



Case Studies of Transportation Investment to Identify the Impacts on the Local and State Economy

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Executive Summary

There remains a large amount of interest at state and local levels in using transportation investment as a means to promote economic development. Cities and regions that are growing slowly or not at all view improvements to infrastructure networks, especially transportation networks, as a potential way to stimulate growth by lowering the costs of local firms and making their location a more attractive place for private investment and expansion. Transportation investment programs often become more attractive when coupled with the offer of grants from higher levels of government. They also benefit from the reputation of infrastructure projects as a “safe” type of investment during periods of lower growth. This has been seen most recently with the United States government’s promotion of the American Recovery and Reinvestment Act, where infrastructure spending became emblematic of the bill’s efforts to promote employment, despite being a relatively small portion of the overall spending. Yet, as fewer resources have become available for such projects at the state and local levels in recent years, state departments of transportation and other public works organizations have begun to sharpen their focus to determine where and how such resources should be deployed to yield the greatest returns. This study evaluates the potential of transportation investment to generate increases in private economic activity by empirically examining a recent set of case studies of highway improvement projects in Minnesota.

Transportation investment is but one of the competing factors influencing patterns of economic development, and so as a first step in our study we examine the empirical literature on a number of factors, including transportation, that have been cited previously as affecting development. The factors reviewed include things like human capital and education, taxation and regulatory regimes, quality of life factors, and other types of non-transportation infrastructure such as sewer and water systems, schools and telecommunication systems. Broadly speaking, the factors centering around human capital and labor quality seem to be most important. Taxation and regulation levels are fairly important as well, though they seem to matter less at the national level than at the boundaries between state and local jurisdictions. Quality of life factors remain fairly prominent as well. The most cited factors in this category include things like favorable climates, which have accounted for a great deal of variation in regional population growth in the U.S. over the past several decades, as well as environmental quality and other natural amenities. Since some of these factors (e.g. environmental quality) are under the purview of state and local governments, they tend to complicate the analysis of factors such as taxation and regulation, as a full accounting these factors requires an analysis of their outcomes (e.g. how tax revenues are spent). Many types of non-transportation infrastructure have been found to correlate with economic development, though the direction of causality between them has not always been clearly identified. Finally, much of the evidence on the relationship between transportation investment and economic development suggests that there could be some moderately positive growth effects from improvements to transportation networks,

but that the returns to transportation investment have been generally declining over time as many types of networks have matured.

How do transportation improvements translate into effects on economic growth? Theory suggests that different forces are at work depending on where the improvements are being made. Within urban areas, the primary contribution of transportation improvements for many types of industries is their ability to facilitate *agglomeration effects*. Firms in the same industry within a city may benefit from the use of certain shared inputs, such as specialized pools of skilled labor. A highly developed transportation network could increase firms' access to these types of inputs and thus make them more productive. Outside of large urban areas, several other types of effects might dominate. These include the ability to expand the use of existing resources such as labor and capital (a scale effect), increases in the productivity of existing inputs, and the attraction of new resources and productive inputs (people and new firms) to an area. Several of these effects can take place simultaneously in response to a transportation improvement, thus making it difficult to disentangle their relative contributions.

These processes are not often observed directly due to the lack of quality data at the level of an individual firm. Thus, many analyses of transportation and economic activity rely on data collected at a geographically more aggregate level. In this study we focus on private sector earnings and employment data, collected at the county and city level, respectively, as appropriate measures of economic activity. Both data sources are used to construct panel data sets, which can be used to estimate the effects of the completion of the projects over time.

The first part of our analysis focuses on the case studies of the expansion of US 71/TH 23 (including the Willmar Bypass) near Willmar, Minnesota and the expansion of TH 371 (including the Brainerd Bypass) between Little Falls and the Brainerd/Baxter area. In both cases, county-level earnings by industry are used as the unit of observation. The analysis focuses on the construction, manufacturing, retail and wholesale industries as these have been identified in previous studies as "transportation-intensive" industries. Earnings data from 1991 to 2009 are collected for the county (or counties, as is the case for the TH 371 project) in which the project is located, along with neighboring counties, forming a panel data set. These data are used to fit an earnings regression with controls for population, state-level earnings in the industry of interest, and national output. The model is estimated using a panel correction technique that accounts for correlation across panels in the data as well as serial correlation. The effect of the improvement is estimated via a series of interaction variables that identify the county in which the improved highway is located, along with the time period of the observation (pre-, post- or during construction). Results indicate that none of the industries studied in either of the case study locations show evidence of statistically significant increases in earnings following completion of the respective improvements, once population and macroeconomic trends are controlled for.

The second part of the analysis examines in greater detail the spatial effects on development that might be expected from the case study highway projects. While the analysis of county-level industry earnings did not indicate any significant growth effects, it is possible that the projects might have induced changes in growth rates at the sub-county level. To test this possibility, we use city-level data on total employment for municipalities within the county where the project is located. Total employment data is used to ensure that smaller towns in the sample are not frequently excluded due to data suppression, a problem that would become more pronounced with further disaggregation. The employment data, which are available from 2000 through 2010, are again assembled to form a panel data set which is used to fit employment regressions. The employment

regressions have a similar structure to the models used in the analysis of industry earnings, except that the “treatment” effect of the highway expansions are specified differently. Cities in the sample are stratified according to their location relative to the improved highway. Cities are identified as being located along the improved highway segment, upstream or downstream from the improved highway (and thus likely to still receive some benefit), or neither. Again, these location attributes are interacted with variables identifying when the observation took place. Due to the shorter time series element in this data set, only pre- and post-construction periods are considered – the “construction” period is combined with the period prior to the commencement of construction. The results of the employment regressions indicate similar findings to those provided by the analysis of industry earnings, with little evidence of statistically significant impacts of the highway expansion projects on employment in the towns most directly affected by them.

The results of the analyses of industry earnings and employment for the various case studies appear to be strikingly consistent across locations, an important finding considering the different growth rates and industrial composition of the various case study locations. We cannot completely rule out the possibility that the projects did have some positive effect on employment, but that it was not distinguishable due to the underlying amount of variance in the data. Were this the case though, the effects in question would still be quite small, in most cases on the order of a couple of percentage points. We also note the effect of the recent recession on our results, especially those using the employment data. Despite our efforts to control for macroeconomic trends, the recession undoubtedly had profound effects on private investment and business formation, both of which coincide with the latter years of our data. These years would also be the period when we would expect to see any growth effects from the improved highways.

With these caveats in mind, we may be able to draw some conclusions about the relative role of transportation investment in economic development. First, the lack of evidence of statistically significant effects on economic growth from the types of projects considered here are not unprecedented. Indeed, as our review of the empirical literature on transportation infrastructure and economic development revealed, a number of recent studies have indicated lower, if still positive, overall returns to transportation infrastructure. This seems plausible. While the introduction of the Interstate highways often provided order of magnitude-type improvements in travel times between large cities, most contemporary projects are generally smaller in scope and involve modifying a relatively mature network. In a similar vein, our review of the factors affecting economic development seemed to indicate a continuing, non-trivial role for several non-transportation factors, some of which may be amenable to economic development policy.

We are certain that there will continue to be significant amounts of transportation investment in highways and other networks in the years to come, whether justified explicitly by economic development criteria or not. An important consideration for the evaluation of these investments should continue to be whether or not these projects generate net social benefits. Evaluations focusing on the user (and to a certain extent, nonuser) benefits that flow from a given transportation project will naturally be able to account for benefits like travel time savings, which are valued by users but which may not show up in conventional economic accounts. Under this type of evaluation, projects that might be justified on economic development grounds (i.e. employment or output effects) would likely be funded anyway, since they would almost certainly generate positive net social benefits. This conclusion also applies to transportation investment undertaken for purposes of fiscal stimulus and macroeconomic stabilization.

Chapter 1

Introduction

Transportation investment in both the private and public sector has historically played a critical role in facilitating economic growth by linking together existing settlement patterns at lower cost and by opening up new territory to development. In the United States, canal systems, railroads, and the Interstate Highway System all made sizable contributions to growth by increasing industrial productivity, boosting trade, and allowing for greater innovation in production processes. However, each of these networks has been deployed to a relatively full extent over time, and has reached a stage of maturity. Canals were largely supplanted by rail freight movement, and although a significant share of freight traffic is still handled by waterways, there has been little need to make major new investments. There has also been relatively little new investment in freight rail networks over the last several decades, as more investment has been directed toward maintenance and rehabilitation of existing capital stocks. The Interstate Highway System, though still slowly expanding, has been essentially completed as originally planned. Its current priorities, as identified in federal transportation legislation, also appear to be shifting toward maintenance and preservation.

Despite these conditions, Many states and state departments of transportation continue to promote transportation investment as an economic development strategy. Policies designed to promote development through transportation investment are becoming more sophisticated, as decisionmakers look for ways to more carefully target investments in order to generate greater returns. In addition to targeting projects to specific geographic locations, projects may also be aimed at particular industries or even in rare cases at large individual firms. This study investigates a set of case studies of highway improvement projects in the state of Minnesota and estimates their effects on economic growth through measurement of private sector employment and earnings. Three of the projects considered are highway expansion projects, expanding segments of trunk highways from two to four lanes (two of the projects also include bypasses of small cities), while the fourth is a new freeway interchange that accompanied the development of an industrial park.

The empirical analysis of these case studies proceeds in two stages, with the first analyzing the effects of two of the projects on variations in private earnings in various industries that have been identified in other published studies as “transportation intensive”, implying that they make greater use of transportation networks as part of their production processes. Industry-level earnings in the counties receiving the improvements are estimated relative to neighboring counties. The second stage of the analysis includes all four case studies and focuses more intently on the question of whether the highway projects in question generate redistributive effects by causing differential rates of growth among cities and towns directly affected by by the improvements relative to those

that were not. This analysis focuses on total employment data aggregated to the minor civil division level (cities and townships). More details of these data are provided in chapter 3. In both stages of analysis, we construct panel data sets that bridge the period of project construction in order to estimate their effects of private employment and earnings.

The general layout of this report proceeds as follows. Chapter 2 provides a review of the empirical literature on a set of factors thought to influence economic development, including an extensive discussion of transportation infrastructure. Non-transportation factors include education and human capital, taxation and tax incentives, regulation, quality of life factors, and non-transportation infrastructure. Chapter 3 offers a more thorough description of the data sets used in the empirical analysis. Chapter 4 describes the results of the analysis of industry-level private earnings for the TH 371 and TH 23/US 71 case studies. Chapter 5 extends the analysis to city-level employment effects of the case study projects and examines whether there are relocation effects associated with the projects. Chapter 6 concludes with a discussion of the findings and their implications for both technical aspects of the analysis of the impacts of transportation improvements (including caveats for the present set of findings), and for policy toward the use of transportation investment as catalyst for economic development.

Chapter 2

Review of the Role of Transportation Infrastructure and Other Factors Influencing Economic Development

Transportation infrastructure investment has long enjoyed favored status among the policy instruments used to promote economic development. Policymakers favor such investment as it provides for their constituents a highly visible and tangible symbol of their efforts to promote development, regardless of whether such development eventually occurs. Likewise, transportation infrastructure investment programs benefit from a reputation as a “safe” investment for public funds, promising short-run employment impacts in the construction sector, along with the potential for indirect growth effects in the longer term due to lower transportation costs for households and firms.

