. The qualitative results support this based on the marked increase of warehousing industry specified earlier and no mention of a higher-wage employers locating to the area. In summary, the qualitative and quantitative results of this study indicate the Northern Wake Expressway provided overall positive direct economic impacts to the study area, mostly conveyed via business development and employment growth. A summary of annual impacts is provided in **Error! Reference source not found.**.

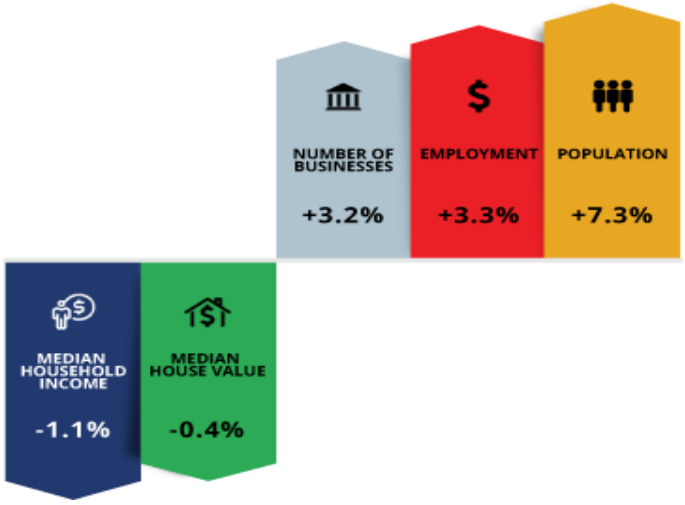

Figure 1. Overall summary of impacts for the Northern Wake Expressway.

3.2 US-64 Widening

US-64 was widened from 2002 to 2012 between Plymouth and Columbia, creating a bypass between the two cities. The motivation for the project was mainly for congestion mitigation as well as to support economic growth and ease of access to the Outer Banks, a major tourist destination in NC that continues to experience growth (James, 2010). The 2008 recession likely stagnated growth in the study area (Gitterman, Coclanis & Quinterno, 2012; CPWO, 2010). Rural communities tend to experience greater negative economic effects as well as longer recovery periods in comparison to urban ones (Sato, 2015). Urbanization, a trend in which the populace migrates to urban areas, is another influence on the findings of this study (Gitterman et al., 2012; CPWO, 2010). The choropleth maps show that the US-64 widening project may have concentrated growth near Plymouth, Columbia and the Outer Banks, while economic activity was stifled between Plymouth and Columbia, which is typical of bypasses. Roper and Creswell were two towns that were bypassed by the road and experienced economic losses. Through surveys, at least five businesses cited the widening of US-64 as a reason for locating their businesses in Plymouth or Columbia. Figure 2 depicts averaged annual percent changes in changes in US Census and economic measures surrounding project construction. Population, population density, and median household income did not change during the selected time period. However, small decreases in median house value, number of businesses, and employment were observed.

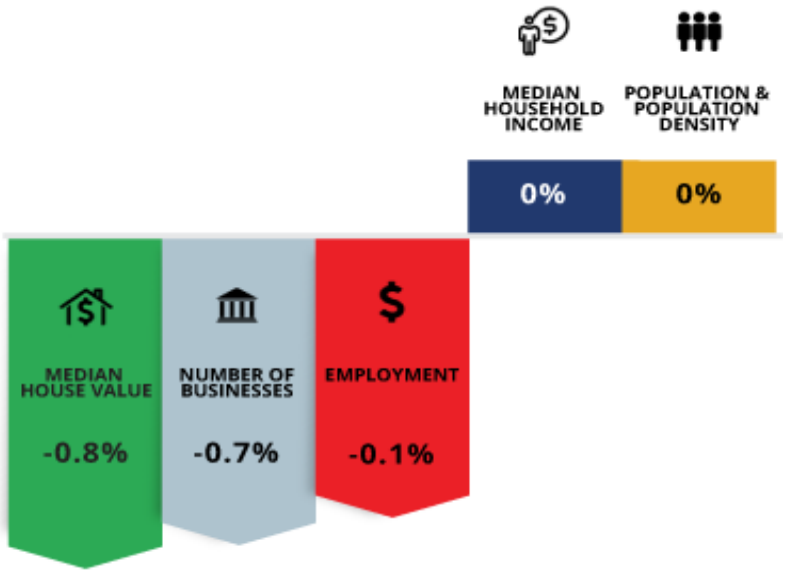

Figure 2. Overall summary of impacts for the US-64 Widening project.

3.3 Clayton Bypass

The Clayton Bypass is a six-lane, median divided highway that was constructed between 2005 and 2010 that bypasses the town of Clayton, beginning near Wilson's Mills and ending in Saint Mary's. The primary motivations for the project included congestion mitigation along the alternative route through Clayton, labor market access, and facilitating an intrastate corridor. Our qualitative analysis indicates these goals were achieved as two out of three local interviewees stated there would be more congestion along US-70 Business through Clayton if the bypass had not been built. Additionally, all three interviewees mentioned Clayton Bypass improved connectivity between the Raleigh/Research Triangle area and Clayton and decreased commuter travel time for Clayton area residents who worked in Raleigh or the Research Triangle. In addition to accomplishing its documented purpose, our qualitative analysis found increases in the number of businesses (2.1% per year) and employment (2.5% per year) between pre- and post-construction years in the area surrounding the Clayton Bypass project. In-depth interviews from knowledgeable local economic development experts and government officials acknowledge economic growth during this period, specifically mentioning the Johnston County Health System as the most influential area business and a notable increase in the service industry. Importantly, the interviewees partially credit the bypass as a reason for the Johnston County Health System moving to the area. This coincides with the results from our business interviews, as the majority of businesses (2 of 3) that cited Clayton Bypass as a reason for locating to the area were health care facilities. We also observed a heavy increase in population (5.8% per year) and no change in median house value (-0.3% per year) in the area surrounding the bypass. These results suggest the project spurred housing development, but did not significantly influence the price gradient of housing in the area. The qualitative analysis supports these findings as in-depth interviews mentioned an increase in housing development around the Clayton Bypass, but no participant stated a shift in type or value of residential property in the area. Finally, the in-depth interviews indicate the project did not significantly change the employment composition aside from a small increase in service jobs. This finding along with knowledge that a recession occurred near the project's completion coincide with the observed decrease in median household income (-1.2% per year). In summary, the qualitative and quantitative results of this study indicate the Clayton Bypass provided some direct economic benefits to the study area, conveyed via increased housing development and partially influencing the influx location of health care and service industry to the area. However, in-depth interviews stressed the primary purpose and benefits of the Clayton Bypass were indirect impacts such as improved connectivity and access between Clayton and Raleigh for commuters. A summary of annual impacts is provided in Figure 3 below.

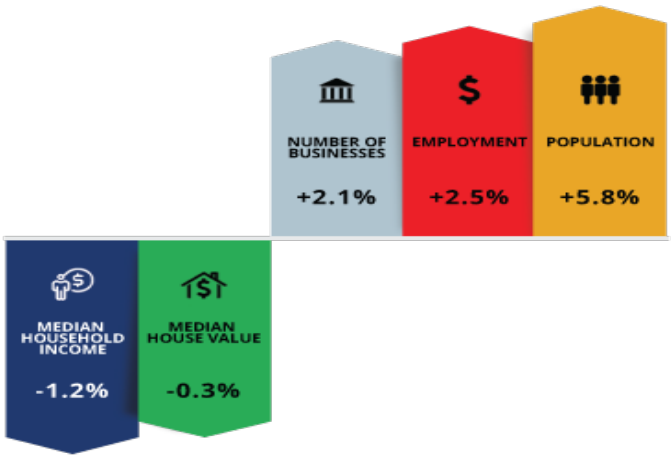

Figure 3. Overall summary of impacts for the Clayton Bypass

3.4 Jacksonville Bypass

The Jacksonville Bypass is a six-lane, median divided highway constructed between 2003 and 2013 that bypasses downtown Jacksonville. The main motivations cited for this project were congestion mitigation and safety improvement for the alternative route in the Jacksonville transportation network. Our qualitative analysis indicates these goals were accomplished as all local interviewees stated that the construction of the bypass alleviated congestion and improved safety along the alternative route with 80% adding that the bypass improved their daily commute travel time. In addition to achieving its documented purpose, this study revealed that the Jacksonville Bypass likely contributed to increases in area residential development and employment as well. Between pre- and post-construction dates we observed a 1.6% average annual increase in median house value within the study area compared to a period of stagnation observed during the decade prior to construction. This coincides with in-depth interviews from knowledgeable local economic development experts and government officials who suggested residential development patterns shifted to be concentrated around the bypass as it provided access and mobility to the surrounding area. Notably, one interviewee states a shift in residential patterns, but not an increase which falls in line with our results showing negligible change in population growth trends between the period of construction and the decade prior to construction. Further, we observed a 2.4% average annual increase in employment within the study area between pre- and post-construction dates and a 0.6% average annual increase in the number of businesses. Brief interviews with local businesses along with the in-depth interviews suggest the Jacksonville Bypass spurred more business relocations than entirely new developments and noted several smaller businesses who were unable to relocate from the alternative route failed. In addition, in-depth interview participants largely noted an overall increase in business activity, specifically mentioning the establishment of large franchises such as Walmart and Lowe's. These findings support the quantitative results; even though we find a small increase in the number of businesses (0.6% per year), the large scale of some of the new businesses explains the higher increase in employment (2.4% per year). Finally, one in-depth interview participant stressed that the commercial composition in Jacksonville did not change when the bypass was constructed which helps explain why we did not observe an increase in median household income between pre- and post-construction dates within the study area. In summary, the qualitative and quantitative results of this study indicate the Jacksonville Bypass provided overall positive direct economic impacts to the study area, mostly conveyed via residential development and employment growth. A summary of annual impacts is provided in Figure 4.

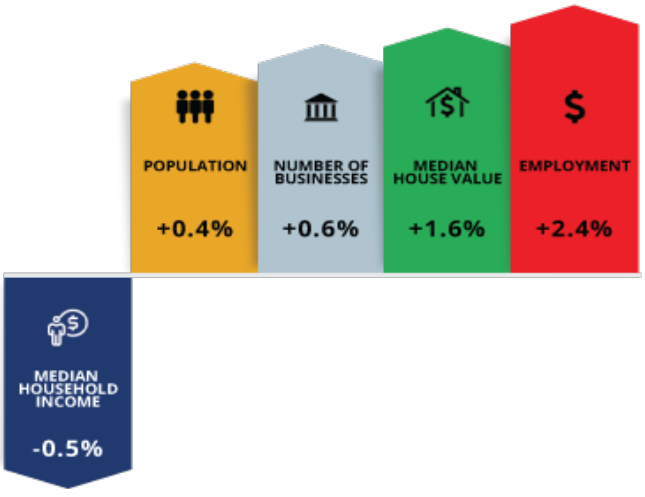

Figure 4. Overall summary of impacts for the Jacksonville Bypass.

3.5 Greensboro Southwest Loop

The Greensboro Southwest Loop (GSWL) is an eight-lane, median divided beltway constructed between 1997 and 2008 that encircles two-thirds of the city of Greensboro. The main motivations cited for this project were congestion mitigation and safety improvement for alternative routes and improve the overall service (i.e. increased capacity and connectivity) of Greensboro's transportation system. Our qualitative analysis indicates these goals were accomplished as all local interviews (4 of 4) stated the GSWL alleviated congestion and improved safety along the various alternate routes and each interviewee mentioned their daily commute would take longer if the GSWL had not been built. Further, these interviews revealed the beltway made it easier to travel in and out of Greensboro as well as travel around Greensboro. Finally, one participant stated the GSWL improved statewide mobility, particularly for commuters between Charlotte, Raleigh, and Greensboro. In addition to achieving its documented purpose, this study revealed the GSWL likely contributed to area business development and employment. We observed an increase in number of businesses (0.9% per year) and employment (1.7% per year) across the entire project. A secondary analysis that split the project into its I-2402 and U-2524 components revealed the majority of economic development occurred surrounding the U-2524 project segments. The overall results coincide with in-depth interviews from knowledgeable local economic development experts and government officials who believe businesses have located to the area because of the project and mentioned a notable increase in grocery, restaurant, and retail franchises such as Harris Teeter, Cracker Barrel, and Walmart. Interviews conducted with businesses in the area further support our qualitative observations as four out of ten participants cited the GSWL as a reason for locating to the area and all four businesses belonged to the service industry. Additionally, one in-depth interview stated there was an increase in residential development around the project while another interviewee believed commuters have moved closer to the project after its completion. A third in-depth interview participant stated that zoning in the area had changed over time with the project and real estate prices had increased. All these findings support our observed increase in population (2.3% per year), but we do not see the increase in real estate value mentioned. We believe the size of our study area limits our ability to observe real estate effects in close proximity to the highway; however, a more complex analysis looks at property prices for this project and is discussed in a separate section of our report. Finally, in-depth and business interviews reveal an increase in service industry jobs and mention no new source of high-value jobs locating to the area, which helps explain why our qualitative analysis did not report a positive impact on median household income. In summary, the qualitative and quantitative results of this study indicate the GSWL provided overall positive direct economic impacts to the study area, mostly conveyed via business development and employment growth. A summary of annual impacts is provided in Figure 1 below. We also split the project based on its two TIP numbers, I-2402 and U-2524. This allowed us to better observe where residential and commercial development occurred geographically and temporally. The results of the split analysis are shown below in Figure 5 and Figure 6.

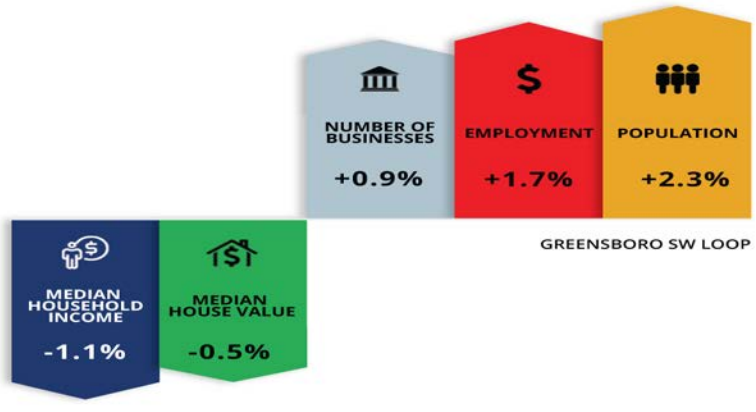

Figure 5. Overall summary of impacts for the Greensboro Southwest Loop.

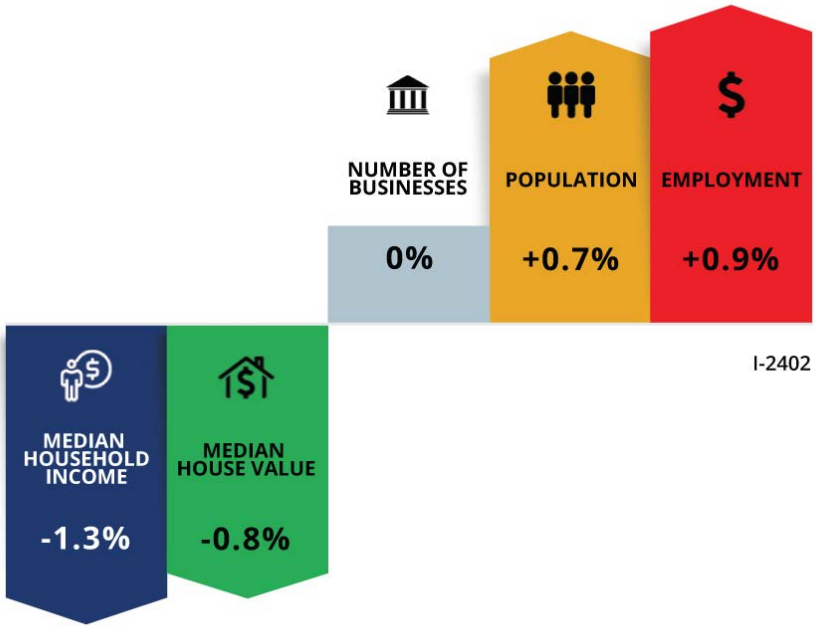

Figure 6. Summary of impacts for segment I-2402 of the Greensboro Southwest Loop.

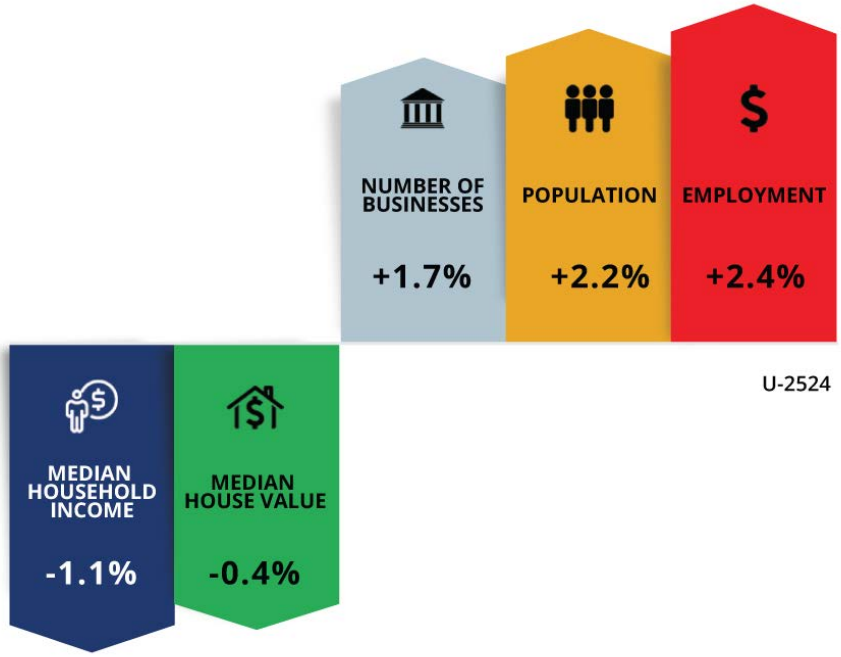

Figure 7. Summary of impacts for segment U-2524 of the Greensboro Southwest Loop.

3.6 Charlotte Outer Loop

The Charlotte Outer Loop (I-485) is a six- to eight-lane beltway that will fully encircle the city of Charlotte when completed. The segments of focus in this study form the western half of the loop and were constructed between 1994 and 2015. The main motivations cited for this project were congestion mitigation and safety improvements along alternative routes, increased capacity of Charlotte's transportation infrastructure, and improved access for trucking and commuting into, out of, and around Charlotte. Our qualitative analysis indicates these goals were accomplished as all local interviewees (4 of 4) stated I-485 alleviated congestion and improved safety on alternative routes and provided more direct access and lower travel times to their destinations. In addition to achieving these goals, this study revealed the project likely contributed to increases in area business and residential development. We observed significant increases in number of businesses (5.2% per year) and employment (5.6% per year) between pre- and post-construction dates within the study area. This coincides with in-depth interviews from knowledgeable local economic development experts and government officials who suggested the Charlotte Outer Loop was highly influential in terms of attracting businesses to the area. Notably, a split analysis of the loop based on TIP number shows the heaviest business growth occurred near the Charlotte/Douglas International Airport. One in-depth interviewee directly supports this stating the project induced economic growth because it provided accessibility to the airport. The qualitative analysis also revealed an increase in manufacturing industry in the area, specifically mentioning the Amazon Distribution Center, which is also attributed to increased airport access provided by the Charlotte Outer Loop. We also observed a significant increase in population (7.5% per year), which indicates substantial residential development occurred around the project. Similar to business development, our split analysis indicates the most substantial development occurred near the airport. These findings coincide with in-depth interviews which state the Charlotte Outer Loop spurred residential development around it due to the increased access it brought to the surrounding area for commuters. The in-depth interviews also mention increased property prices along with the residential development, but we only observe an increase in median house value at the southernmost portion of the project, R-2248 AA-AB. We believe the size of our study area limits our ability to observe real estate effects in close proximity to the highway; however, a more complex analysis looks at property prices for this project and is discussed in a separate section of our report. Finally, the in-depth interviews state the commercial composition of Charlotte is different before and after the project, so we expect there was some change in median household income within the study area. However, we believe market disturbances, such as the 2008 recession, make it difficult to correctly interpret the results observed for median household income. In summary, the qualitative and quantitative results of this study clearly indicate the Charlotte Outer Loop provided overall positive direct economic impacts to the study area, mostly conveyed via residential development, business development, and employment growth. A summary of annual impacts is provided in Figure 8 and summaries of our analysis split by TIP number are provided in Figure 9, Figure 10, Figure 11, and Figure 12.

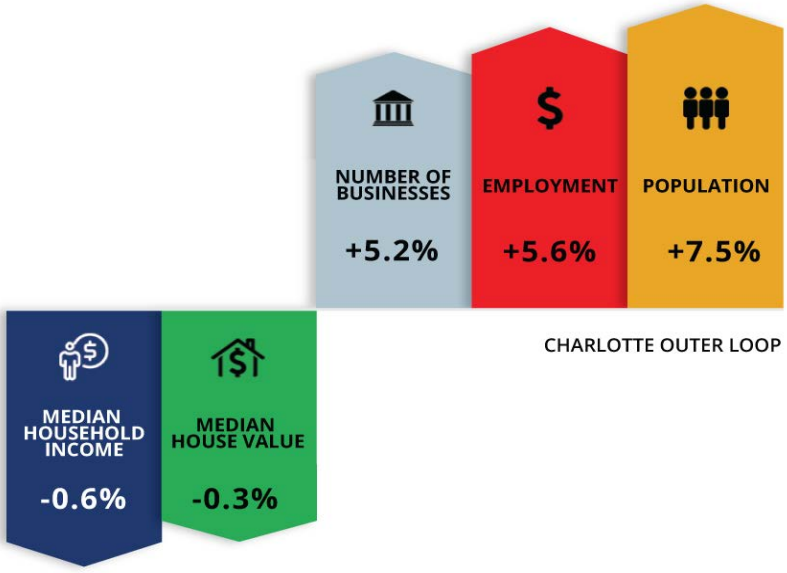

Figure 8. Overall summary of impacts for the Charlotte Outer Loop.

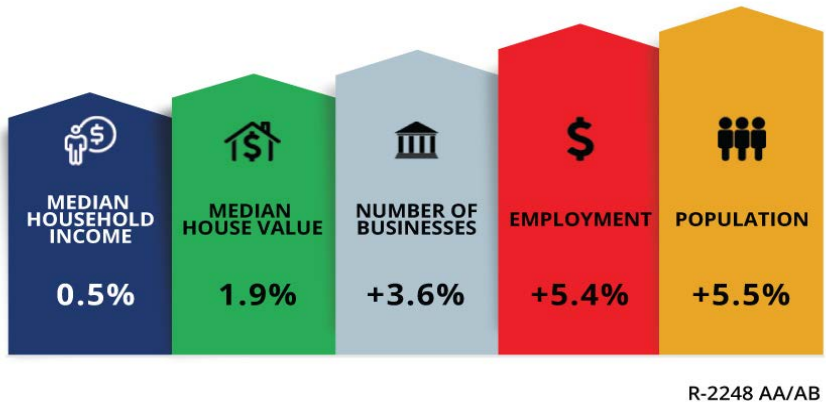

Figure 9. Summary of impacts for segments AA-AB of the Charlotte Outer Loop.