Until the 1970s and 1980s, economists had paid little attention to the effects of transportation infrastructure and other types of “public capital” on economic growth. The slowdown in national productivity during the early 1970s and continuing through much of the 1980s generated much interest in studying possible causes, not the least of which was believed to be the level of investment in the public capital stock [62]. While there was no single “watershed” moment that precipitated the intense interest in the topic that ensued, researchers who were active during this period have identified at least two major publications that helped focus attention on the relationship between public capital and growth. The first was the publication of Choate and Walter’s *America in Ruins* [31], a short volume that provided stark commentary on the condition of the nation’s infrastructure, suggesting that the decline in its condition may have had a much broader impact on the performance of the economy [43]. The second was a series of papers published in 1989 and 1990 by Aschauer [4, 3, 5] and Munnell [93], employing production functions to relate economic output to various inputs, including the public capital stock. The finding of a rather large marginal product for the public capital stock led to interest among policymakers, who viewed it as a strong justification for increased spending on infrastructure projects, as well as academics, who were eager to try to replicate the findings using more refined data sets and analytical methods.

Subsequent analyses of the topic revealed much lower estimates of the returns to public capital spending, including transportation infrastructure. Researchers identified several possible reasons for the differences, including the use of more spatially and functionally disaggregate data on the stock of public capital, the ability to account for spillover effects among neighboring jurisdictions, model structures that accounted for the mutual (two-way) causality between growth and infras-

tructure investment, measurement error, and dynamic relationships. While the level of interest in the topic by economists had waned by the late 1990s, infrastructure investment continued to enjoy broad popular support as a public spending program, with new interest groups coalescing around the increasing levels of spending provided for in federal, state and local programs.

As of the late 2000s, a renewed interest has been expressed in using transportation investment as an economic development tool. In late 2010, the Obama Administration unveiled a proposal for \$50 billion in new infrastructure spending loosely tied to the impending reauthorization of the federal surface transportation program. An October 2010 report issued by the U.S. Department of the Treasury reaffirmed the desirability of such a program, offering several reasons for its timely passage [115]:

- Well designed infrastructure investments have long term economic benefits
- The middle class will benefit disproportionately from this investment
- There is currently a high level of underutilized resources that can be used to improve and expand our infrastructure; and
- There is strong demand by the public and businesses for additional transportation infrastructure investments

While the arguments about the distributional impact of the program and its countercyclical effects as a fiscal stimulus during a recession are beyond the present scope of interest here, the claim that “well-designed” infrastructure projects will yield long-term economic benefits is a familiar one, and likely underscores the Administration’s desire to present the program as more than another mere spending program. Many states are also viewing public capital investment as a potential tool to stimulate the economy. While most states have balanced-budget requirements that prevent them from engaging in the type of deficit spending favored by the federal government, spending on long-term capital improvements remains one of the few tools available to state governments to promote growth during a recession. The low long-term borrowing rates that currently prevail make this strategy all the more attractive.

What is likely to come of all this new investment, and are there ways that it can be designed to reposition states and the country as a whole to promote long-term growth? Or are there other, more important factors that overshadow transportation infrastructure as sources of growth? Can any of these factors play a complementary role to transportation? This paper reviews several of the factors cited in the empirical literature as determinants of economic development, including transportation infrastructure. We offer summary judgements, at least qualitatively, about the relative importance of each factor in an attempt to identify what role (if any) transportation investment ought to play in state and local government strategies to promote economic growth. Where possible, we try to distinguish between policies aimed at metropolitan versus rural and small urban areas, as the implications for each may be quite different.

2.1 Defining Infrastructure

It will be useful to have a working definition of the term “infrastructure” with which to frame the discussion that follows. While most observers have at least a vague notion of what infrastructure

entails, some detail can be added to lend specificity to its description. Fox and Porca [52] offer this definition of infrastructure:

Infrastructure is defined as the services drawn from the set of public works that traditionally have been supported by the public sector, although in many cases the infrastructure services may be produced in the private sector. Water, sewerage, solid waste management, transportation, electricity, and telecommunications are examples. Firms' investments in their own productive capacity are not included as infrastructure in this article. Similarly, human capital investment in workers is excluded.

Fox and Porca [52] thus note the important distinction between the physical facilities from which infrastructure services are provided and the services themselves. Ideally, one would like to directly measure the services provided by a given stock of infrastructure in order to evaluate its economic impact, however, as a practical matter, many economic analyses of infrastructure investment have resorted to the use of measures of the stock of infrastructure. Partly, this is due to the difficulty of identifying an appropriate measure of service (as in the case of transportation infrastructure), but also the use of measures of capital stock can be easily accommodated within the specification of an econometric production function.

2.2 Conceptual Relationships Between Infrastructure and Economic Development

It is important to understand the mechanisms by which investments in transportation infrastructure might contribute to economic development. Since these mechanisms tend to be somewhat different for urban versus rural locations, we will treat each separately.

Within cities, transportation and other types of infrastructure networks can foster growth by contributing to the realization of *agglomeration economies*. Agglomeration economies are a form of positive externality in which a firm's production costs are lowered by increases in the output of other unrelated firms. These economies are thought to arise from the shared use of non-excludable inputs, such as labor pools, transportation networks and other types of urban infrastructure [43]. Transportation networks may play an especially important role in cities, since the accessibility provided by them affords access to larger and more specialized pools of labor. Adequate investment in transportation infrastructure is critical as cities grow in size, since larger cities may experience certain types of external diseconomies, such as traffic congestion [61], which may limit the ability of firms in those cities to take advantage of the benefits of agglomeration. Thus, the capacity of urban infrastructure must periodically be increased to mitigate the negative effects of growth.

Outside of urban areas, agglomeration effects are less critical. Smaller cities are able to emerge through the exploitation of internal scale economies, that is, a single firm being able to reduce its costs through increases in its own output irrespective of the behavior of other nearby firms. In smaller cities and rural areas, there are basically three ways in which improved infrastructure can lead to growth. First, such improvements can allow expansion of the use of existing resources (labor, capital and others). Secondly, improved infrastructure may raise the productivity of rural firms. This is the primary source of benefits from infrastructure projects in rural areas. The third way in which infrastructure may lead to growth is by attracting new resources and productive inputs (such as firms and households) to an area [52]. If improved infrastructure improves the quality of

life in an area significantly, it may influence the location decisions of firms. This type of relationship between improved infrastructure and growth is perhaps the most difficult to measure, since data of good quality is scarce and location decisions are complex decisions that reflect multiple criteria. More generally, while it is difficult to disentangle the effects of these three mechanisms when observing and measuring the relationship between infrastructure and economic growth, it is nonetheless important to note that one or more of them may be acting simultaneously to influence economic outcomes.

How then have researchers gone about measuring the contribution of transportation investment to economic growth? The next section will outline and offer evidence on several of the approaches that have been undertaken to measure this relationship.

2.3 Evidence on the Economic Impact of Infrastructure

2.3.1 Transportation Infrastructure

Public Capital

The most well-developed and widely cited body of research relating to the economic impacts of transportation infrastructure development is the series of papers reporting on the growth effects of public capital stocks. Motivated initially by interest in identifying the cause of the productivity slowdown in the United States during the 1970s and 1980s, these studies generally employed some sort of econometric production function to relate economic output to a set of production inputs (labor, capital and others) at some level of aggregation. Public and private capital stocks were developed separately to determine whether they represented complements or substitutes as inputs. As mentioned previously, early findings of large returns in studies by Aschauer and Munnell led to numerous attempts to replicate these results using different data and econometric methods.

Later studies attempted to disaggregate the data used in the analysis. On one hand, there was a need to disaggregate stocks of highway capital from other types of public capital [94, 21] to identify certain types of infrastructure that might yield greater productivity benefits. On the other was the need to disaggregate the level at which variations in output were observed in order to determine whether the observed returns to infrastructure were truly a nationwide phenomenon, or whether they were restricted to a handful of states or particular regions. Studies that employed state-level data on capital stocks and output in order to control for unobserved heterogeneity [76, 77, 55] tended to show much smaller returns to public capital stocks, including highways. At least one [76] found no statistically significant effect on private output. Studies that used city-level (metropolitan) data tended to show returns that were smaller still [23]. Other econometric issues were also being resolved, such as common trends among inputs and spurious correlation, which led some authors to use models specified in first differences, essentially measuring the *change* in output and input levels.

In addition to studies that used production functions to model the relationship between public capital investment and economic output, a related set of studies exploited the duality relationship between production and costs [109] in order to estimate cost functions for particular industries. The manufacturing sector was a common focus of analysis in several studies, largely due to its continued decline during the 1970s and 1980s. Similar to the behavior of the greater economy, it was believed that inadequate infrastructure investment might be a source of rising costs and lack of

productivity. Some studies did find evidence that greater stocks of public roadway and other capital reduced manufacturing costs, including those using data from Sweden [16], the UK [85], and the former West Germany [107]. Comparable studies using US data also showed a relationship between public capital and declining manufacturing costs [95, 91], though the magnitude was modest and could potentially be outweighed by the costs of the public capital, especially taking into account the marginal costs of taxation [91]. One of the more thorough studies of the relationship between highway capital and costs was conducted by Nadiri and Mamuneas [94]. Using data on 35 different US industries for the period 1950 to 1989, they estimated the effects of National Highway System (NHS) and non-NHS highway capital stocks on industry-level and aggregate productivity and costs. They also estimated the net social returns to each type of capital stock during the different decades of their data set. The results indicated that at an aggregate level, returns to total highway capital in the early years of their data (1950 to 1959) were quite large, on the order of 35 percent. However, the returns to highway capital tended to decline in subsequent decades, and by the 1980s had approached the rate of return for private capital at around 10 percent. Returns to non-local highway capital stocks were slightly higher. Manufacturing industries appeared to have cost structures that allowed them to derive greater benefits from infrastructure investments than other industries.

This last point is an important one and a recurrent theme in some of the production and cost literature. The studies that have gone beyond looking at aggregate input classes and total output have found some evidence of disproportionate returns to certain industries and sectors from infrastructure investment. As mentioned above, manufacturing industries are often beneficiaries of improved infrastructure, and this in turn affects their location choices, as will be subsequently discussed. Likewise, transportation industries and industries that use transportation as a key input tend to benefit more. For example, Keeler and Ying [83] sought to evaluate the benefits of the US Federal Aid Highway System by estimating its impacts on costs and productivity in the road freight transport industry. They estimated a total cost function for this industry using data from 1950 to 1973 and found significant benefits from productivity improvements which would have justified one-third to one half of the cost of the highway system on the basis of benefits to trucking alone. This finding of large returns from highways in the first couple of postwar decades coincides with the findings of Nadiri and Mamuneas [94]. A separate study by Fernald [47] using data on 29 private sector US industries over the period from 1953 to 1989 found that industries that were “vehicle-intensive”, as measured by the stock of vehicles employed by the industry, tended to experience greater productivity gains from highway investment. Again, these results indicated that the greatest benefits were derived in the form of a large, one-time productivity boost during the 1950s and 1960s, with the returns from investment falling since then.

The treatment of space and scale have been important developments in the public capital literature also. Analysts note the importance of linking the infrastructure stocks and their users spatially when investigating their contribution to growth, which has led to the use of more local units of analysis. States have been a common unit of analysis, but increasingly, attention is being given to counties and metropolitan areas. However, given the networked nature of transportation infrastructure, the benefits of an infrastructure improvement are often not limited to its immediately adjacent area, which may lead studies using smaller units to underestimate the returns to infrastructure stocks [92]. This problem of spatial spillovers has generally been addressed by expanding the definition of the infrastructure stock in a particular jurisdiction to include elements of neighboring jurisdictions’ capital stocks as well [77, 20, 21, 90]. Other approaches to identifying spillovers have emphasized measures of interaction between neighboring jurisdictions, such as trade flows [33, 111].