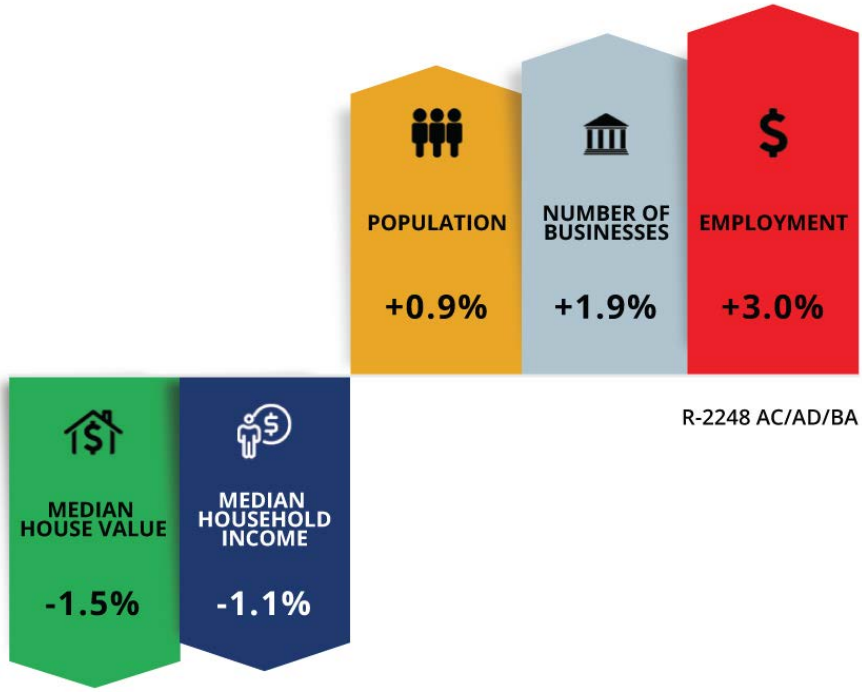

Figure 10. Summary of impacts for segments AC-AD-BA of the Charlotte Outer Loop.

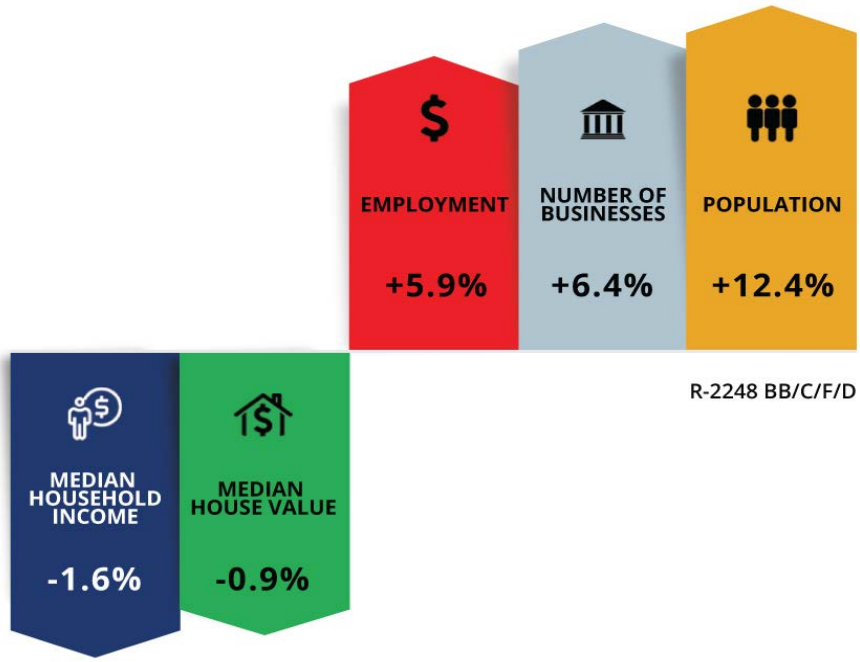

Figure 11. Summary of impacts for segments BB-C-F-D of the Charlotte Outer Loop.

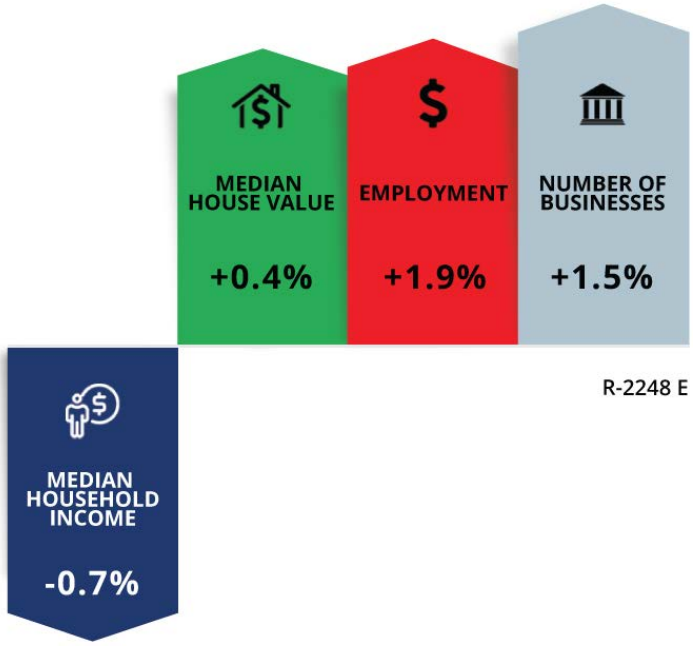

Figure 12. Summary of impacts for segment E of the Charlotte Outer Loop.

3.7 Wilmington Bypass

The Wilmington Bypass (I-140) is a four-lane median divided highway that was built between 2001 and 2006 that bypasses the city of Wilmington. The main motivations cited for the project were facilitation of tourist travel to the coast by bypassing coastal cities and consequently alleviate congestion and improve safety within the city. Our qualitative analysis indicates these goals were accomplished as all local interviewees (3 of 3) stated the bypass improved congestion and safety on alternate routes through the city and decreased travel time for commuters, including themselves. Additionally, the interviewees stated the bypass made travel easier through Wilmington to other destinations, such as South Carolina or the coast. In addition to achieving its documented purpose, this study revealed the Wilmington Bypass likely contributed to increases in area residential and business development. We observed increases in median house value (0.6% per year) and population (2.3% per year) between pre- and post-construction dates, which suggests new residential development and increased value of property occurred in the area surrounding the bypass. This coincides with in-depth interviews with officials at governmental organizations related to planning/administration stated there were neighborhoods built in the area primarily because they could get on the bypass and quickly get in to town. One interviewee specifically stated that sewer and water facilities would not have been initiated and area development would not have occurred if the Wilmington Bypass was not built. As for business development, we observed increases in number of businesses (0.8% per year) and employment (1.6% per year) which suggest the bypass induced economic growth in its vicinity. None of the seventeen businesses located near the project interviewed stated they located to the area due to Wilmington Bypass; however, all of these businesses belong to industries that saw significant growth in the area after the bypass was completed, according to the in-depth interviews. The in-depth interviews cite significant growth in smaller employers like grocery stores, restaurants, and retail establishments as well as notable growth in industrial establishments. Additionally, the in-depth interviews specifically mention there are two General Electric manufacturing plants in the area that are large employers. The existence of large employers helps explain why we observed a greater the increase in employment compared to number of businesses in the study area. Finally, while the results suggest burgeoning service and manufacturing industries in the area after completion of the Wilmington Bypass, there was no mention of a large, higher-education employer. This supports our observation of negligible change in median household income pre- and post-construction of the bypass. A summary of annual impacts is provided in Figure 13.

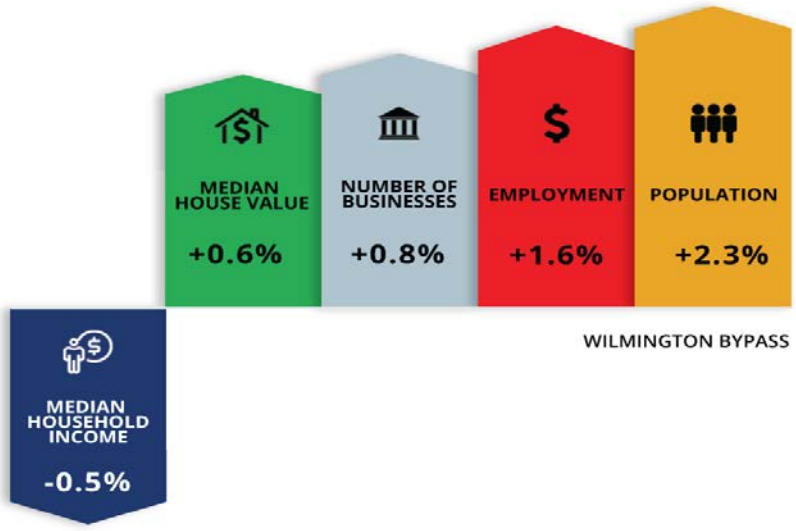

Figure 13. Overall summary of impacts for the Wilmington Bypass.

3.8 US-15/501 Widening

The US-15/501 widening project (R-942) widened a 20-mile segment of US-15/501 that connects Pittsboro and Chapel Hill from two-lanes, undivided to four-lanes, median divided. The project was constructed between 1998 and 2005 and the main motivations cited were congestion mitigation, safety improvement, and increasing labor market access. Our qualitative analysis indicates these goals were accomplished as all three interview participants that provided in-depth information stated that the widening decreased travel time for commuters and improved safety on this segment of US-15/501. Additionally, the observed decrease in travel times implies the project both alleviated congestion and improved labor market access in Pittsboro and Chapel Hill. In addition to achieving its documented purpose, our study suggests the US-15/501 widening heavily contributed to economic growth in the area. We observed increases in median house value (2.5% per year) and population (1.7% per year) between pre- and post-construction dates, which suggest the improved access provided by the widening significantly impacted real estate values in the surrounding area and spurred residential development. This coincides with in-depth interviews from three government officials knowledgeable about local area development and the US-15/501 widening; participants attributed housing development, in areas such as Southern Village, with the completion of the project. One interviewee mentioned the development of expensive homes located near the roadway in particular, which suggests an influx of higher-education residents to the area. Our observed increase in median household income (1.0% per year) supports the idea that the surrounding area experienced a shift in its residential composition after the project's completion. Finally, we observed similar increases in number of businesses (8.5% per year) and employment (9.4% per year) within the study area between pre- and post-construction dates. These results suggest the project had significant, positive impacts on economic growth in the study area. Brief interviews with businesses revealed many new "Mom and Pop" establishments and franchise expansions located near the project during or after its construction. While only two businesses interviewed identified the widening as a reason for locating near the road, two of the three in-depth interviews stressed the widening project heavily influenced economic development in the area as it had helped attract commercial developers to the area. In summary, the qualitative and quantitative results suggest the US-15/501 widening project provided significant, positive economic impacts to the study area and is conveyed via every economic impact measure utilized in this study. A summary of average annual impacts is provided in Figure 14.

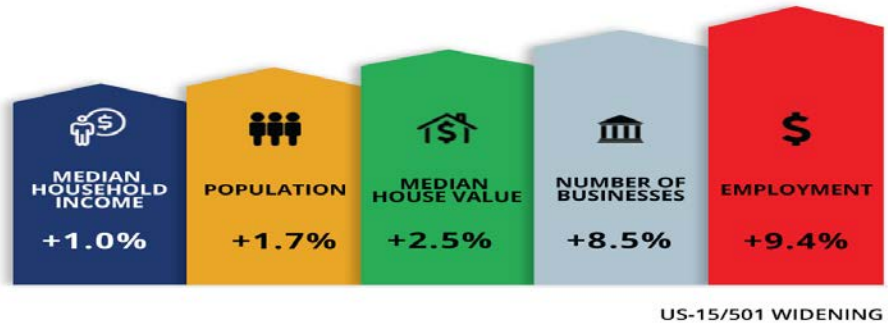

Figure 14. Overall summary of impacts for the US-15/501 Widening project.

3.9 Cameron/Vass Bypass

The US-1 Cameron/Vass Bypass (R-210) is a 4-lane, median divided highway constructed between 2002 and 2005 that bypasses the cities Cameron and Vass. The main motivations cited for this project were congestion mitigation and safety improvement on the alternate route through Cameron and Vass (Old US-1) as well as increasing mobility between counties in the area. Our qualitative analysis indicates these goals were accomplished to varying degrees; in-depth interviews with knowledgeable local economic development experts and a government official revealed that the bypass did improve safety and increase mobility in the area. However, this caused increased tourism traffic through the area, which spilled over into the alternate route through Cameron and Vass. Therefore, the bypass did not alleviate congestion to the degree expected during planning. In addition to achieving its documented purpose, this study revealed the Cameron/Vass Bypass likely contributed to economic growth in the area, specifically in terms of business development and employment growth. First, the average annual changes in population, median household income, and median house value between pre- and post-construction dates in the study area follow similar trends observed at the state level, which suggests the project had no impact on residential development or workforce composition in the study area. This is supported by the in-depth interviews, where there is no mention of residential development or an influx of higher/lower wage businesses relative to businesses in the area prior to construction of the bypass. Conversely, we observed significant increases in both number of businesses and employment immediately following completion of the bypass, which suggests the project spurred business development in the area. The qualitative analysis supports this assertion as all the in-depth interviews associate economic growth in the form of retail and tourism businesses with the construction of the bypass as well as growth of healthcare industry in the area. Note that the results of our overall analysis for number of businesses (0.2% per year) and employment (3.5% per year) are diluted by the negative impacts of the recession in the late 2000's and do not fully reflect the impacts to these measures. In summary, the qualitative and quantitative results of this study indicate the Cameron/Vass Bypass had positive direct economic impacts in the study area, specifically by stimulating growth in the retail, tourism, and healthcare industries. A summary of average annual impacts is provided in Figure 15.

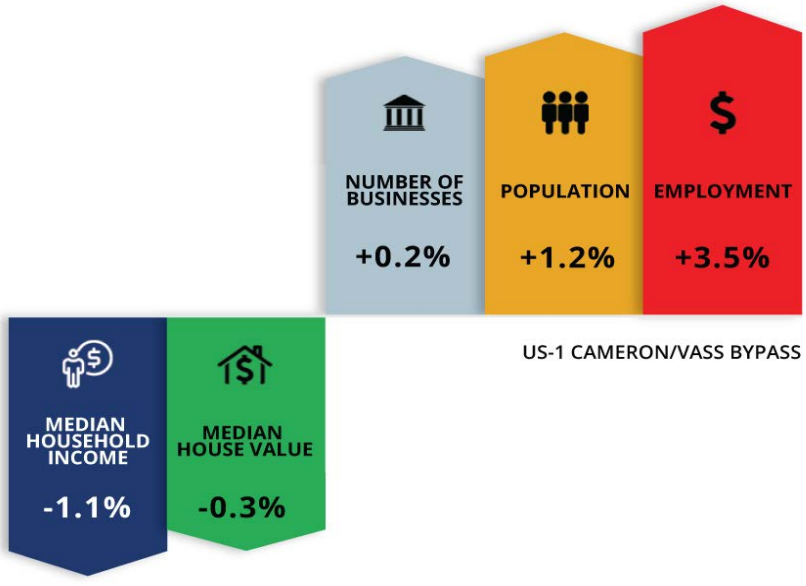

Figure 15. Overall summary of impacts for the Cameron/Vass Bypass.

3.10 US-421 Widening

The US-421 widening project expanded an approximately 40-mile stretch of US Highway 421 to four-lanes, median divided primarily between Yadkinville and Wilkesboro. The project was constructed in multiple phases; the first phase began in 1992 and the final phase was finished in 2003. The main motivations cited for this project were congestion mitigation and safety concerns along the original US-421 alignment as well as improving mobility and connectivity for travel both within and through the area. Our qualitative analysis indicates these goals were accomplished; three in-depth interviews with knowledgeable local economic development experts and government officials all suggested the project alleviated congestion and improved safety compared to the route prior to its widening. In addition to achieving its documented purpose, this study revealed that the US-421 widening project likely to commercial growth in both Wilkesboro and Yadkinville as well as residential development in Yadkinville alone. We determined it was beneficial to perform quantitative analyses for the whole project as well as the project split between the two largest cities adjacent to this section of US-421, Wilkesboro and Yadkinville. This lead to several key insights, such as the observation that employment decreased in the entire study area (-0.5% per year) as well as both sub-areas. This finding is explained in the in-depth interviews which mention a substantial loss of manual labor jobs in the area due to changes in NAFTA and other policy changes. However, the interviews also state that the widening project was very influential in attracting new businesses, specifically restaurants and retail establishments which support our observed increase in new businesses for the whole project as well as both sub-areas (~1% per year for all areas). Additionally, we observed increases in population (1.1% per year) and median house value (0.6% per year) for the whole project which suggests the widening stimulated residential development in the study area. The split analysis provides more clarity and shows the residential development occurred in the Yadkinville half of the project. Out qualitative analysis helps explain this as one in-depth interview noted an increase in population around US-421after the project who commuted to Winston-Salem where higher wage jobs existed, and this increase was attributable to the better travel time and access the US-421 widening provided. Further, this explains the increase we observed in the Yadkinville portion's median household income (2.0% per year) which we did not observe for the Wilkesboro portion or at the whole project level. In summary, the qualitative and quantitative analyses indicate the US-421 widening project spurred commercial business growth throughout the entire study area, specifically bringing restaurant and retail businesses that helped offset major economic losses in the apparel industry due to policy changes. Additionally, the improved access and commute times to Winston-Salem from Yadkinville resulted in an increased residential development and associated commuter population who held higher paying jobs than the existing Yadkinville workforce. An impact summary for the whole project is displayed in Figure 16, and the two sub-areas analyzed are shown below in Figure 17 and Figure 18.

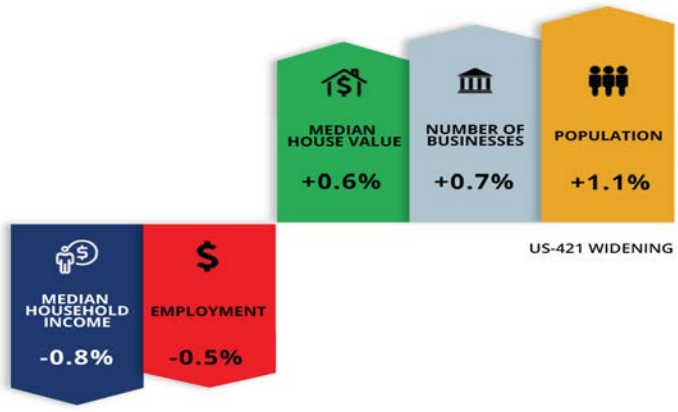

Figure 16. Overall summary of impacts for the US-421 Widening project.

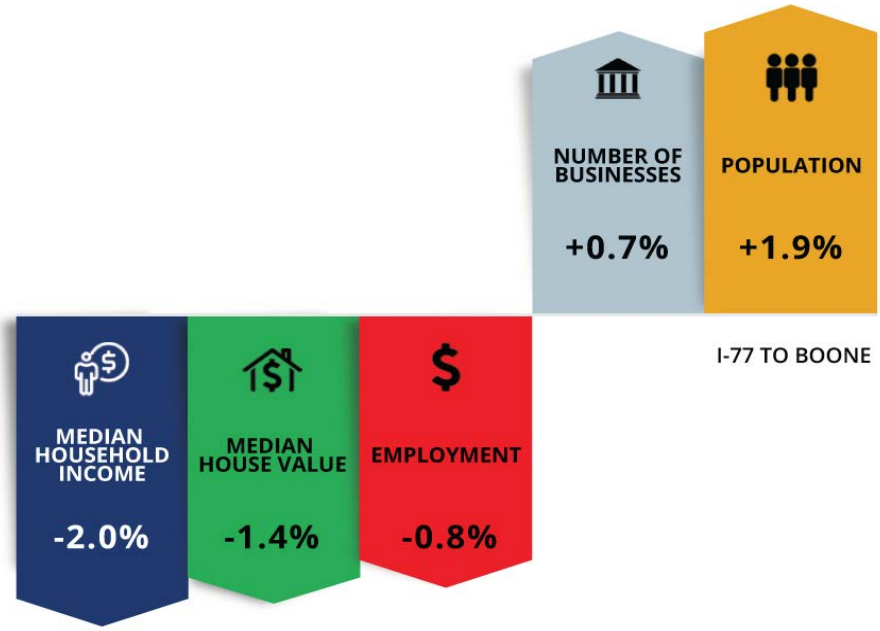

Figure 17. Summary of impacts for US-421: I-77 to Boone.

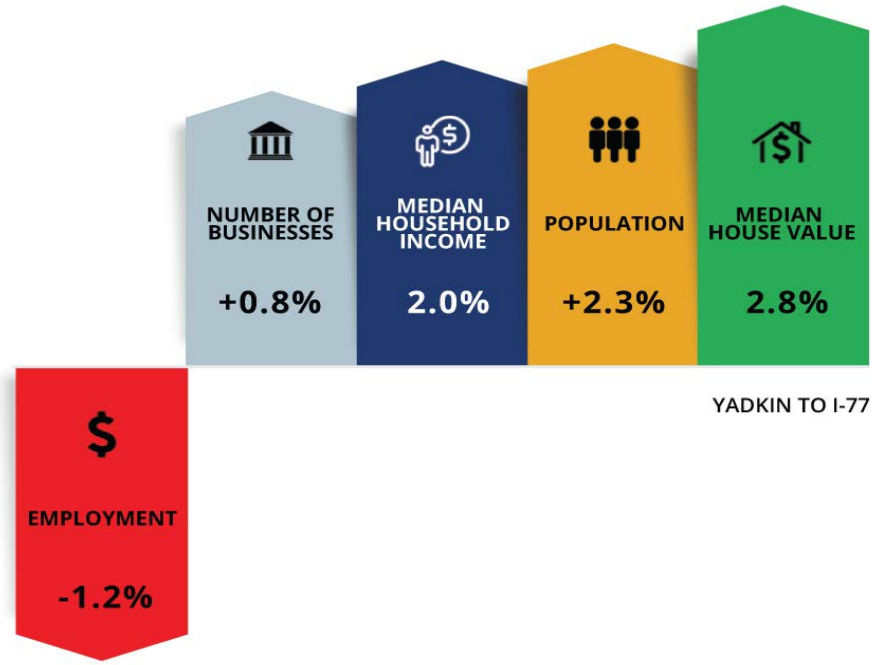

Figure 18. Summary of impacts for US-421: Yadkin to I-77.

4 Analysis and Conclusions

4.1 Summary of Objectives and Methodology

Like many other states, North Carolina's Department of Transportation (NCDOT) uses economic competitiveness as one of the criteria for prioritizing transportation projects. This denotes the need for structured research that documents and quantifies the long-term economic impacts of major highway expansion projects completed as part of the 1989 Highway Trust Fund Act. This research project aims to enhance current ex-post, empirical economic analyses of NCDOT projects with regards to quantifying long-term, direct economic impacts of major highway expansion projects, specifically those authorized as part of the 1989 Trust Fund Act. In coordination with NCDOT, our team selected and developed case studies for ten highway projects located throughout North Carolina. The chosen projects cover a wide range of various characteristics (urban/rural, east/central/west North Carolina, and bypass/widening/beltway) to provide a broad reference set to inform future investment decisions. Figure 1 shows the project locations for the ten case studies throughout North Carolina.