A related spatial issue in public capital research that has garnered relatively less attention has been the longer-term, spatial reorganization impacts of public capital investments. While there has been a general recognition that infrastructure, especially major highway links, can affect the location of economic growth, this effect has generally been considered a distributional issue, with few overall implications for growth. The implicit assumption was that at any appreciable level of aggregation (e.g. state or national level) these effects were basically transfers with no overall growth impact. However, given the recent attention, particularly in the urban economics literature, to the effects of agglomeration, there has been some consideration given to the effects that new investment might have on growth (particularly in cities) where such investment alters spatial structure in such a way as to either encourage or discourage agglomeration economies [69].

Growth Regressions

A variety of other empirical approaches have been taken to examining the relationship between transportation investment and economic growth, often with fewer restrictions on model specification than those implied by the public capital line of research, which tend to derive model forms from explicit theoretical considerations. These approaches generally take some measure of economic outcomes (e.g. employment levels, output, wages) and relate them empirically to some measure of the transportation network, among other explanatory factors. The diversity of approaches, both in specifying an independent variable to measure economic growth and in defining a variable to measure characteristics of the transportation network, lead us to summarize them under a broad category which we will term “growth regressions” for the sake of convenience.

Many of the studies that fall under this category do not necessarily have as their primary focus the relationship between transportation networks and economic development, but rather seek to identify more broadly the set of determinants that account for changes in employment levels, population, output, wages or other measures of development, with some measure of transportation identified as an important factor. A classic example is a paper by Carlino and Mills [25]. The authors used Census data on all US counties, along some supplementary data sources, to fit a model that predicted 1980 population and employment densities at the county level. The model (attributed to Steinnes and Fisher [113]) employed a distributed lag structure, and so used 1970 levels of the dependent variables as predictors, along with a variety of economic, demographic, climatic and policy-related variables. The variable that measured the influence of transportation was the density of the interstate highway network in each county. Their results indicated that a doubling of the square miles of interstate per mile of land in a county would be expected to lead to a six percent increase in employment density over the course of a decade and a 2.8 percent increase in population density.

The approach of Carlino and Mills was repeated in a subsequent paper by Clark and Murphy [32] who used a similar model to extend the analysis to employment change in five major sectors for the period from 1981 through 1989. Clark and Murphy used a measure of the transportation network that differed slightly from the one employed by Carlino and Mills in that they measured the density of total road mileage, as opposed to focusing only on interstate highways. Also, they split the highway variable into two separate measures in order to test for possible variations in the effect of road network density by region (a “North” variable for the Northeast and Midwest census regions and a “South” variable for the South and West regions, along with a “total highway” variable that combined the regions). Their results indicated that the road density measure had no

statistically significant effect on population density, however it did have mixed effects on employment density. The highway variable had a positive effect on employment density for the southern and western parts of the country, but a negative effect for the Northeast and Midwest, leading the authors to speculate that the negative effects observed in the northern locations were related to existing congestion levels in their urban areas while road network density was viewed as an asset in the South and West.

Other variations of this modeling approach using national, county-level data, have sought to explain economic growth using specifications that treat transportation infrastructure as intermediate input. For example, Wu and Gopinath [120] estimate a structural model of labor and housing markets (predicting wages and housing prices) in which transportation, defined as state and local road network density, is endogenously determined and affects the demand for both labor and urban space. The transportation variable was found to be a statistically significant predictor of labor demand, as well as the demand for and supply of urban space (measured as developed area). The causality between the transportation network and measures of employment and developed area was found to run in both directions.

A two-way relationship between transportation network development and the location or magnitude of economic activity is a common finding among studies that employ model structures allowing for such a relationship. In a previous section, we noted that one of the primary channels through which transportation investment can affect economic development is by attracting economic inputs, including workers and employers, to a particular location. Studies of long-term population change in response to the development of highway networks provide some additional support for this hypothesis. For example, Voss and Chi [116] used data on all major highways expansions in the state of Wisconsin from the late 1960s through the 1990s and population counts at the minor civil division (MCD) level to examine the causal relationship between highway development and population growth. They found evidence of causality in both directions, with location of an MCD within 20 miles of a major highway expansion project being associated with greater population growth in subsequent periods and, in turn, population growth serving as a reliable predictor of the likelihood of highway expansion.

Findings of two-way causality between investment and economic growth tend to present one type of methodological challenge that must be overcome in modeling this relationship, as the location of new network improvements often can be endogenous to the growth process. Additionally, as was hinted at in the review of the public capital literature, estimated effects of transportation investment may vary across space (spillover effects) as well as by industry. One recent study by Chandra and Thompson [27] accounted for both of these types of effects, while also estimating the variation in economic impact of a transportation improvement over time. The authors compiled a unique data set including non-metropolitan US counties that received or did not receive a new interstate highway between 1969 and 1993, coupled with data on earnings by 1-digit SIC (Standard Industrial Classification system) industry. They specified a regression function relating earnings in a particular industry for each county and year to earnings in the same industry at the state and national level and to a series of dummy variables representing the presence or absence of an interstate highway in each year. The authors estimated separate equations for each industry and split their data sets into counties that received interstates, counties adjacent to those that received interstates (in order to test for spillover effects), and counties that did not receive interstates. The basic assumption underlying their analysis was that the addition of an interstate highway was exogenous in the sense that it was not affected by growth rates in the counties under study. In other words,

the location of a highway in a non-metropolitan county was more likely to be the result of other external factors, such as the need to link larger urban areas, with the routing through certain non-metropolitan counties being merely incidental. This assumption was tested and found to be valid by fitting models that related the likelihood of receiving an interstate to growth rates in the prior four years. Their empirical results suggested that interstates had a positive effect on earnings in the counties they passed through, but that this effect was tempered by slower growth rates in adjacent counties. Also, the results tended to vary by industry, with certain industries such as manufacturing, retail trade and services showing larger positive impacts.

Lastly, one another approach within this broad subset merits attention. Some researchers have hypothesized that, apart from direct effects on output or employment levels, public infrastructure may have important economic effects by serving as a household amenity, and thus affecting indirectly outcomes such as wage levels and household location choices. This view contrasts with the framework of production functions employed in the public capital literature, which emphasize public capital as an unpaid factor of production. Dalenberg and Partridge [36] investigated the role of state infrastructure, emphasizing highway capital stocks, as a household amenity and thus a determinant of state wage levels. Using a panel of state-level data from 1972 to 1991, they estimated reduced-form equations for overall private sector wage levels, as well as manufacturing wages. Their results indicated that increases in the highway capital stock *reduced* private wages, while the opposite effect was found for manufacturing wages. Their interpretation of these findings was that highways serve as a household amenity (or “compensating differential”), thus increasing their utility and, in turn, making them more willing to accept lower wages. The finding of a positive relationship between highways and manufacturing wages was interpreted as evidence that, for the manufacturing sector at least, the productivity effects of highways dominated the amenity effect. Dalenberg et al. [37] followed up this study with another paper providing empirical evidence of a relationship between highway capital and employment growth at the state level. They had hypothesized previously [36] that a finding of positive amenity effects from infrastructure (in the form of lower wages) could help to explain the previous conflicting findings of negligible impacts of public infrastructure capital on output, but positive effects on employment levels. This result can be explained, they suggest, by observing that highways can act as an amenity that attracts in-migrants (thus increasing employment), while not materially affecting average private sector productivity. An important caveat to this finding is that Dalenberg and Partridge [36] did not attempt to control for possible reverse causality between wage or employment growth and increases in highway capital stocks, as some other studies have [41, 27].

Matching Techniques

Though experimental data in transportation-related research are rare, some researchers have developed evaluation techniques that mimic the process of controlling (to the extent possible) for external sources of variation in outcomes, similar to controlled experiments. Rephann and Isserman [102] applied a matched pairs technique referred to as a “quasi-experimental matching” method [81] to evaluate the effects of interstate highways built between 1963 and 1975 as part of the Appalachian Regional Development Program on economic growth in counties that received or were near counties that received new interstate links. Statistical clustering techniques were used to identify counties as members of control and/or treatment groups, with the presence of a new interstate highway serving as the “treatment” effect. Their results indicated that the greatest beneficiaries of

highway development were residents of counties in close proximity to large cities or that had some prior degree of urbanization (defined as having a city of 25,000 or more people). In contrast, rural counties that received interstates and counties with no interstate access saw little evidence of new growth.

Firm Location

Any serious state or local economic development program is likely to be concerned not simply with attempting to attract mobile factors of production (firms, households, investment capital) away from other locations, but also with attempting to foster an environment that is conducive to the location of new firms and the growth of existing ones. Some economists argue that observing the location choices of new firms provides a better indication of the economic health of a location, since newly locating firms are responding purely to the current set of economic incentives in a location, while existing firms may be somewhat influenced by prior location decisions Carlton [26]. Thus, another important method for examining the relationship between transportation investment and economic development is the study of firm location decisions.

Research into firm location decisions is often not motivated primarily by interest in the impact of transportation networks, though they are frequently identified as an important factor. Much of the research on firm location has developed out of fields such as economics, regional science, and geography, where the objective has been to identify the set of determinants that influence location choices and their implications for public policy. Certain factors, such as taxation levels, labor quality and cost, unionization, as well as some regulatory measures, are frequently employed as explanatory variables. While some earlier studies of firm location used more aggregated observational units, such as metropolitan statistical areas [26], the dominant trend in this line of research has been toward improved, micro-level firm or plant location data. These data have been combined with some more sophisticated econometric techniques for handling discrete or count-type data in order to produce more reliable and meaningful results.

The type of firm being studied tends to influence whether the measure of transportation employed in each study has an indentifiable impact on firm location. In a study of the location choices of small business start-ups in a range of manufacturing industries, Bartik [9] found mixed evidence on the impact of highway network density on the probability of a firm choosing a given location (state). Estimates from a larger, pooled cross-sectional data set indicated a positive and significant relationship, while no such relationship was found when the sample was restricted to a smaller panel data set. These results contradicted earlier findings by Bartik [8] that a similarly defined highway density variable had a positive influence on the state location choice of new manufacturing plants under a less restrictive model specification. Other empirical studies which examined the location of new foreign-owned manufacturing plants in the US [119, 112, 34] also found evidence that location choices were positively and statistically significantly affected by the presence of major highways, usually interstates.

Evidence from European countries tends to support the hypothesis of a relationship between transportation infrastructure and location of new firms. Papers by Holl [73, 72] which examine firm births in Portugal and Spain, respectively, during the 1980s and 1990s (a period of major highway development in both countries), find evidence of a relationship between the location of highways and the spatial distribution of new firm births. The results tended to vary across the different sectors of the economy included in the analysis, as well as by location. In each study, some evidence was

found for the geographic concentration of firms in certain industries near highway links, primarily within 10 to 20 kilometers (6 to 12 miles) of a major highway. However, similar to some of the other studies cited previously, Holl found some evidence of “negative spillovers” in which locations nearest the highway links received the greatest benefits, but largely at the expense of slower growth or decline in neighboring jurisdictions.