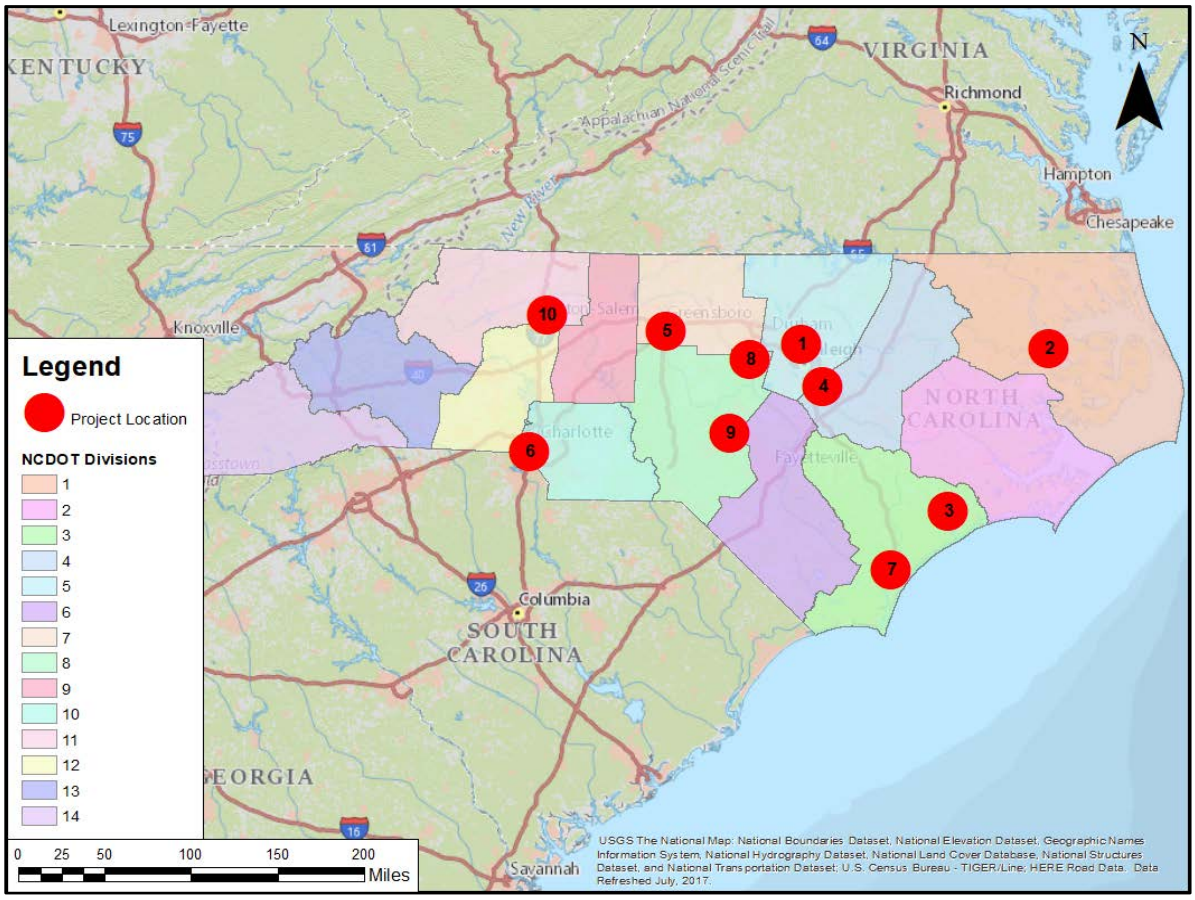

Figure 19. Project locations for case studies analyzed in this research.

The ten case studies as shown in the map are numbered below corresponding to their labels in Figure 19:

1. I-540 Northern Wake Expressway (R-2000 & R-2641)
2. US-64 Widening (R-2548)
3. Jacksonville Bypass (U-2107)
4. US-70 Clayton Bypass (R-2552)
5. Greensboro S &W Loop (I-2402 & U-2524)
6. I-485 Charlotte Outer Loop (R-2248)
7. I-140 Wilmington Bypass (R-2633)
8. U-15/US-501 (R-942)
9. US-1 Cameron/Vass Bypass (R-210)
10. US-421 Widening (R-2120, R-2239 & R-2240)

The quantitative analysis for each case study compared time trends between metrics within the study area, surrounding area, and the state of North Carolina. The study area was delineated by a 5-mile buffer around the project segments and the surrounding area was delineated as the county a project fell within excluding the 5-mile buffer area. The time trend analysis focuses on changes across four time periods:

1. Before project construction
2. At time of project completion
3. Within a year after project completion (short-term effects)
4. Between five and ten years after project completion (long-term effects)

The following six economic impact measures comprise the core analysis profile this study uses to quantify possible direct economic impacts: jobs and unemployment rate, income, number of businesses, population, property values, and capital investment. In addition, each case study is supplemented with relevant data specific to that project. All measures except capital investment are included in the *quantitative* data analysis. Capital investment is analyzed *qualitatively* via interviews with various project stakeholders and surrounding businesses in which specific examples of business growth due to the transportation project of focus are identified. Table 8 summarizes the data metrics and data sources for the economic impact measures featured in the case studies.

Table 8. Six impact measures of focus in the case studies.

Impact Category	Economic Impact Measure	Data Source
Property Demand	Property values	Decennial Census and ACS
	Income	Decennial Census and ACS
Business Growth	Jobs	County Business Patterns
	Number of businesses	County Business Patterns
	Population	Decennial Census
Overall Growth	Economic distress (area unemployment rate relative to national)	BLS: Local Area Unemployment Statistics

The qualitative analysis for each case study consisted of in-depth interviews with local governmental officials, economic development experts, local business owners, local community members, and NCDOT officials who were involved in the project as well as brief interviews with local businesses located around

the project. The interviews were used to identify area context, specific impacts related to the transportation projects, and businesses that had located in the area because of the transportation project. Additionally, the interviews provided context and support to the quantitative results and provided a causal argument for any observed economic impacts.

4.2 Comparison of Qualitative Results

To identify tangible examples of businesses that have located to an area due to the highway project of interest, nearby businesses were identified and contacted for each case study. Table 2 displays for each case study the number of businesses contacted, the number of total businesses that participated in telephone interviews, the number of businesses that reported moving to the area because of the transportation project (i.e. "yes" column), and the response rate (total participating businesses divided by the number of businesses contacted).

As can be viewed in Table 9, the US-64 Widening project had the greatest percentage of responding businesses indicate that the project was a reason for locating to the area, while the Northern Wake Expressway had the second greatest percentage of businesses respond that the roadway was a factor in their decision to locate to the area, with 52% responding affirmatively. Much of the business growth associated with the Northern Wake Expressway, which partially encircles Raleigh, tended to be near Knightdale, which is a growing area.

The third highest percentage of businesses having moved to the area was for the Greensboro Southwest Loop (GSWL), with 40% of participating businesses having moved to the area in part because of the GSWL. The Jacksonville Bypass had 14% of businesses respond affirmatively, and 10% of businesses located near the US-15/501 Widening project cited the road as a reason for locating to the area. Only one out of 13 businesses (8%) located near the Charlotte Outer Loop cited it as a reason for locating to the area, and one out of 14 businesses (7%) mentioned the US-421 Widening project as a factor in the decision to move to the area.

Finally, we were unable to identify any specific businesses via telephone interviews that had located to the area because of the Wilmington Bypass or the Cameron/Vass Bypass, with 0% of business representatives responding affirmatively; seventeen total businesses had been interviewed for the Wilmington Bypass and five for the Cameron/Vass Bypass. Also worth noting is that there were a small number of businesses located in proximity to the Cameron/Vass Bypass. The Wilmington Bypass may not have been associated with businesses moving to the area because the area had already been growing due to tourism, and the bypass primarily helps to move existing traffic between the coast and inland areas.

Table 9. Summary of findings from brief telephone interviews with area businesses for each case study (n=145 total brief telephone interviews completed).

No.	Case study	No. Businesses Moving to Area Based on Project	No. Businesses (Total)	No. Businesses Contacted	Response Rate
1	Northern Wake Expressway (I-540)	12 (52%)	23	32	72%
2	US-64 Widening	5 (71%)	7	21	33%
3	Clayton Bypass (US-70)	3 (21%)	14	35	40%
4	Jacksonville Bypass (US-17/NC-24)	3 (14%)	22	40	55%
5	Greensboro Southwest Loop (I-85)	4 (40%)	10	40	25%
6	Charlotte Outer Loop (I-485)	1 (8%)	13	36	28%
7	I-140 Wilmington Bypass	0 (0%)	17	40	43%
8	US-15/US-501 Widening	2 (10%)	20	39	51%
9	US-1 Cameron/Vass Bypass	0 (0%)	5	11	45%
10	US-421 Widening	1 (7%)	14	51	27%

In addition to the completion of brief business interviews, 3 to 5 in-depth interviews were also completed with knowledgeable local officials (e.g. governmental officials, planners, transportation officials, economic development experts, etc.) for each case study to obtain more in-depth local knowledge on the project, such as community context. Table 10 displays the number of in-depth interviews completed for each case study, as well as the number of interview participants who perceive the respective transportation projects to have had an impact on area economic growth. The three case studies for which 100% of the in-depth interview participants believed there to be economic growth due to the transportation projects included: the US-64 Widening project, the Charlotte Outer Loop, and the US-421 Widening project. Following these, 67% of in-depth interview participants believed the US-15/501 Widening project to have influenced area economic growth. Both the Clayton Bypass and the Greensboro Southwest Loop were reported to have spurred business growth by 50% of interview participants. Forty percent of respondents believed the Jacksonville Bypass to have positively influenced economic activity. Thirty-three percent of interview participants believed the Wilmington Bypass to have influenced economic growth, and 20% believed the Northern Wake Expressway to have been an important influence. Finally, none of the interview participants for the Cameron/Vass Bypass believed the project had been associated with economic activity in the area.

Table 10. Number of in-depth interviews completed with local officials knowledgeable about the project, as well as the number who believed the road project in question had spurred economic activity (n=37 total in-depth interviews completed).

No.	Case study	No. in-depth interviews	No. who believe businesses have located to the area because of the project
1	Northern Wake Expressway (I-540)	5	1 (20%)
2	US-64 Widening	3	3 (100%)
3	Clayton Bypass (US-70)	4	2 (50%)
4	Jacksonville Bypass (US-17/NC-24)	5	2 (40%)
5	Greensboro Southwest Loop (I-85)	4	2 (50%)
6	Charlotte Outer Loop (I-485)	4	4 (100%)
7	I-140 Wilmington Bypass	3	1 (33%)
8	US-15/US-501 Widening	3	2 (67%)
9	US-1 Cameron/Vass Bypass	3	0 (0%)
10	US-421 Widening	3	3 (100%)

4.3 Comparison of Quantitative Results

The reported annual average percent changes for each case study were compared to see if any economic impacts were shared across projects based on type, cost, and classification (urban/rural). Additionally, we made the following generalizations about the economic measures for this analysis: 1) the business and employment measures are indicators of business development 2) the population and median house value measures and indicators of residential development 3) the median household income is indicative of a shift in the employment composition and 4) the income measure is skewed due to the recession in the late 2000's because it accounts for both wage and investment earnings.

This analysis yielded several key insights – based on this sample of projects; for example, beltway projects appear to have the most substantial effect on business development compared to the other project types. This is shown in Figures 2 and 4 where the beltway projects are clustered above the other projects. At the same time, the beltway projects showed very high yearly increases in population, but no substantial impact on housing price. These results suggest beltway projects make the area more attractive for businesses and stimulate economic growth, but may not have the same effect on residential development. Conversely, bypass projects appear to substantially improve residential property value, but are generally not associated with business growth. This is shown in Figures 2, 3, and 4 where bypass projects are generally clustered below beltways in terms of business measures and above other projects in terms of median house values. This suggests the access and mobility a bypass project brings to an area stimulates residential development but is less attractive to businesses. Finally, the widening project results are mixed. One shows outstanding economic impacts in all measures while the other shows improved median house values, but minimal changes otherwise. We believe the outlier (US-15/501 widening) is due to scale. This project has the lowest cost and the smallest footprint. Additionally, the study area included very few other roadway segments compared to the other nine projects. This suggests the US-15/501

widening analysis contained significantly less confounding factors, which is why we observe clear economic impacts in every category. The other widening (US-421) involved over 40 miles of roadway and showed signs of both residential and business development, but the magnitude observed is much lower. The widening projects provide an important insight that extends to the other projects in our study; there is variability associated with larger scale projects that likely dilutes observable impacts.

In summary, a comparison of economic impact measures across all ten case studies suggests all projects likely have some impact on business growth, residential development, and property price in the study area. However, beltways tend to have a greater impact on business growth while bypasses tend to have a greater impact on residential development and property price and widenings appear to have an even impact across all these measures. Note that we performed a more in-depth analysis on residential property values for the three beltway projects and were able to define the spatial characteristics and extents of this specific impact. The paper discussing the results of this supplemental analysis is included with the rest of the deliverables. The projects are labeled using numbers in the figures below, Table 11 denotes what project each number is associated with as well as all average annual percent changes for each impact measure.

Table 11. Summary of annual percent changes to economic impacts within the study area.