The representation of highways in empirical studies of firm location tends to be rather simple, as it often is in other empirical studies that relate transportation networks to economic growth. Treatment of transportation infrastructure commonly reduces to the form of a presence/absence dummy variable for some level of the highway network or some measure of road network density. Partly, this is due to many of these studies originating in fields outside of transportation, but consideration must also be given to the fact that many studies that include transportation as an explanatory factor do not consider it to be the primary focus of the analysis, and thus not worthy of greater attention than is accorded to other explanatory factors. Despite this limitation, there seems to be fairly strong evidence of a positive association between the location of major transportation infrastructure, primarily highways, and the location choices of firms. This relationship appears to be especially strong in manufacturing industries or other industries where transportation serves as a key input to production.

2.3.2 Other Infrastructure

Apart from transportation, other classes of infrastructure have received considerable attention from economists to determine their contribution to economic growth. Interest in the economic implications of infrastructure predates the barrage of published studies in the public capital literature following the findings of Aschauer and Munnell. Earlier theoretical work in development economics had hypothesized the concept of “social overhead capital”, or some minimal level of infrastructure services that could facilitate the transition to self-sustaining growth. This concept was believed to be an important source of agglomeration economies and a possible explanation for persistent difference in levels of development between urban and rural regions. However, empirical support for this hypothesis was scarce until the early 1970s, due largely to the absence of available data sets on public capital stocks at regional levels. A paper by Mera [88] compiled data on public and private capital stocks from Japanese prefectures and used them to estimate three-factor (labor, public and private capital) production functions for each region. The findings of positive effects of public capital on production in a range of sectors propelled interest in better defining and measuring infrastructure as a productive input.

The definitions of social overhead capital and infrastructure are rather vague, and can be interpreted much more broadly than conventional definitions of physical infrastructure. For example, in his study of Japanese regions, Mera [88] identified four classes of social overhead capital, each with several components.

- The first class of public capital included soil and water conservation, flood control, irrigation, and other governmentally provided improvements for the primary sector (i.e. agriculture, forestry, fishing, hunting and marine culture)
- The second class included coastal improvements, industrial water supply, vocational training facilities, and public facilities for supplying power and gas

- The third class included transportation and telecommunications facilities, and
- The fourth class included health, educational and welfare facilities, including public housing

As Mera's classifications indicate, social capital can include a broad range of public services, including education and health services, that are not conventionally thought of as "infrastructure". Other studies by Blum [19] and Nijkamp [96] had similarly broad classifications for types of infrastructure, including categories for social, cultural, natural endowment, sports and tourism activities, and the environment. Nadiri and Mamuneas [95] considered public research and development (R&D) capital as a production factor, while Andersson et al. [2] extended the concept of "knowledge infrastructure" to a measure of research and cognitive education, proxied by the number of professorial chairs in a given region. Despite their heterogeneity, many of the services considered as infrastructure or public capital share the characteristics of being unpaid inputs to private production and being subject to scale economies, meriting their inclusion in analyses of production or cost functions. Many of these factors continue to be relevant for economic development, and will be mentioned in a subsequent discussion of quality of life issues.

Quite often, the studies that have examined the relationship between infrastructure and economic growth have taken the production and cost function approach cited in the previous discussion of the public capital literature, and have considered several types of infrastructure simultaneously. Analyses that have collected data on several different types of infrastructure stocks have generally found mixed results. Some have found evidence of positive effects on output or firm costs across a range of types of public capital [101, 35, 39, 97], while others have found little or no effect [114, 45, 76]. Some studies have found positive returns to certain types of infrastructure or activities. For example, Evans and Karras [44] examined a range of government capital and services categories and only found educational services to be productive. Andersson et al. [2] found R&D capacity, along with transportation and communications services, to be the components of infrastructure most strongly associated with regional productivity. Eberts [42] found evidence of positive, though modest, impacts on manufacturing output of a public capital stock consisting of highways, sewage treatment facilities, and water distribution facilities. Feltenstein and Ha [46] found that electrical and communications infrastructure lowered production costs in several sectors of the Mexican economy using data from 1970 through 1990. Interestingly, they also found a *positive* relationship between transportation infrastructure and costs, a finding which Krol [84] speculates may be attributable to congestion problems on Mexican highways.

One other type of infrastructure that has recently grown in importance is telecommunications, encompassing a range of services such as mobile telephony and broadband internet services. Systematic evidence on the relationship between telecommunications and economic growth is somewhat limited, though a study by R'oller and Waverman [105] provides some of the best evidence to date. The authors use data on 21 OECD countries from 1970 to 1990 and develop a structural model which involves jointly estimating a model of the demand for telecommunication (mainly telephone) services and a macroeconomic production function. Their results indicate a strong causal link between telecom investment and aggregate output. Moreover, they suggest that this relationship is accelerated when a critical mass of telecom infrastructure, which is apparently near universal services, is present. This finding is attributed by the authors to the presence of network externalities in information and communications technologies.

2.4 Other Factors Influencing Economic Growth

2.4.1 Education and Human Capital

One of the most consistently high-ranking factors influencing economic development at all geographic scales is the bundle of attributes commonly referred to by economists as “human capital”. Human capital refers to the set of education, skills and knowledge individuals accumulate throughout the course of their working career, and can represent a measure of the quality and productivity of the labor force. Since it is often difficult to observe the full set of characteristics that comprise human capital, studies that relate human capital to measures of economic development typically use one or more proxy measures, such as literacy rates or years of schooling.

In the empirical literature relating human capital to growth, a recurrent issue has been the choice of a suitable proxy measure to represent human capital. Nearly all proxy measures have some shortcomings in terms of accurately measuring the value added from education, job training, or other relevant components of human capital. Measures of the quantity of schooling provided are often employed due to the availability of relatively standardized data sets across geographic locations. This advantage permits the analysis of the impact of variations in education and human capital across states and also across countries.

While the definitional issues are complex, the evidence of the contribution of education and human capital to economic growth is fairly consistently positive regardless of measure, though the magnitudes of estimates vary. The largest estimates are typically derived from regressions which identify the determinants of growth in a cross-section of countries using educational proxies such as enrollment rates in primary or secondary schooling [6, 86] or composite measures of years of schooling among primary, secondary and higher education institutions [15]. Likewise, Glaeser et al. [60] found evidence of a positive association between years of schooling and population growth rates among a sample of US cities between 1960 and 1990.

Some other studies have found smaller [66, 17] and even ambiguous [40] relationships between education, as measured in terms of educational attainment (years of schooling) or educational inputs (i.e. spending), and growth. The findings have prompted closer examination of the complex linkages between schooling and growth, including consideration of mutual causation between educational [17] attainment and economic growth and the role of educational quality versus quantity in generating human capital [99]. Studies that control for quality variation in schooling, often by measuring achievement levels on standardized tests [68, 7], tend to find positive residual effects of school quality, especially when quality is measured in terms of mathematics and science test scores [68].

Another important, but less thoroughly studied aspect of human capital is entrepreneurship. The skills required to successfully run a business are critical to economic growth, especially in places where they are in short supply, such as less developed countries. Of course, many of the definitional and measurement issues that complicate other aspects of human capital research also apply to entrepreneurship. One recent study by Acs and Varga [1] that managed to operationalize this concept (by measuring the share of adults engaged in starting up a business or operating a newly-started business) found a positive relationship between entrepreneurial activity and the creation of knowledge spillovers, as measured by the number of patent applications, in a sample of European countries. Though it was not directly measured in this case, knowledge spillovers are implied to have a positive impact on long-run growth.

2.4.2 Taxation and Tax Incentives

Perhaps one of the most debated and controversial questions regarding economic development is the role that taxation and business incentives play in promoting or inhibiting growth. At the state and local level, modifications in tax rates and special packages of tax breaks for certain firms or industries are a favored tool for promoting economic development, despite being viewed skeptically by many economists [10, 11, 98]. Some have suggested that the popularity of tax incentives, despite the lack of evidence on their efficacy, derives from the fact that citizens are largely unaware of their presence or costs [22]. If the incentives are successful at generating new jobs or income, politicians who authorized them can take credit. On the other hand, if they fail to produce the desired results, there is little political backlash due to their low profile.

Reviews of the literature on the effects of state and local taxes on economic development tend to focus on estimates of the *tax elasticity*, that is, the response of business activity to changes in tax rates holding all other factors constant. Studies are generally sorted according to whether they study interregional (intermetropolitan or interstate) or intraregional variations in business activity or firm location due to the large difference in reported elasticities. Studies of interregional tax elasticities tend to find values of between -0.2 and -0.3 [11, 98, 117], meaning that a 10 percent (not percentage point) decrease in tax rates will, all else equal, lead to an increase of between 2 to 3 percent in business activity. Intraregional tax elasticities tend to be considerably higher, perhaps quadruple the value of interregional elasticities or more. This is primarily because cost and other market variables tend to be rather similar at the intraregional level, implying that fiscal differences take on greater importance in location choices [117].

Researchers offer some caveats to interpretation of tax elasticities however. First, at the interregional level, tax elasticities must be interpreted in the context of overall state and local tax levels in the place of interest as well as its neighbors. If overall tax levels in neighboring states are similar, the estimated tax elasticities will likely be small [117]. Secondly, if state and local tax cuts must be financed with cuts to public services, the response of business activity may be small (or even negative) [12]. This is because at least some public services have positive utility for prospective firms.

One recent study has evaluated the early effects of a state-level tax incentive program in Minnesota. The Job Opportunity Building Zone (JOBZ) program was enacted by the Minnesota Legislature in 2003 to encourage job growth in underdeveloped rural areas. The program creates tax-free zones that offer special incentives to new firms that locate within the zone or incumbent firms within the zone that choose to expand there. The tax benefits associated with the zones are conditioned upon the recipient agreeing to create a minimum number of jobs in that location within a specified time frame (typically one year). An evaluation of the program's first three years of operation by Hansen and Kalambokidis [67] used employment data reported by the program's participating firms along with county-level economic data to evaluate the program's early impacts. They find rather modest impacts on job growth, with businesses signing deals in 2004 and 2005 reporting the creation of 4,891 new jobs. Putting this in perspective, the authors note that this figure represents less than one percent of total private, nonfarm employment. Capital investment levels were similarly modest. A preliminary empirical analysis found little evidence of an impact of JOBZ-related employment and investment on county-level growth in population, employment or income levels. One other notable finding was that the reported job creation and investment levels varied widely across zones, with some zones reporting as many as 1,332 new jobs, and others as few as 51

jobs. Likewise, one zone accounted for nearly one-third of all capital investment reported during the study period. The results suggest a need for continued examination of the program's impacts and a more disaggregate analysis to determine what accounts for the large differences in economic impact across zones.

2.4.3 Regulation

Regulation affects economic outcomes in two separate ways. First, regulations generally have negative effects on firms and households by restricting the scope of their activities and often, in the case of firms, by raising their production costs. Regulations may also affect the location and expansion decisions of firms in the longer term. However, regulations may also have significant positive social benefits by reducing external costs or risks, or by ameliorating recognizable instances of market failure.

At the national level the effects of regulations are not as critical to the function of the economy, but at state and local levels they can have greater impacts, since many regulations vary by jurisdiction. For example, state labor laws regarding unionization have had a market impact on firm location in recent decades [8]. Holmes and Stevens [75] notes that many southern states have had success in luring manufacturing activities due to the presence of right-to-work laws which limit mandatory unionization and thus indirectly affect labor costs. This effect appears to be particularly strong near state borders [74], reflecting differences in regulatory regimes.

Compliance with regulatory measures can be troublesome for local jurisdictions, especially when regulations are imposed by higher levels of government. A much-studied example of this is the Clean Air Act (CAA) of 1970 and its subsequent amendments. Measurements of air quality are taken within counties and, when counties are found not to be in compliance with permissible air quality standards, local regulatory efforts are triggered to improve compliance. As several economists have noted, an unintended effect of this more stringent regulatory policy has been to induce firms to move out of non-attainment areas and to reconsider plans to site new facilities there [87, 71]. One study by Becker and Henderson [14] used plant-level manufacturing activity data over a 30-year period (1963-1992) spanning the introduction of the CAA and estimated that polluting industries in non-attainment areas saw declines in firm births of 26 to 45 percent due to the regulation differential. Another study by Greenstone [63] using data from the Census of Manufactures estimated that during the first 15 years of enforcement of the CAA, non-attainment counties lost approximately 590,000 jobs, \$37 billion in capital stock, and \$75 billion of output in pollution-intensive industries.

To be sure, the net effects of most regulations are not uniformly negative. Most regulations provide at least some benefits to some group of constituents. Returning to the example of the Clean Air Act, there is evidence that the benefits from air quality improvement, particularly in urban areas, were real and of significant size. Chay and Greenstone [28] examined the relationship between observed levels of total suspended particulates (TSP) and housing prices at the county level, finding that the improvements in air quality induced by the non-attainment designation were associated with a \$45 billion aggregate increase in housing values in non-attainment areas. Similarly, while air quality regulations had a generally negative effect on manufacturing activity in polluted locations, the disappearance of those polluting firms and the resulting improvement in air quality tended to confer significant benefits on many Rust Belt cities in the US. Kahn [82] documents how the decline of manufacturing in Rust Belt cities led to dramatic improvements in air quality, estimating

that the air quality improvement in Pittsburgh would be expected to lead to an increase of \$15,000 in the price of the average home. Thus, effective regulations can confer benefits in the form of improvements in the quality of life for urban residents, generating amenities for which they may be willing to pay a premium.

2.4.4 Quality of Life

Increasingly, the role of amenities and factors that influence the quality of life in different places are affecting the location choices of firms and households. Changing locations is not a costless decision, but when the differences in costs or levels of amenities between locations is large enough, increasingly mobile households and firms may decide to relocate. Thus, an important element of contemporary economic development policy involves identifying the fostering the set of amenities that are observed to attract mobile factors of production, mainly capital and a high-quality labor force.

The theory behind formal estimates and rankings of quality of life across locations, attributable to Rosen [106] and Roback [104], suggests that tastes for certain amenities differ among the population. Those with stronger preferences for amenities tend to sort themselves into more amenable places, ultimately being willing to accept a lower wage in exchange for this better bundle of locational attributes. Additionally, those with weaker preferences toward amenities will be willing to accept a lower wage to go without the same level of amenities, and thus would be likely to be found in less amenity-rich cities [104]. Thus, empirical studies of the quality of life across locations frequently use models which predict both wages and housing prices (or rents) across locations. Development of quality of life rankings involves using the estimated coefficients from these models to identify the value consumers place on different locational attributes, and thus uses them as weights in composite quality of life rankings [64].

Which attributes matter most for a place's quality of life, then? One of the most widely cited attributes of location which varies significantly from place to place is climate. Climate is actually a bundle of weather-related attributes, most of which are found to have some impact on the amenity level of a location. In general, most studies have found that, all else equal, households prefer locations which are warmer, drier, and sunnier [104, 18, 54]. Some have also found evidence of an intrinsic preference for coastal locations [100]. Other environmental attributes contribute to quality of life as well, especially ambient air quality. As noted in the previous section on regulation, households generally value air quality and the empirical evidence from the quality of life literature tends to support this [104, 18, 82, 54]. Various studies have cited total crime [104] rates, as well as rates of violent crime [18, 65, 54] as important disamenity effects. The quality of many types of public services is also frequently cited as an important quality of life factor [48]. Measures of school quality such as the ratio of teachers to pupils have been shown to positively affect quality of life in some studies [18], but show no effect in others [54]. Other measures of state and local public expenditure cited by Gabriel et al. [54] included higher education expenditures, which had a negative but insignificant implicit price, and spending on highways and public welfare, both of which appeared to be valued positively. Lastly, most studies find increases in average commute times to have significant negative effects on quality of life.

While important quality of life factors like climate are intrinsic to location, many of the other attributes are available to some extent across locations and can be influenced by public policy decisions. However, in recent years more attention has been focused on the efforts of state and local

jurisdictions to promote growth by attracting and retaining certain types of workers. High-quality and highly-skilled workers and entrepreneurs are now seen as critical to the success of places [108], and attempts to cater to the tastes of these individuals has become a distinguishing feature of the economic development strategy in many places. While cities are coming to be recognized as important places of consumption, and thus attractive to higher-skilled and higher-income workers [59], there is much speculation as to which types of features are critical to attracting such talent. Many cities have spent money on cultural attractions such as theaters and sports facilities in the hope that these amenities will help retain key talent, though there is little supportive evidence for the contention. Likewise, popular works that emphasize strategies for attracting the “creative class”, most notably by Florida [49, 50], have suggested that cities differentiate themselves by attracting “bohemian types” and encouraging social tolerance. Intriguing as these hypotheses are, they still lack solid empirical foundations [56].

Quality of life is an issue that matters to rural economic development as well. Researchers have noted that economies outside of large urban areas are no longer primarily based on agriculture or resource extraction, but that recent and projected future growth in many rural areas is likely to be based on recreation and consumption of natural amenities [80]. The source of this growth is likely to extend beyond the seasonal tourism activities that are important sectors of the economy in many locations, to include retirees and other new year-round residents who are attracted to locations featuring favorable climate or natural amenities (lakes, mountains, etc.). One study by Deller et al. [38] examined data from 2,243 rural US counties and used principal components analysis to identify five broad measures of natural amenities relating to land, climate, water features and recreational activities, winter activities, and recreational infrastructure, which were found to be positively related to changes in population, income, and employment at the county level.

2.5 Summary

This survey of the literature on transportation and economic development has served to provide evidence on two types of questions. The first question relates to the identification of factors which have been shown to influence economic development, including transportation infrastructure investment. Four non-transportation factors (education and human capital, taxation and incentives, regulation, and quality of life factors) were reviewed, along with transportation and non-transportation infrastructure. The second question relates to how analysts have gone about measuring the relationship between transportation networks and economic growth, and how previous research approaches can inform the design of subsequent analyses.

Our review of the determinants of economic growth suggests that the most important factors are those which allow locations to attract mobile capital and labor. In particular, the ability to attract, retain and develop a skilled, high-quality workforce seems to be a critically important factor. As the literature on quality of life has shown, some locations have intrinsic advantages due to a favorable climate or other natural amenities. The long-term trend of disproportionate population growth in the southern and western portions of the US bears this out. Such amenities can be a double-edged sword, however. California’s experience in recent decades provides an illustrative example. Its combination of favorable climate and considerable natural amenities has led to a population boom that has extended over several decades. However, the effects of this rapid population growth has had a degrading effect on its quality of life, particularly in urban areas. Research into patterns

of out-migration in California during the 1980s finds at least some of the trend attributable to changes in quality of life factors [53]. In fact, California is not alone in this regard. Other research into changes in quality of life rankings across states during the same period [54] found that other states that experienced rapid growth often suffered declines in quality of life due to many of the same problems that plagued many urban areas in California, namely increased traffic congestion, worsening air pollution and reduced infrastructure spending. These quality of life problems were aggravated in California by the addition of high housing costs in many large cities, adding a high cost of living to the state's other disamenities. Despite these factors California continues to attract new residents, perhaps a testament to the influence of amenity-rich locations.

Places that do not enjoy such advantages have had to find other ways to make themselves attractive to prospective workers and firms. The continued growth of cold-weather states like Minnesota and Massachusetts in many ways reflects the combination of other factors that can make a place economically attractive. High-quality public services, a noted quality of life factor, combined with a highly-educated and skilled workforce, help to sustain both of these locations as attractive places for growth and expansion.

Other factors reviewed here, such as tax rates, incentives, and regulations, seem to play a modest role in influencing economic growth. The effects of these factors on growth seem to be highly location-specific and to have their greatest impact near jurisdictional boundaries, especially where the differences between jurisdictions (in terms of tax rates or regulatory stringency) are large. As noted before, some southern states have managed to achieve a moderate degree of success in luring some manufacturing industries by focusing on low tax rates and business-friendly regulatory regimes, but this trend does not seem to have carried over to nearly as great an extent in most white-collar industries.

Our review of studies of the impact of transportation investment on economic performance shows somewhat mixed results. The largest strain of this literature, namely studies of the growth effects of public capital stocks, has shown a trend toward declining returns over time. The results tend to be more pronounced when focus is shifted away from nationwide studies toward smaller levels of aggregation. What accounts for this trend toward declining returns? Three possible explanations, perhaps complementary to each other, emerge from the literature:

- The first explanation emphasizes the steep decline in transport costs over time. Glaeser and Kohlhase [58] report that the share of GDP in transportation industries fell from 8 percent in 1929 to just 3 percent in 1990. Falling transportation costs are undoubtedly a good thing, economically speaking, though they suggest that the possibility of large private returns from new network investment is unlikely due to the relatively small role of transportation as in input.
- The second explanation, and a related one, is that modest returns from additional investment in transportation should be expected due to the relative maturity of most transportation networks. For most transportation networks, the most productive or profitable links have already been built and so new investments will likely be subject to diminishing marginal returns.
- The third explanation emphasizes the role of political interference in reducing the efficiency of infrastructure spending, and thus affecting its economic impact. This explanation is not simply limited to the prevalence of "pork-barrel" spending, which does have a detrimental

impact [70, 110, 24] and is highly visible. It also relates to the inefficient operation of infrastructure, such as mispricing of use (or absence of pricing), which has led to both congestion problems and to the premature deterioration of infrastructure capital [118].

None of this is to suggest that no new investment is warranted. There may well be many new projects which generate respectable rates of social return, but these should first be rigorously evaluated [79, 62]. Additionally, the issue of making more efficient use of existing transportation networks merits considerable attention. Most of the studies in the public capital literature emphasize the role of spending and the accumulation of public capital stocks on output. Few such studies considered the efficiency with which transportation infrastructure is managed and operated [78]. As we argued previously, the most useful definition of infrastructure is one which emphasizes the flow of services it produces. These are what allow the scale and agglomeration benefits associated with rural and urban areas, respectively, to be obtained. Efficiently managing infrastructure, for example through direct pricing, seems to be a more promising way to deal with the impacts imposed on infrastructure networks by growth without sacrificing the levels of service those networks provide.

Another methodological issue that emerges from the studies reviewed here is the representation of transportation networks. Most of the studies classified as growth regression or firm location studies tend to involve relatively simple treatments of transportation. Many of the studies using county-level data sets account for transportation by including dummy variables to indicate the presence or absence of some type of highway, typically interstates. Again, it should be noted that many of these studies originated outside the field of transportation, and that in several of them the impact of transportation infrastructure was of secondary concern. Nonetheless, more detailed representations of transportation networks would be useful. Some of the studies from the public capital literature include measures of the extent of the transportation network, such as highway miles per square mile (a network density measure). This represents an improvement over measures of levels of spending or measures of the value of the capital stock in that it is more closely related to the services provided by the infrastructure. Still, we would ideally like to have measures that can account for the impact of marginal changes to the network, as opposed to simply measuring stocks at given points in time.