#	Name	Type	Cost (millions 2017 $)	Pop.	Median HH Income	Median House Value	Number of Businesses	Emp.
1	Northern Wake Expressway	Beltway	957	7.3	-1.05	-0.37	3.15	3.27
2	US 64 Bypass	Bypass	227	0	-0.81	-0.01	-0.68	-0.1
3	Clayton Bypass	Bypass	275	5.8	-1.15	-0.31	2.08	2.54
4	Jacksonville Bypass	Bypass	239	0.42	-0.46	1.59	0.56	2.4
5	Greensboro SW Loop	Beltway	1,137	2.25	-1.13	-0.5	0.93	1.69
6	Charlotte Outer Loop	Beltway	1,055	7.54	-0.58	-0.3	5.18	5.64
7	Wilmington Bypass	Bypass	748	2.34	-0.54	0.64	0.79	1.6
8	US-15/501 Widening	Widening	128	1.68	1.02	2.5	8.54	9.4
9	Cameron/Vass Bypass	Bypass	104	1.24	-1.07	-0.34	0.23	3.53
10	US-421 Widening	Widening	370	1.06	-0.8	0.63	0.71	-0.51

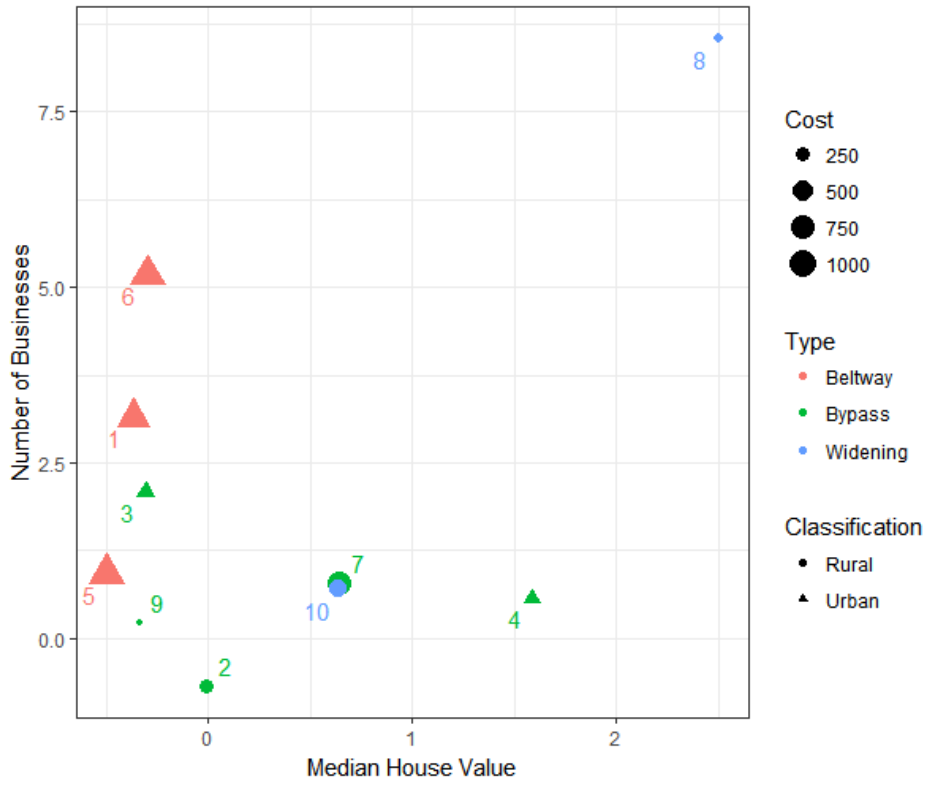

Figure 20. Average annual percent changes in businesses and median house value in study area.

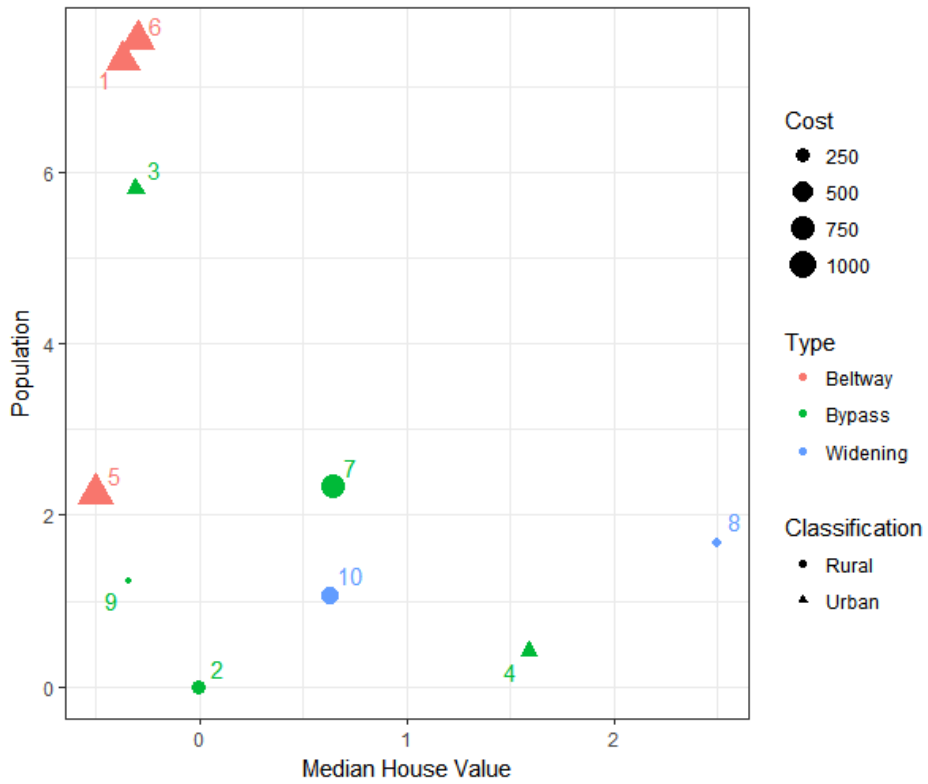

Figure 21. Average annual percent changes in population and median house value in study area.

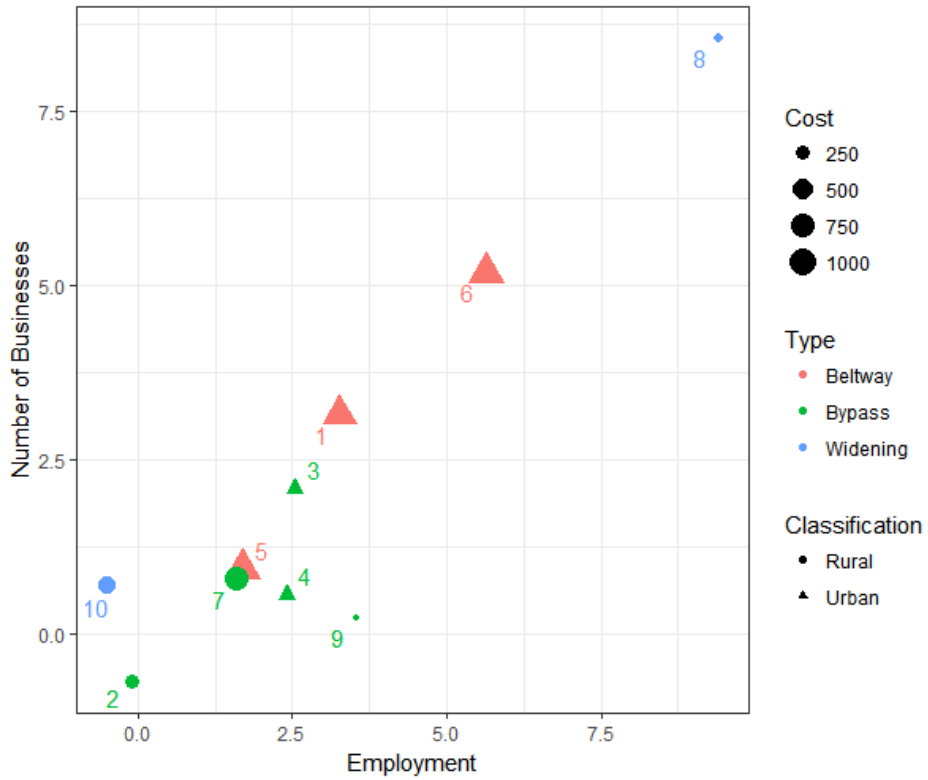

Figure 22. Average annual percent changes in number of businesses and employment in study area.

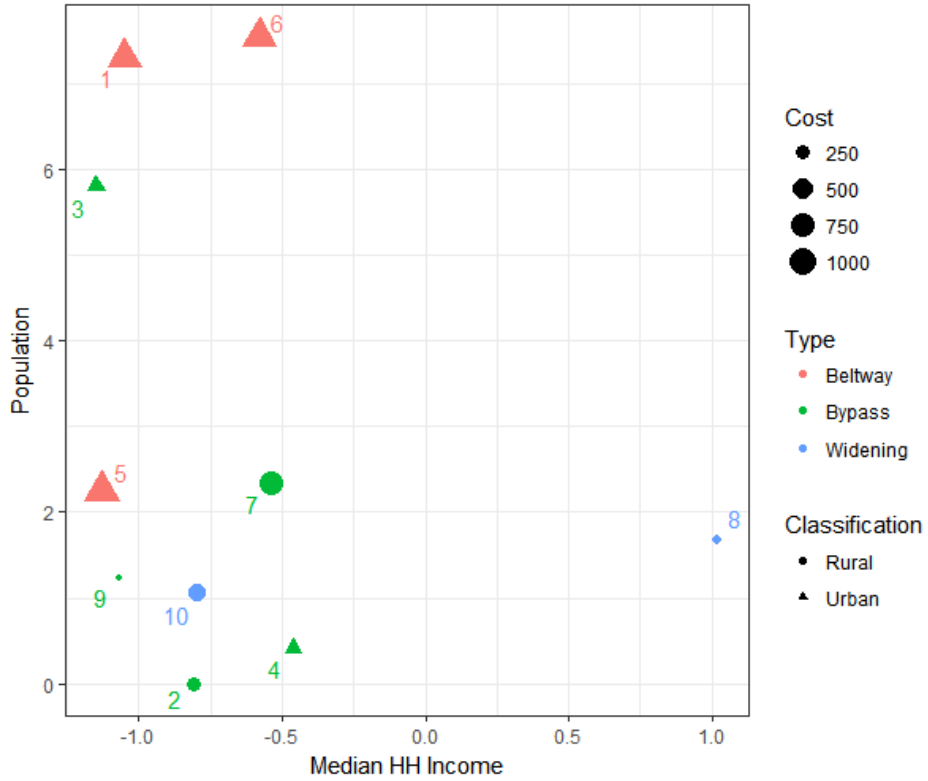

Figure 23. Average annual percent changes in population and median household income in study area.

5 Appendices – Please see supplementary documents for the following ten case study reports:

5.1 The Northern Wake Expressway
5.2 The US-64 Widening Project
5.3 The Clayton Bypass
5.4 The Jacksonville Bypass
5.5 The Greensboro Southwest Loop
5.6 The Charlotte Outer Loop
5.7 The Wilmington Bypass
5.8 The US-15/501 Widening Project
5.9 The Cameron/Vass Bypass
5.10 The US-421 Widening Project

Analysis and Validation of Historical Transportation Investments

Brittany V. Gaustad, MPP
John Murray, Graduate Research Assistant
Eleni Bardaka, PhD, Principal Investigator
Daniel Findley, PhD,
Russell Smith, Graduate Research Assistant,
James B. Martin, PE

Institute for Transportation Research & Education
North Carolina State University
Research IV, 909 Capability Dr.
Raleigh, NC 27606

Sept. 18, 2018
NCDOT Project
RP 2017-22

1 Analysis and Conclusions

1.1 Summary of Objectives and Methodology

Like many other states, North Carolina's Department of Transportation (NCDOT) uses economic competitiveness as one of the criteria for prioritizing transportation projects. This denotes the need for structured research that documents and quantifies the long-term economic impacts of major highway expansion projects completed as part of the 1989 Highway Trust Fund Act. This research project aims to enhance current ex-post, empirical economic analyses of NCDOT projects with regards to quantifying long-term, direct economic impacts of major highway expansion projects, specifically those authorized as part of the 1989 Trust Fund Act. In coordination with NCDOT, our team selected and developed case studies for ten highway projects located throughout North Carolina. The chosen projects cover a wide range of various characteristics (urban/rural, east/central/west North Carolina, and bypass/widening/beltway) to provide a broad reference set to inform future investment decisions. Figure 1 shows the project locations for the ten case studies throughout North Carolina.