It may also be worthwhile to consider the possibility of mutual causality between transportation investment and economic growth. Several of the econometric studies reviewed here either chose an explicit specification which allowed for the direction of influence between these factors to run both ways [41] or tested for the possibility of such an effect [27]. This approach has proven to be particularly important in the public capital literature, where the relationship between economic growth and public capital formation is most clear-cut.

Lastly, the matter of spatial scale is instrumental to understanding and measuring the relationship between transportation and economic development. Estimates of the direction and magnitude of the influence of transportation networks on economic development depend strongly on the choice of observation units and the level of aggregation they represent. As Rietveld [103] notes, the determination of whether observed growth effects from infrastructure improvements are generative or redistributive depends on where one demarcates boundaries. Thus, it may be important to consider spillover effects across neighboring locations, especially when the units of analysis are geographically small. As some of the studies reviewed here have shown, infrastructure investments may generate both positive and negative spillovers. Positive spillovers appear to be common with

transportation infrastructure due to the networked nature of its structure. However, as some of the studies of the impacts of rural interstates have shown, some of the gains observed in locations adjacent to the highways were countered to some extent by losses in neighboring locations. Thus, evaluating the gains from transportation infrastructure improvements may involve tallying the net effects across all impacted locations.

Chapter 3

Data

The analyses of economic impacts of transportation investments in the following chapters will make use of data on industry earnings and employment, both of which are available from the federal government's Bureau of Economic Analysis (BEA). This section will introduce the data sets used for each type of analysis, identify their scope and completeness, and note any other issues that may arise in their application to the empirical analysis.

3.1 Industry Earnings Data

The analysis that looks at aggregate, county-level impacts of specific projects uses industry earnings as a key measure of economic impact. The data on earnings are made available by the BEA as part of its Regional Economic Accounts. The term "earnings" specifically refers to three components of personal income: wage and salary disbursements, supplements to wages and salaries, and proprietors' income.

An important consideration in using the BEA data on earnings is that, over the time period that will be evaluated in the county-level analysis (1991 to 2009), the industrial classification system that is used to aggregate data to various industry levels was converted from the former Standard Industrial Classification (SIC) system to the currently-used North American Industrial Classification System (NAICS). One impact of this reclassification was that the number of "one-digit" industries (the highest level of industry aggregation in the data) included in the data set increased from nine to 20. Another related impact was that many of the former SIC one-digit industries were split up, or in some cases recombined, to form new industries. For example, the one-digit industry classified as "Transportation and Public Utilities" (SIC code 500) under the SIC system was reclassified into two new one-digit industries under the NAICS system, "Utilities" (NAICS code 300) and "Transportation and Warehousing" (NAICS code 800). The full list of one-digit industries under each classification system is provided in Figure 3.1.

Industry Codes

SIC (1969-2000)

- 1) Agricultural services, forestry and fishing
- 2) Mining
- 3) Construction
- 4) Manufacturing
- 5) Transportation and public utilities
- 6) Wholesale/Retail trade
- 7) Finance, insurance and real estate
- 8) Services (includes health, legal, entertainment)
- 9) Government and government enterprises



NAICS (2001-2009)

- 1) Forestry, fishing and related activities (includes ag)
- 2) Mining
- 3) Utilities
- 4) Construction
- 5) Manufacturing
- 6) Wholesale Trade
- 7) Retail Trade
- 8) Transportation and Warehousing
- 9) Information
- 10) Finance and Insurance
- 11) Real estate and rental and leasing
- 12) Professional, scientific and technical services
- 13) Management of companies and enterprises
- 14) Administrative and waste services
- 15) Educational services
- 16) Health care and social assistance
- 17) Arts, entertainment, and recreation
- 18) Accommodation and food services
- 19) Other services, except public administration
- 20) Government and government enterprises

Figure 3.1: One-digit industries under SIC and NAICS classification systems

While there is some overlap between the two classification systems, including a few years for which data were reported in both systems, data are generally available for download from BEA using the SIC system for the years 1969 through 2000, while the NAICS system is used for more recent years leading up to 2009.

Another issue that arises with the use of the industry-level data is data suppression. BEA may suppress data at any level of industry aggregation if 1) the total annual earnings for a given year are less than \$50,000 or 2) publication of the figure would disclose confidential information (for example, an industry in which a single firm greatly influences aggregate trends at a county level). In either case, the figures are included in any higher-level totals aggregated by industry or geography. Fortunately, there are few instances of missing or suppressed data among the counties at the one-digit industry level. The few observations that contained missing or suppressed data were removed from consideration.

3.2 Employment Data

The analysis of more spatially disaggregate economic effects resulting from transportation projects is carried out using data on employment from the BEA's Quarterly Census of Employment and Wages (QCEW). The State of Minnesota's Department of Employment and Economic Development (DEED) has developed an online tool for querying this data set and downloading the data in summarized form, with results reported at the minor civil division (MCD) level (i.e. cities and townships).

The online tool developed by DEED allows the user to query the data for each year from 2000 to 2010, with all four quarters reported, subject to disclosure limitations. Figure 3.2 shows the typical display from a query for employment data.

As the figure indicates, there are several criteria with which one can refine their query. In this case, a city (St. Cloud) is chosen as the unit of geography. Certain large cities also report data below the city level, for example using zip codes as sub-city units. At larger units of aggregation it is also possible to extract totals by industry level. Figure 3.2 shows quarterly employment totals for the manufacturing industry. It is also possible to refine a search by type of ownership, for example, limiting a search to employment only in private sector industries or a particular level of government. Finally, as the set of tabs in Figure 3.2 indicate, other economic variables are available in addition to employment, such as number of establishments, total wages, average weekly wages, and gross employment gains or losses.

Change Saint Cloud, largely Stearns
 Change 2010
2009
2008...
 Change Private
 Change Manufacturing (1013)
 Start Over

OCEW RESULTS

Download	Employment	Establishments	Wages	Average Weekly Wages	Gross Employment Gains*	Gross Employment Loss*	More BED*>	
Geography	Industry	Ownership	Year	Q1	Q2	Q3	Q4	Annual
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2010	5,497	5,613	5,708	NA	NA
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2009	5,636	5,776	5,960	5,786	5,790
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2008	6,608	6,633	6,683	6,474	6,600
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2007	6,519	6,587	6,678	6,727	6,628
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2006	6,601	6,732	6,754	6,646	6,683
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2005	6,746	6,812	6,925	6,819	6,826
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2004	6,960	6,923	7,165	7,139	7,047
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2003	6,874	6,789	7,107	7,182	6,988
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2002	7,010	7,048	7,061	6,961	7,020
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2001	7,320	7,260	7,276	7,157	7,253
Saint Cloud, largely Stearns	Manufacturing (1013)	Private	2000	7,510	7,631	7,730	7,039	7,478

* Business Employment Dynamics

Figure 3.2: Sample output from a query for employment data in St. Cloud, MN

Chapter 4

Aggregate Analysis of Impacts: County and Industry-Level Earnings

In the previous chapter, we reviewed some of the evidence from empirical research into transportation and several non-transportation factors that have traditionally been thought to influence economic development. We now turn to an analysis of several case studies of road network improvements in Minnesota using aggregate (county-level) data as units of observation. Our analysis investigates both total earnings by county as well as earnings in specific industries which use transportation as an input more intensively. These industries include construction, manufacturing, wholesale, retail, and trucking.

Due to the difficulty of characterizing and operationalizing in a quantitative sense the types of highway improvements considered as case studies in our analysis, we adopt two different sets of approaches. One approach treats the improvement as a discrete event or “shock” to the local economy, and attempts to estimate the effect of the improvement through the designation of a series of time and county-specific indicator variables. The second approach uses statewide county-level data and estimates the relationship between the extent of the highway network and total county earnings. This second approach treats the road network as a continuous variable and investigates the relationship between changes in road capacity (as measured by lane-miles) and changes in earnings over the period of study. To the extent that a consistent relationship between capacity and economic growth is found, this relationship may be used to estimate the impact of the case study projects.

4.1 Project-Level Case Studies

The first part of our analysis of economic impacts focuses on a set of case studies of improvements to major highways in Minnesota. Initially, four such projects were identified for study:

- The expansion of US Highway 53 north of Virginia, Minnesota. This project involved expansion of an 11-mile segment of rural highway from a two-lane to a four-lane divided highway on a new alignment.
- Construction of a new interchange on Interstate 94 at Opportunity Drive (CSAH 75) southeast of St. Cloud, Minnesota.

- The incremental expansion of Minnesota Trunk Highway (TH) 371 along a roughly 30-mile segment between Little Falls and Brainerd, Minnesota. The project involved expansion of a two-lane highway to a four-lane divided highway and included the construction of a new bypass around the city of Brainerd.
- The completion of a four-lane bypass along US Highway 71 around the city of Willmar, Minnesota. This project was initiated in the mid-1980s, with much of the grading work being done then, but the construction of the full, freeway-grade four-lane bypass with interchanges was not completed until the early 2000s.

One project, the expansion of US Highway 53, was not included in the analysis due to its late date of completion. Construction was not completed until late 2009, which was the latest year for which county-level earnings data were available. Another, the Opportunity Drive interchange project, was not evaluated in this section due to the fact that it was undertaken largely to provide direct freeway access to several local businesses in a location that was already reasonably accessible via the county highway network and unlikely to generate impacts beyond the immediate area. We return to these projects in the following section, where we evaluate their impacts using a more geographically disaggregate data set. The focus in this section will be on the latter two projects, which were substantially complete by the mid-2000s, and for which adequate data are available.

Our analysis of these projects takes as the period of study the 19-year period between 1991 and 2009. This represents a long enough time period to examine the changes in economic activity which occurred both before and after the completion of the case study projects. Our focus is on the changes in private earnings in the four industries described above. Data sets for each of the study locations are constructed from the county (or counties) in which the project is located, along with all neighboring counties. We model the earnings in each industry at the county level as a function of national and state-level economic trends, along with changes in population. The effect of a highway project is represented as a series of indicator variables identifying the county in which the project is located, along with a specific time period, either before, during, or after completion of construction, when the improved highway is opened to traffic. In each case, this series of indicator variables breaks the study period into three distinct phases and attempts to measure changes in industry-level earnings in the county receiving the highway improvement over time relative to neighboring counties. Formally, we can write the model predicting county-level earnings in a given industry as:

$$\ln y_{it} = \alpha + \beta_1 \ln GDP_t + \beta_2 \ln StateEarn_t + \beta_3 \ln Pop_{it} + \sum_{j=1}^3 \gamma_j County_j + \epsilon_{it} \quad (4.1)$$

where:

$\ln y_{it}$ = natural log of earnings in a given industry in county i at time t

$\ln GDP_t$ = natural log of real GDP (in 2009 dollars) at time t

$\ln StateEarn_t$ = natural log of state-level earnings in a given industry at time t

$\ln Pop_{it}$ = natural log of population in county i at time t

$County_j$ = indicator variable identifying the county (or counties) in which the highway improvement was located during a specific period, j

ϵ_{it} is an error term, and $\alpha, \beta_1, \beta_2, \beta_3,$ and γ_j are parameters to be estimated

The model represented by Equation 4.1 includes controls for three exogenous factors. The first is national output, which may be seen as influencing the demand across all sectors. The second is state-level earnings in a given industry. This variable is taken to represent industry-level demand shifts which are unrelated to broader economic growth [57, 27]. The third factor is population, which we assume to be exogenous for the purpose of this analysis, and which is assumed to influence the local demand for goods in each industry.

The series of county-time period indicator variables, $County_j$, provide the interpretation of the economic impact of the project on earnings in a given industry. If the difference in the estimated coefficients of these variables in the pre-construction period (period 1) and the post-construction period (period 2) is statistically significant, this would provide possible evidence of an increase in earnings attributable to the project under study.

4.1.1 TH 371 Expansion

Our first case study, described briefly above, is the expansion of Minnesota TH 371. This project was completed in various phases between August 1998 and October 2005. The first phase involved completion of a bypass around the city of Brainerd on TH 371 and a new interchange at the junction of the new TH 371 alignment and the old alignment, now a business route for 371 which serves the city directly. The remainder of the project expanded the roughly 30-mile segment of 371 between Little Falls (in Morrison County) and Brainerd (in Crow Wing County) in two phases, the first upgrading the highway to four lanes between the junction with US Highway 10 near Little Falls and CSAH 48 near Camp Ripley, MN, and the second phase completing the new four-lane segment between Camp Ripley and the new Brainerd bypass. These latter two phases included the construction of two new interchanges and were completed between May 2003 and October 2005. Taken together, the improvements to TH 371, including the right-of-way and construction costs, had a combined cost of around \$60 million.

It will be useful for the purposes of this analysis to consider these projects together as a complete set of improvements. There are practical reasons for doing so, since the projects were considered part of an integrated strategy for improving TH 371 as an inter-regional highway corridor. More importantly, considering them together allows us to define a single construction period for the improvements which fits the modeling framework described above. We define the construction period as covering the years from 1998 through 2005. The years prior to 1998 are considered part of the “pre-construction” period, while the years after 2005 are considered “post-construction”.

We fit the model described in Equation 4.1 to four data sets representing earnings data for the construction, manufacturing, retail and wholesale industries. The county/time indicator variables were defined for both Crow Wing and Morrison counties, since each of these counties contained a substantial share of the improved section of TH 371. The other neighboring counties included in the data were Aitkin, Cass, and Mille Lacs counties. Each of the industry-level regressions had 95 observations, with the exception of the “wholesale” data set, which was missing one observation due to data suppression.

We estimate the models using ordinary least squares with panel-corrected standard errors. This technique allows us to fully exploit the panel structure of the data, accounting for correlation across

panels within the data set, while also correcting for serial correlation among the residuals in the model, and has been shown via simulation to generate efficient parameter estimates [13]. Our estimates are generated using the “xtpcse” procedure in Stata (version 10), with the Prais-Winsten method for correcting for serial correlation and an AR(1) structure assumed for correlation among the residuals. The estimation results for the four industry-level earnings regressions are provided below in Table 4.1.

Table 4.1: Industry-level earnings regressions for TH 371 improvements

Variable	Construction			Manufacturing			Retail			Wholesale		
	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value
$\ln GDP_t$	-0.648	0.303	-2.14	0.654	0.239	2.73	-0.390	0.131	-2.97	-1.713	1.048	-1.63
$\ln StateEarn_t$	1.084	0.174	6.24	0.871	0.233	3.73	0.839	0.076	10.99	2.192	0.853	2.57
$\ln Pop_{it}$	0.743	0.155	4.79	-0.091	0.179	-0.51	1.063	0.122	8.70	0.231	0.145	1.59
CrowWing ₁	0.685	0.179	3.82	2.194	0.188	11.67	0.515	0.144	3.59	1.181	0.137	8.64
CrowWing ₂	0.698	0.179	3.90	2.139	0.188	11.38	0.510	0.144	3.55	1.174	0.133	8.81
CrowWing ₃	0.797	0.184	4.34	2.013	0.192	10.46	0.530	0.148	3.57	1.110	0.143	7.76
Morrison ₁	0.211	0.099	2.13	1.504	0.133	11.28	-0.030	0.098	-0.31	0.779	0.138	5.66
Morrison ₂	0.116	0.091	1.28	1.537	0.124	12.41	-0.019	0.092	-0.20	0.704	0.134	5.28
Morrison ₃	0.183	0.093	1.96	1.433	0.131	10.97	0.040	0.094	0.43	0.948	0.173	5.47
Constant	11.839	6.863	1.73	-10.220	4.510	-2.27	-10.247	1.685	-6.08	5.307	8.677	0.61
ρ	0.688			0.723			0.746			0.540		
Wald $\chi^2(9)$	1699.83			2359.04			2047.87			912.80		
Adjusted R^2	0.997			0.961			0.997			0.971		
N	95			95			95			94		

The use of the panel correction procedure results in very high R^2 values for each of the models due to the correction for autocorrelation among the residuals and cross-panel correlation among observations. The Wald χ^2 statistic provides a test of the null hypothesis that the parameters of all nine independent variables are jointly equal to zero. The large test statistic for each of the models allows this hypothesis to be rejected at any reasonable level of significance. Table 4.1 also provides the estimated ρ autocorrelation parameter for each of the models.

The models appear to provide a good fit to the data. The population and state-level industry earnings variables are positive and highly statistically significant for nearly every industry, with one exception being the population variable in the manufacturing regression. Of interest, a negative coefficient is observed for the GDP variable in three of the four regressions (the exception being manufacturing), indicating that growth in national output adds little to earnings growth in these industries once state-level industry output is controlled for.

Examining the county-time indicator variables for the two counties where the improvement occurred, we see little evidence of a statistically significant effect of the completion of the highway on earnings in each of the four industries. Again, these variables capture any unobserved differences in earnings between the counties where the highway improvements occurred and neighboring counties, observed at three points in time (before, during, and after completion of construction). For example, looking at the manufacturing regression we see a small increase in earnings in Crow Wing County between time periods 1 and 3 (before and after construction) relative to neighboring counties. However, the difference in parameter values between these two periods is less than one standard error for either of the parameter estimates, indicating that this difference is not statistically significant, or rather that the change in parameter values from the pre- to post-construction period is simply the result of chance variation. Comparing the estimates for the county-time indicators in the other models reveals largely the same result. Where there is any evidence of an increase in earnings, it fails to be large enough to rise to the level of statistical significance.

4.1.2 US 71/TH 23 Expansion

We now apply the same method of analysis to look at the possible economic impacts due to the completion of improvements to US Highway 71 (the bypass of Willmar, Minnesota) and TH 23. As the previous description indicated, the primary objective of this project was to construct a four-lane, freeway-grade bypass of the city of Willmar, which had a reported population of just under 20,000 as of the 2010 census. Grading work for the new highway was begun during the 1980s, along with expansion of a 5-mile segment of US 71 and Minnesota TH 23 just north of Willmar from two to four lanes. Due to funding constraints, the bypass of Willmar was not completed as a four-lane highway until the fall of 2001. Shortly after the bypass was completed, an additional segment of TH 23 northeast of Willmar (from the junction of US 71 and TH 23 north of Willmar to New London, MN) was expanded to four lanes, completing a continuous four-lane section of TH 23 from New London, MN to the south end of Willmar. This latter project was completed in the spring of 2003. The two projects together were largely completed over the period from 1999 to 2003 at a combined cost of around \$60 million.

Similar to the case study of the TH 371 expansion, we identify periods before, during, and after completion of construction to examine changes in earnings. The analysis is simplified slightly in this case, since all of the highway improvements are contained within Kandiyohi County. Accordingly, the number of explanatory variables in our model is reduced from nine to six. The data

set is comprised of six counties, Kandiyohi plus five neighboring counties (Chippewa, Meeker, Pope, Renville and Swift). Stearns County, while also contiguous to Kandiyohi, is excluded from the data set due to it being the location of a separate case study project (I-94/Opportunity Drive interchange). The data sets for the manufacturing and retail industries contain a full set of 114 observations, while the construction and wholesale industries are missing four and three observations, respectively, due to data suppression. The models are fitted using the same techniques as were applied to the TH 371 case study. A summary of the model results is presented below in Table 4.2.

The results of the earnings regressions for the US 71/TH 23 study area are similar to those observed in the previous case study. The population and statewide industry earnings variables are uniformly positive and statistically significant at the $p < 0.05$ level. The national GDP variable still has a negative coefficient in two of the four industry regressions, though one of the two is not statistically significant. National output is positive and significant for the manufacturing and wholesale industry regressions.

Looking at the county-time period indicators, there is again little evidence of statistically significant changes in earnings for each of the four industries examined. Comparing the coefficients for the pre- and post-construction periods, there is only a small change for the construction and manufacturing industries, neither rising to any level of significance. There is a slightly larger change for the county-time indicators in the retail and wholesale industry regressions. However, the magnitude of the difference in each case is only equal to roughly one standard error, indicating that the difference is not statistically significant. Moreover, in the case of the wholesale industry the coefficients decline in value over time indicating that, all else equal, earnings in Kandiyohi County were declining relative to those in neighboring counties.

Table 4.2: Industry-level earnings regressions for US 71 improvements

Variable	Construction			Manufacturing			Retail			Wholesale		
	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value
$\ln GDP_t$	-0.314	0.291	-1.08	1.196	0.125	9.57	-0.348	0.151	-2.30	0.640	0.219	2.92
$\ln StateEarn_t$	0.706	0.175	4.03	0.371	0.155	2.40	0.349	0.082	4.27	0.684	0.204	3.35
$\ln Pop_{it}$	1.590	0.205	7.77	1.212	0.116	10.42	0.826	0.114	7.27	0.425	0.209	2.03
Kandiyohi ₁	-0.230	0.235	-0.98	-0.121	0.119	-1.01	0.715	0.139	5.13	0.951	0.223	4.27
Kandiyohi ₂	-0.233	0.236	-0.99	-0.140	0.120	-1.17	0.796	0.139	5.71	0.760	0.225	3.38
Kandiyohi ₃	-0.206	0.238	-0.86	-0.163	0.122	-1.34	0.864	0.140	6.16	0.727	0.226	3.21
Constant	-7.203	7.039	-1.02	-43.272	4.654	-9.30	11.114	4.666	2.38	-24.603	4.956	-4.96
ρ	0.759			0.608			0.862			0.701		
Wald $\chi^2(6)$	1035.86			990.15			1457.04			1064.78		
Adjusted R^2	0.979			0.983			0.998			0.979		
N	110			114			114			111		

4.2 Statewide Analysis

Having examined the effects of individual projects on industry-level earnings in their respective study areas, we now complement these results with evidence from a separate method. In the case studies, the effect of a highway improvement was characterized as a shift in the fixed, unobserved component of industry earnings over time. In this section, we will consider the highway network (specifically, highway capacity) as a continuous variable and estimate whether there is a systematic, statewide relationship between highway capacity and county-level earnings.

We use statewide, county-level data on road network capacity (lane-miles) from 2002 to 2008, since 2002 is the earliest year for which these data are published. The road network data used are restricted to interstate highways and US highways (parts of the National Highways System), state trunk highways, and county state-aid highways. These higher-order components of the road network are seen as most likely to foster trade and goods movement, thus they are the focus of the road data. County-level data on total earnings are also collected and used to construct a variable measuring the change in earnings from 2002 and 2008. Noting the problem of simultaneity between inputs and outputs (road capacity and earnings), we transform both the road capacity and earnings variables into differences, measuring the change from 2002 to 2008. There are a total of 87 observations in the data set, one for each county in the state.