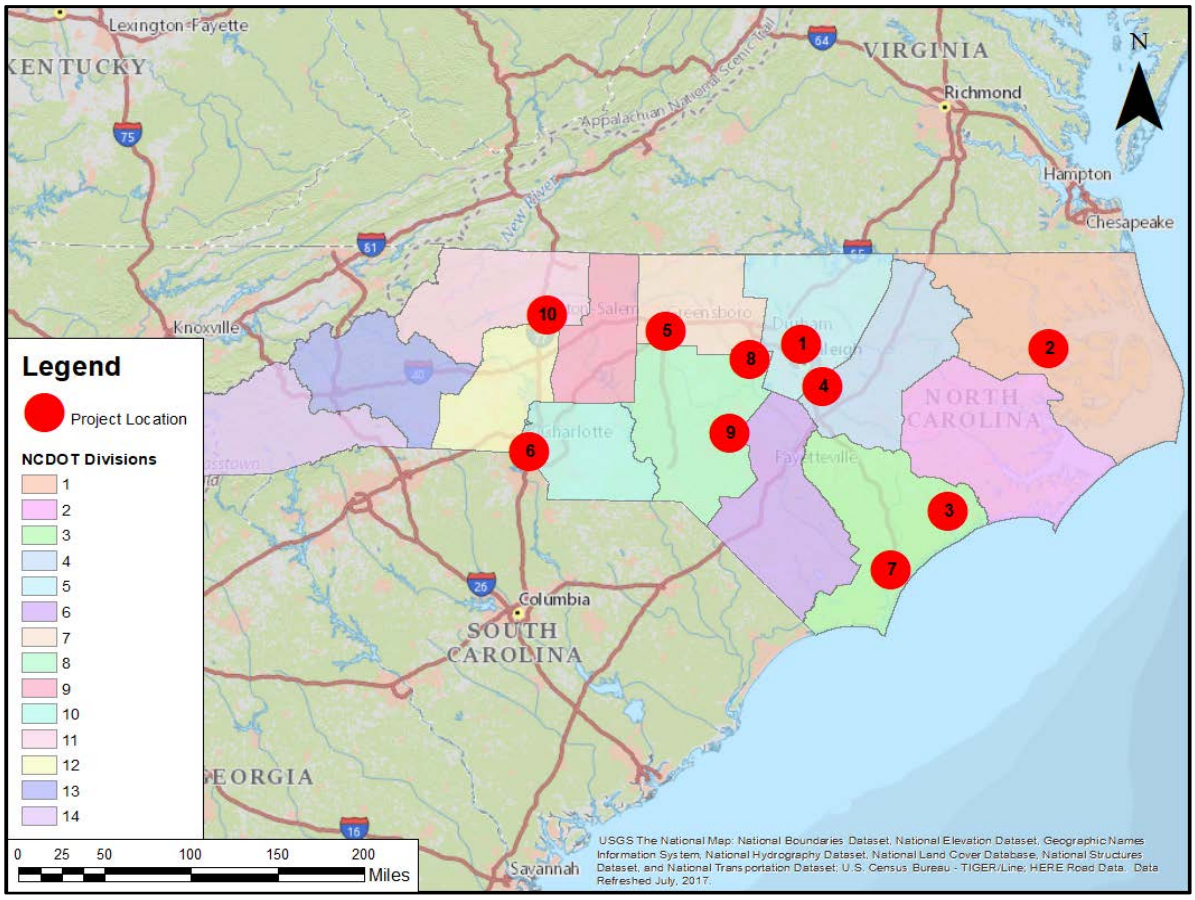

Figure 1. Project locations for case studies analyzed in this research.

The ten case studies as shown in the map are numbered below corresponding to their labels in Figure 1:

1. I-540 Northern Wake Expressway (R-2000 & R-2641)
2. US-64 Widening (R-2548)
3. Jacksonville Bypass (U-2107)
4. US-70 Clayton Bypass (R-2552)
5. Greensboro S &W Loop (I-2402 & U-2524)
6. I-485 Charlotte Outer Loop (R-2248)
7. I-140 Wilmington Bypass (R-2633)
8. U-15/US-501 (R-942)
9. US-1 Cameron/Vass Bypass (R-210)
10. US-421 Widening (R-2120, R-2239 & R-2240)

The quantitative analysis for each case study compared time trends between metrics within the study area, surrounding area, and the state of North Carolina. The study area was delineated by a 5-mile buffer around the project segments and the surrounding area was delineated as the county a project fell within excluding the 5-mile buffer area. The time trend analysis focuses on changes across four time periods:

1. Before project construction
2. At time of project completion
3. Within a year after project completion (short-term effects)
4. Between five and ten years after project completion (long-term effects)

The following six economic impact measures comprise the core analysis profile this study uses to quantify possible direct economic impacts: jobs and unemployment rate, income, number of businesses, population, property values, and capital investment. In addition, each case study is supplemented with relevant data specific to that project. All measures except capital investment are included in the *quantitative* data analysis. Capital investment is analyzed *qualitatively* via interviews with various project stakeholders and surrounding businesses in which specific examples of business growth due to the transportation project of focus are identified. Table 1 summarizes the data metrics and data sources for the economic impact measures featured in the case studies.

Table 1. Six impact measures of focus in the case studies.

Impact Category	Economic Impact Measure	Data Source
Property Demand	Property values	Decennial Census and ACS
	Income	Decennial Census and ACS
Business Growth	Jobs	County Business Patterns
	Number of businesses	County Business Patterns
	Population	Decennial Census
Overall Growth	Economic distress (area unemployment rate relative to national)	BLS: Local Area Unemployment Statistics

The qualitative analysis for each case study consisted of in-depth interviews with local governmental officials, economic development experts, local business owners, local community members, and NCDOT officials who were involved in the project as well as brief interviews with local businesses located around

the project. The interviews were used to identify area context, specific impacts related to the transportation projects, and businesses that had located in the area because of the transportation project. Additionally, the interviews provided context and support to the quantitative results and provided a causal argument for any observed economic impacts.

1.2 Comparison of Qualitative Results

To identify tangible examples of businesses that have located to an area due to the highway project of interest, nearby businesses were identified and contacted for each case study. Table 2 displays for each case study the number of businesses contacted, the number of total businesses that participated in telephone interviews, the number of businesses that reported moving to the area because of the transportation project (i.e. "yes" column), and the response rate (total participating businesses divided by the number of businesses contacted).

As can be viewed in Table 2, the US-64 Widening project had the greatest percentage of responding businesses indicate that the project was a reason for locating to the area, while the Northern Wake Expressway had the second greatest percentage of businesses respond that the roadway was a factor in their decision to locate to the area, with 52% responding affirmatively. Much of the business growth associated with the Northern Wake Expressway, which partially encircles Raleigh, tended to be near Knightdale, which is a growing area.

The third highest percentage of businesses having moved to the area was for the Greensboro Southwest Loop (GSWL), with 40% of participating businesses having moved to the area in part because of the GSWL. The Jacksonville Bypass had 14% of businesses respond affirmatively, and 10% of businesses located near the US-15/501 Widening project cited the road as a reason for locating to the area. Only one out of 13 businesses (8%) located near the Charlotte Outer Loop cited it as a reason for locating to the area, and one out of 14 businesses (7%) mentioned the US-421 Widening project as a factor in the decision to move to the area.

Finally, we were unable to identify any specific businesses via telephone interviews that had located to the area because of the Wilmington Bypass or the Cameron/Vass Bypass, with 0% of business representatives responding affirmatively; seventeen total businesses had been interviewed for the Wilmington Bypass and five for the Cameron/Vass Bypass. Also worth noting is that there were a small number of businesses located in proximity to the Cameron/Vass Bypass. The Wilmington Bypass may not have been associated with businesses moving to the area because the area had already been growing due to tourism, and the bypass primarily helps to move existing traffic between the coast and inland areas.

Table 2. Summary of findings from brief telephone interviews with area businesses for each case study (n=145 total brief telephone interviews completed).

No.	Case study	No. Businesses Moving to Area Based on Project	No. Businesses (Total)	No. Businesses Contacted	Response Rate
1	Northern Wake Expressway (I-540)	12 (52%)	23	32	72%
2	US-64 Widening	5 (71%)	7	21	33%
3	Clayton Bypass (US-70)	3 (21%)	14	35	40%
4	Jacksonville Bypass (US-17/NC-24)	3 (14%)	22	40	55%
5	Greensboro Southwest Loop (I-85)	4 (40%)	10	40	25%
6	Charlotte Outer Loop (I-485)	1 (8%)	13	36	28%
7	I-140 Wilmington Bypass	0 (0%)	17	40	43%
8	US-15/US-501 Widening	2 (10%)	20	39	51%
9	US-1 Cameron/Vass Bypass	0 (0%)	5	11	45%
10	US-421 Widening	1 (7%)	14	51	27%

In addition to the completion of brief business interviews, 3 to 5 in-depth interviews were also completed with knowledgeable local officials (e.g. governmental officials, planners, transportation officials, economic development experts, etc.) for each case study to obtain more in-depth local knowledge on the project, such as community context. Table 3 displays the number of in-depth interviews completed for each case study, as well as the number of interview participants who perceive the respective transportation projects to have had an impact on area economic growth. The three case studies for which 100% of the in-depth interview participants believed there to be economic growth due to the transportation projects included: the US-64 Widening project, the Charlotte Outer Loop, and the US-421 Widening project. Following these, 67% of in-depth interview participants believed the US-15/501 Widening project to have influenced area economic growth. Both the Clayton Bypass and the Greensboro Southwest Loop were reported to have spurred business growth by 50% of interview participants. Forty percent of respondents believed the Jacksonville Bypass to have positively influenced economic activity. Thirty-three percent of interview participants believed the Wilmington Bypass to have influenced economic growth, and 20% believed the Northern Wake Expressway to have been an important influence. Finally, none of the interview participants for the Cameron/Vass Bypass believed the project had been associated with economic activity in the area.

Table 3. Number of in-depth interviews completed with local officials knowledgeable about the project, as well as the number who believed the road project in question had spurred economic activity (n=37 total in-depth interviews completed).

No.	Case study	No. in-depth interviews	No. who believe businesses have located to the area because of the project
1	Northern Wake Expressway (I-540)	5	1 (20%)
2	US-64 Widening	3	3 (100%)
3	Clayton Bypass (US-70)	4	2 (50%)
4	Jacksonville Bypass (US-17/NC-24)	5	2 (40%)
5	Greensboro Southwest Loop (I-85)	4	2 (50%)
6	Charlotte Outer Loop (I-485)	4	4 (100%)
7	I-140 Wilmington Bypass	3	1 (33%)
8	US-15/US-501 Widening	3	2 (67%)
9	US-1 Cameron/Vass Bypass	3	0 (0%)
10	US-421 Widening	3	3 (100%)

1.3 Comparison of Quantitative Results

The reported annual average percent changes for each case study were compared to see if any economic impacts were shared across projects based on type, cost, and classification (urban/rural). Additionally, we made the following generalizations about the economic measures for this analysis: 1) the business and employment measures are indicators of business development 2) the population and median house value measures and indicators of residential development 3) the median household income is indicative of a shift in the employment composition and 4) the income measure is skewed due to the recession in the late 2000's because it accounts for both wage and investment earnings.

This analysis yielded several key insights – based on this sample of projects; for example, beltway projects appear to have the most substantial effect on business development compared to the other project types. This is shown in Figures 2 and 4 where the beltway projects are clustered above the other projects. At the same time, the beltway projects showed very high yearly increases in population, but no substantial impact on housing price. These results suggest beltway projects make the area more attractive for businesses and stimulate economic growth, but may not have the same effect on residential development. Conversely, bypass projects appear to substantially improve residential property value, but are generally not associated with business growth. This is shown in Figures 2, 3, and 4 where bypass projects are generally clustered below beltways in terms of business measures and above other projects in terms of median house values. This suggests the access and mobility a bypass project brings to an area stimulates residential development but is less attractive to businesses. Finally, the widening project results are mixed. One shows outstanding economic impacts in all measures while the other shows improved median house values, but minimal changes otherwise. We believe the outlier (US-15/501 widening) is due to scale. This project has the lowest cost and the smallest footprint. Additionally, the study area included very few other roadway segments compared to the other nine projects. This suggests the US-15/501

widening analysis contained significantly less confounding factors, which is why we observe clear economic impacts in every category. The other widening (US-421) involved over 40 miles of roadway and showed signs of both residential and business development, but the magnitude observed is much lower. The widening projects provide an important insight that extends to the other projects in our study; there is variability associated with larger scale projects that likely dilutes observable impacts.

In summary, a comparison of economic impact measures across all ten case studies suggests all projects likely have some impact on business growth, residential development, and property price in the study area. However, beltways tend to have a greater impact on business growth while bypasses tend to have a greater impact on residential development and property price and widenings appear to have an even impact across all these measures. Note that we performed a more in-depth analysis on residential property values for the three beltway projects and were able to define the spatial characteristics and extents of this specific impact. The paper discussing the results of this supplemental analysis is included with the rest of the deliverables. The projects are labeled using numbers in the figures below, Table 4 denotes what project each number is associated with as well as all average annual percent changes for each impact measure.

Table 4. Summary of annual percent changes to economic impacts within the study area.

#	Name	Type	Cost (millions 2017 $)	Pop.	Median HH Income	Median House Value	Number of Businesses	Emp.
1	Northern Wake Expressway	Beltway	957	7.3	-1.05	-0.37	3.15	3.27
2	US 64 Bypass	Bypass	227	0	-0.81	-0.01	-0.68	-0.1
3	Clayton Bypass	Bypass	275	5.8	-1.15	-0.31	2.08	2.54
4	Jacksonville Bypass	Bypass	239	0.42	-0.46	1.59	0.56	2.4
5	Greensboro SW Loop	Beltway	1,137	2.25	-1.13	-0.5	0.93	1.69
6	Charlotte Outer Loop	Beltway	1,055	7.54	-0.58	-0.3	5.18	5.64
7	Wilmington Bypass	Bypass	748	2.34	-0.54	0.64	0.79	1.6
8	US-15/501 Widening	Widening	128	1.68	1.02	2.5	8.54	9.4
9	Cameron/Vass Bypass	Bypass	104	1.24	-1.07	-0.34	0.23	3.53
10	US-421 Widening	Widening	370	1.06	-0.8	0.63	0.71	-0.51

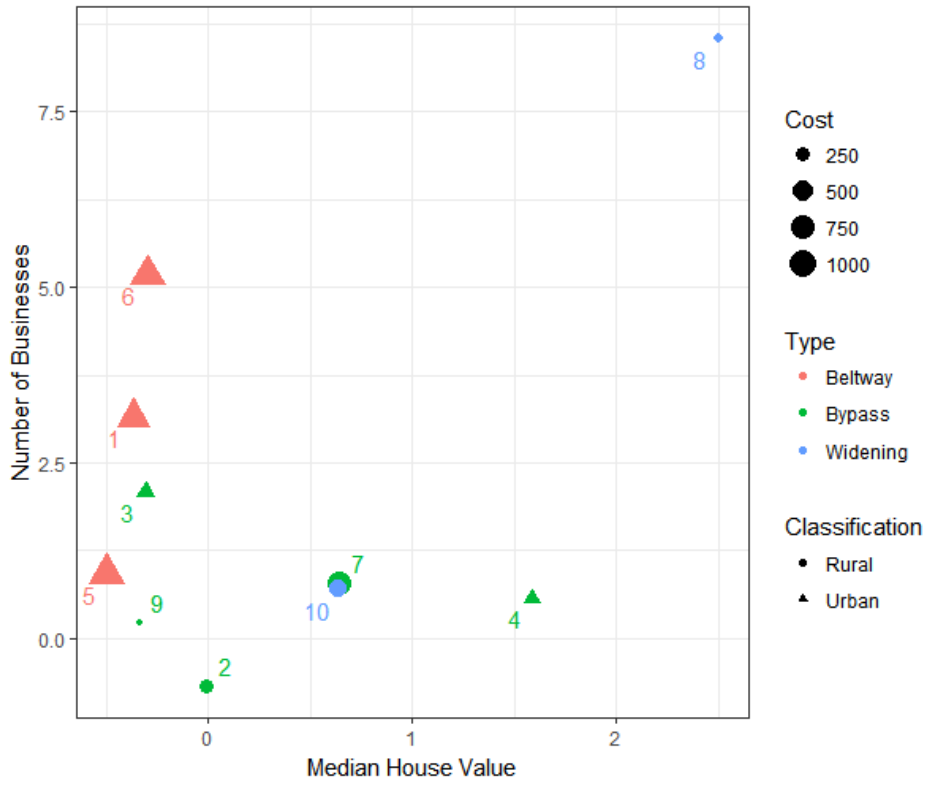

Figure 2. Average annual percent changes in businesses and median house value in study area.

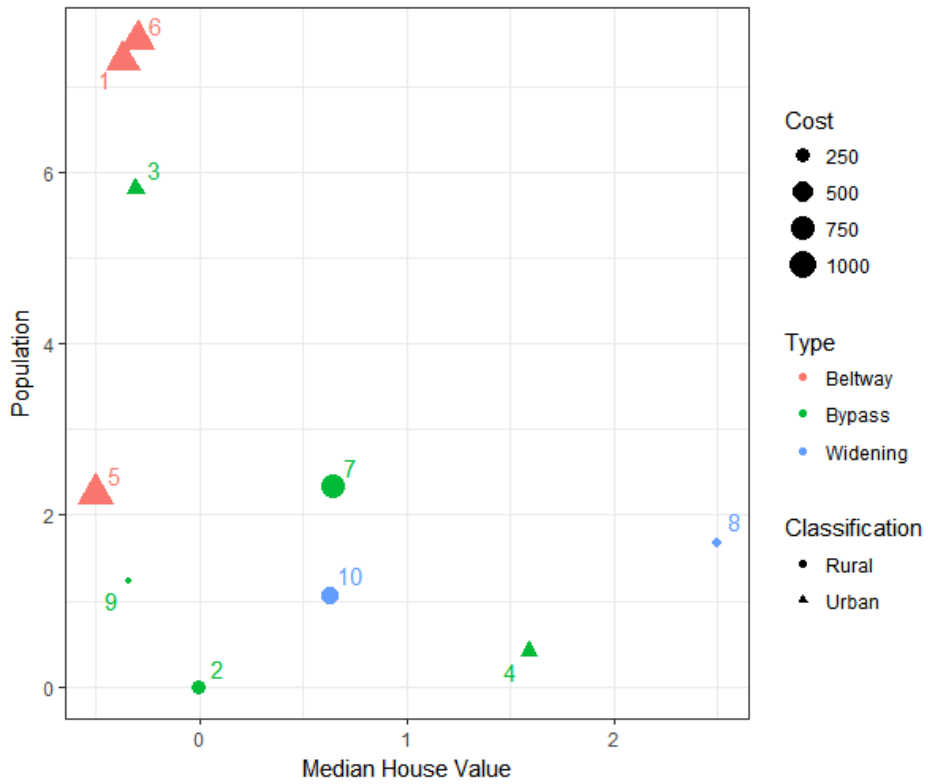

Figure 3. Average annual percent changes in population and median house value in study area.

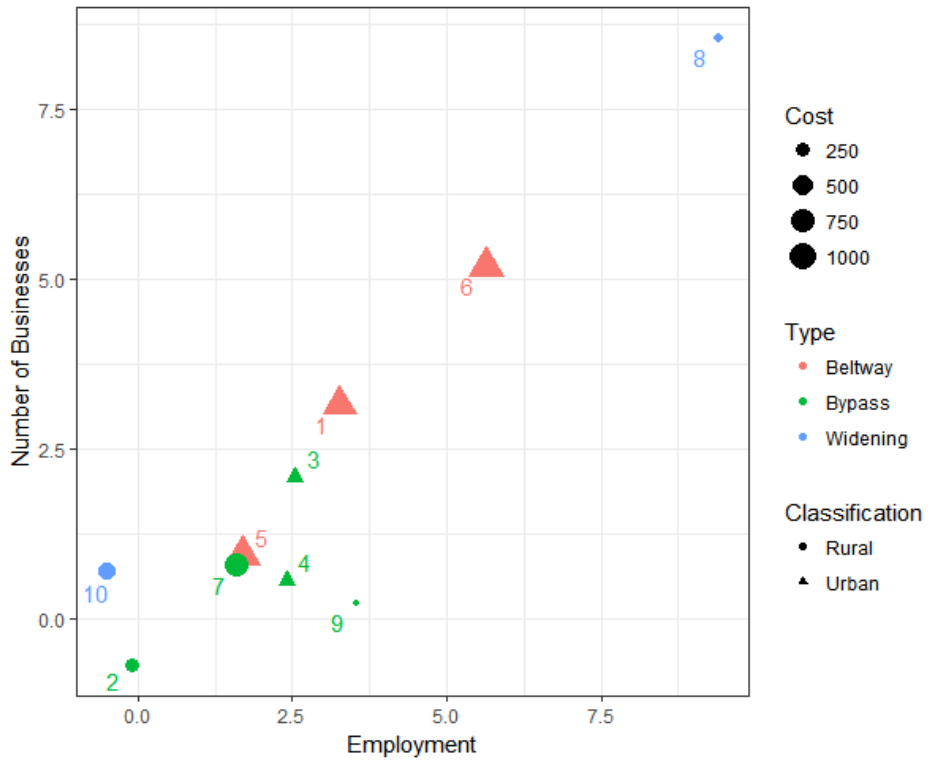

Figure 4. Average annual percent changes in number of businesses and employment in study area.

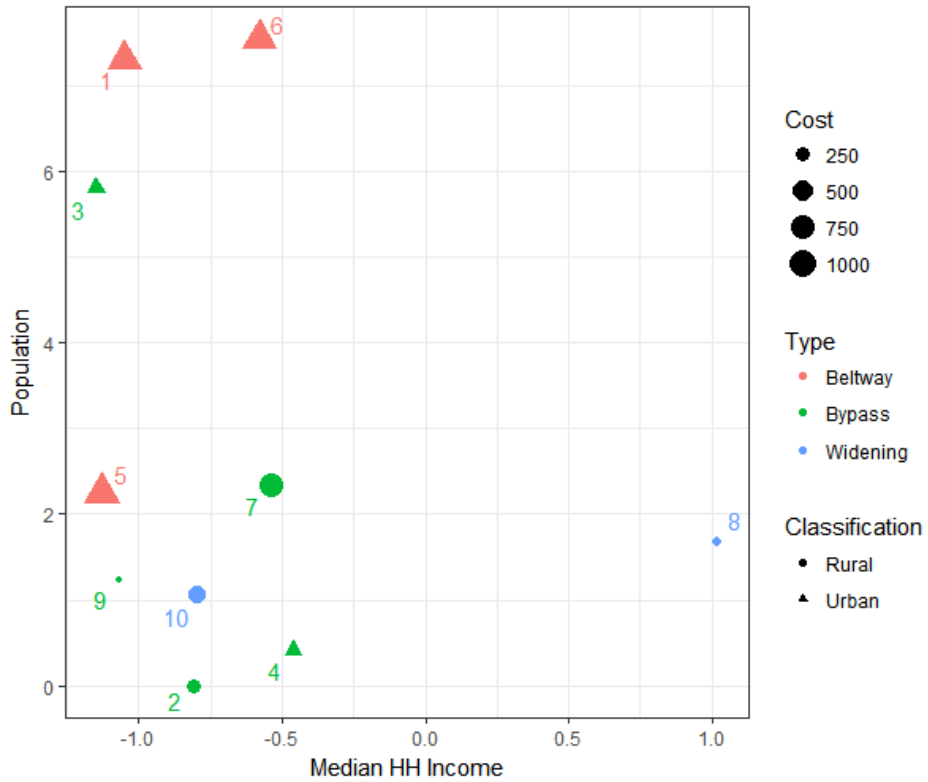

Figure 5. Average annual percent changes in population and median household income in study area.