Our basic specification for predicting the change in earnings includes as explanatory variables the *level* of earnings in a given county in 2002 (measured in thousands), along with the change in population and the change in total lane-miles in the county between 2002 and 2008. Specifically, we can write this relationship as:

$$\Delta Earnings_{i,2002-2008} = \alpha + \beta_1 Earnings_{i,2002} + \beta_2 \Delta Population_i + \beta_3 \Delta TotalLM_i + \epsilon_i \quad (4.2)$$

where:

$\Delta Earnings_{i,2002-2008}$ = Change in total earnings in county i from 2002 to 2008

$Earnings_{i,2002}$ = Total earnings in county i in 2002

$\Delta Population_i$ = Change in population in county i from 2002 to 2008

$\Delta TotalLM_i$ = Change in total highway lane-miles in county i from 2002 to 2008

ϵ_i is an error term, and

α, β_1, β_2 and β_3 are parameters to be estimated

Along with the basic specification, we also test the inclusion of two other variables, the change in population density (as a substitute for population and a proxy for agglomeration effects) and the share of the population in a county over the age of 25 with at least a bachelor's degree as of 2002. The latter variable is a proxy for human capital and/or labor quality. We also test the disaggregation of the lane-miles variable into changes in rural and urban lane-miles. The hypothesis behind this change is that the addition of lane-mileage in urban areas, where traffic levels are generally higher, may offer greater economic benefits than additional capacity in rural areas. We identify counties as "urban" if they are formally listed as part of a metropolitan statistical area.

Lastly, recognizing that there may be mutual causation between economic growth and the growth of road networks, we specify simple regressions to predict the change in lane-miles in a county as a function of changes in population and total earnings between 2002 and 2008. Total

lane-miles in a county in 2002 is also tested as a possible explanatory variable in a separate regression. The results of the earnings and lane-miles regressions are provided below in Table 4.3. All six models are estimated using ordinary least squares.

The first four models in Table 4.3 show the results of various specifications of the regressions predicting changes in earnings from 2002 to 2008. The basic specification (Model 1), including the level of earnings in 2002, the change in population and the change in lane-miles, accounts for most of the variation in the change in earnings. Again, we consider the change in population to be exogenous in this model, which is a fair assumption given the relatively short time period covered by the data. The variable representing the change in total lane-miles has a negative coefficient, indicating a negative association between the growth in lane-miles in a county and total earnings growth over the period considered. The results for Model 4 further disaggregate the lane-mile variable into changes in lane-miles for rural and urban counties. The negative effect of the lane-miles variable in Model 1 appears to be dominated by the effect of road capacity in urban areas, as the urban lane-miles variable has a larger, negative coefficient, while the rural lane-miles variable has a positive (though statistically insignificant) coefficient.

Model 2 contains the variable measuring the change in population density from 2002 to 2008. Like the population variable, it has a positive sign and is significant. The inclusion of this variable does not appear to substantially affect the estimates of the other variables, indicating that population and population density may be interchangeable in this model and substantially measuring the same thing. The inclusion in Model 3 of the variable measuring education attainment produces a negative sign for this variable. This outcome is most likely the result of the effect of education being absorbed by the variable measuring earnings in 2002, given the typically strong and positive correlation between education and earnings at nearly all levels of aggregation.

Models 5 and 6 show the results of the regressions predicting changes in lane-miles in each county between 2002 and 2008. Change in population is the only variable in the two models which appears as statistically significant. The change in earnings over the same period does not have an effect. Including the lane-miles in each county as of 2002 does not add any explanatory power to the model.

While the results of the analysis of statewide changes in highway capacity and earnings is suggestive, it would be useful to be able to examine these relationships over longer periods of time. The data sets used here are limited by the availability of historical data on road capacity, with 2002 being the earliest year in the data set. Relationships between changes in transportation networks, population growth and changes in the level and location of economic activity often involve substantial lags, which are difficult to identify without a greater longitudinal element to the data set. Data sets on highway mileage and capacity which go back many more years are compiled by the Federal Highway Administration, but what these data sets add in temporal coverage they lack in depth and detail. It would not be possible to obtain this information at the county level, which is the focus of the current analysis. Thus, studies which seek to add this level of geographic and temporal detail often involve extensive data collection efforts (see, for example, [27]).

Table 4.3: Statewide county-level regressions for changes in earnings and highway lane-miles, 2002-2008

Variable	Earnings change						Highway lane-mile change					
	Model 1 Coeff.	Sig.	Model 2 Coeff.	Sig.	Model 3 Coeff.	Sig.	Model 4 Coeff.	Sig.	Model 5 Coeff.	Sig.	Model 6 Coeff.	Sig.
Earnings ₀₂	0.068 (0.002)	0.000	0.070 (0.002)	0.000	0.070 (0.002)	0.000	0.069 (0.002)	0.000	9.59e-07 (3.66e-06)	0.794	-5.53e-07 3.96e-06	0.889
Δ Earnings												
Δ Population	11.957 (2.551)	0.000			14.063 (2.705)	0.000	14.328 (2.610)	0.000	0.0017 (0.0003)	0.000	0.0017 (0.0003)	0.000
Δ PopDen			5442.84 (969.09)	0.000								
College ₀₂					-5768.82 (2809.76)	0.043						
Δ TotalLM	-2795.82 (815.13)	0.001	-2456.14 (730.03)	0.001	-2465.50 (815.81)	0.003						
Δ UrbanLM							-3954.15 (894.66)	0.000				
Δ RuralLM							788.12 (1539.42)	0.610				
TotalLM ₀₂											0.003 (0.003)	0.318
Constant	18229.8 (14298.9)	0.206	17889.4 (13668.3)	0.194	109048.2 (46405.6)	0.021	11744.2 (13989.6)	0.404	4.197 (1.879)	0.028	0.596 (4.049)	0.883
Adjusted R ²	0.949		0.953		0.951		0.953		0.302		0.302	
N	87		87		87		87		87		87	

Notes:

Dependent variable for earnings equations is the change in earnings from 2002 to 2008 (in thousands).

Dependent variable for highway lane-mile equations is the change in highway lane-miles from 2002 to 2008.

Standard errors in parentheses below estimated coefficients.

4.3 Summary

Our analysis of the case studies of transportation improvements, namely the improvements to TH 371 and US Highway 71/TH 23, provided no evidence of statistically significant gains in private sector earnings for the industries we considered. The case study approach considered the industry-level effects of the projects as a growth residual, an unobserved increase in earnings not attributable to the other observed factors such as national economic growth, state-level industry trends, and population change. While this approach leaves open the possibility that changes in earnings in the studied industries may be related to other unobserved factors aside from changes to the transportation network, the differences between the periods before and after the completion of the projects are so small (and statistically insignificant), that there is little need to attempt to further disaggregate them.

The findings of no statistically significant impact are corroborated by the statewide county-level analysis of changes in highway lane-miles and total earnings. While the time period for this analysis was shorter (seven years as opposed to the nearly 20 years in the case study analysis), the use of a larger cross-section of counties, rather than just those believed to be impacted by the case study projects, and the investigation of *changes* in the extent of the highway network over time, allow us to have more confidence that our findings are systematic and fairly consistent across locations.

It is possible, however, that the case study projects may still have had some measurable impact on the local economy, albeit at a smaller scale than could be identified from the county-level data. The projects may have also redistributed economic activity across locations within a single county, shifting it toward those locations which are better served by the improved highways. In the next chapter, our analysis turns to sub-county-level data on employment which will permit an investigation of these hypotheses. Perhaps as importantly, these data will allow investigation of the remaining two case studies (US Highway 53 and I-94/Opportunity Drive interchange) that were not feasible with the county-level data.

Chapter 5

Disaggregate Analysis of Impacts: Employment Change

In the previous chapter, we examined the impacts of highway improvements in two of the case study locations by estimating their effects on private earnings in several sectors of the economy. While no evidence of statistically significant were found, we noted the possibility that some impacts might exist at a smaller geographic scale due to relocation or changes in the location of new economic activity induced by the highway improvements. In this chapter, we examine this possibility by using more disaggregate data on employment levels and changes from the Quarterly Census of Employment and Wages (QCEW), described in more detail in the previous section on data collection.

All four of the case study locations are analyzed in this section. Empirical models are fit using data from three of the case studies (US71/TH23, TH371 and US 53). The fourth project, the I-94/Opportunity Drive interchange, could not be analyzed through a full empirical analysis due to its localized nature and lack of a larger impact area. We do, however, investigate changes in private sector employment due to firm openings and closings, as well as industry-level changes in firm size. The employment data for these analyses is restricted to the portion of the city of St. Cloud that is within Stearns County, the part of the city which is closest to the case study interchange.

5.1 Data and Methods

As was done with the county-level earnings analysis, we assemble a panel data set to analyze the changes in a cross-section of locations through time in response to the case study projects. The use of disaggregate employment data from the QCEW allows us to construct models that are more spatially explicit, accounting for the likelihood that locations that are directly served by the improved highway will benefit more than those not served.

Our unit of analysis for each the case studies is the municipal level, including all incorporated cities for which at least total annual employment figures are reported. Many cities also have industry-level annual totals, but the lack of consistency in reporting due to suppression (particularly among smaller towns) leads us to focus our attention on total employment in order to avoid a potential source of bias. In analyzing the US71/TH23 and US 53 case studies, we restrict the sample of cities included in the analysis to those within the county where the project is located. In the case

of the improvements to TH 371 we include cities in both Crow Wing and Morrison Counties, since the expanded section of highway spans parts of both counties and connects the largest cities in each county (Brainerd and Little Falls).

The QCEW employment data are available annually dating back to 2000, with the most recent year of complete data being 2010 as of the time of this writing (though some quarterly data are available for 2011). While the QCEW data contain relatively detailed information about employment at the minor civil division (MCD) level, it is somewhat difficult to find other variables that are measured at the same geographic scale and that are available on an annual basis. Similar to our analysis of county-level earnings, we focus on predicting employment levels as a function of a few, relatively straightforward demographic and economic factors.

City population and per capita incomes are the primary statistical controls employed. The former variable helps to control for the cross-sectional heterogeneity in the sample of employment data and represents an indicator of market size, since larger cities are likely to be served by a larger base of service industries. A variable representing income levels is included, both to account for differences in consumption levels (holding population constant) and as a way to account for some of the macroeconomic trends present during the study period, primarily the onset of the recession toward the end of the decade. Since no measure of municipality-level incomes is available on an annual basis, we use as a proxy measure per capita wages. Wages represent one of the major components of personal income and correlate reasonably well with other measures of total income. There are, however, a couple of notable limitations to their use as a proxy for incomes. The first is that they ignore other potentially important sources of income, such as proprietors' income, transfers, and other sources of non-wage income. The second is that, as economists have noted, wages tend to be "sticky" in the downward direction during recessions. That is, they do not fall as fast as output during a recession, due to previous contractual commitments and imperfect information with regard to price changes.

In order to account for the possible differential effects on city-level employment due to the highway improvements in each case study, we introduce into each model a set of time- and location-specific indicator variables. These variables combine the time element, which identifies whether the observation took place before or after the highway improvement was completed, with a spatial indicator to identify the location of the city or town relative to the improved highway. Spatially, the observations are split into three groups:

- Cities that are located directly on the improved segment of highway
- Cities that are located upstream or downstream from the improved segment of highway
- Cities that are located neither on nor upstream or downstream from the improved segment of highway

We hypothesize that, all else equal, the cities located along the improved segment of highway will experience more employment growth than those not near the highway ("non-highway" cities). Cities located upstream or downstream from the improved segment of highway may also see some growth effects, since they may also be beneficiaries of the improved highway, though not as much as those cities directly effected. These cities are expected to experience employment growth greater than the non-highway cities, but not as great as the cities directly affected. The general spatial

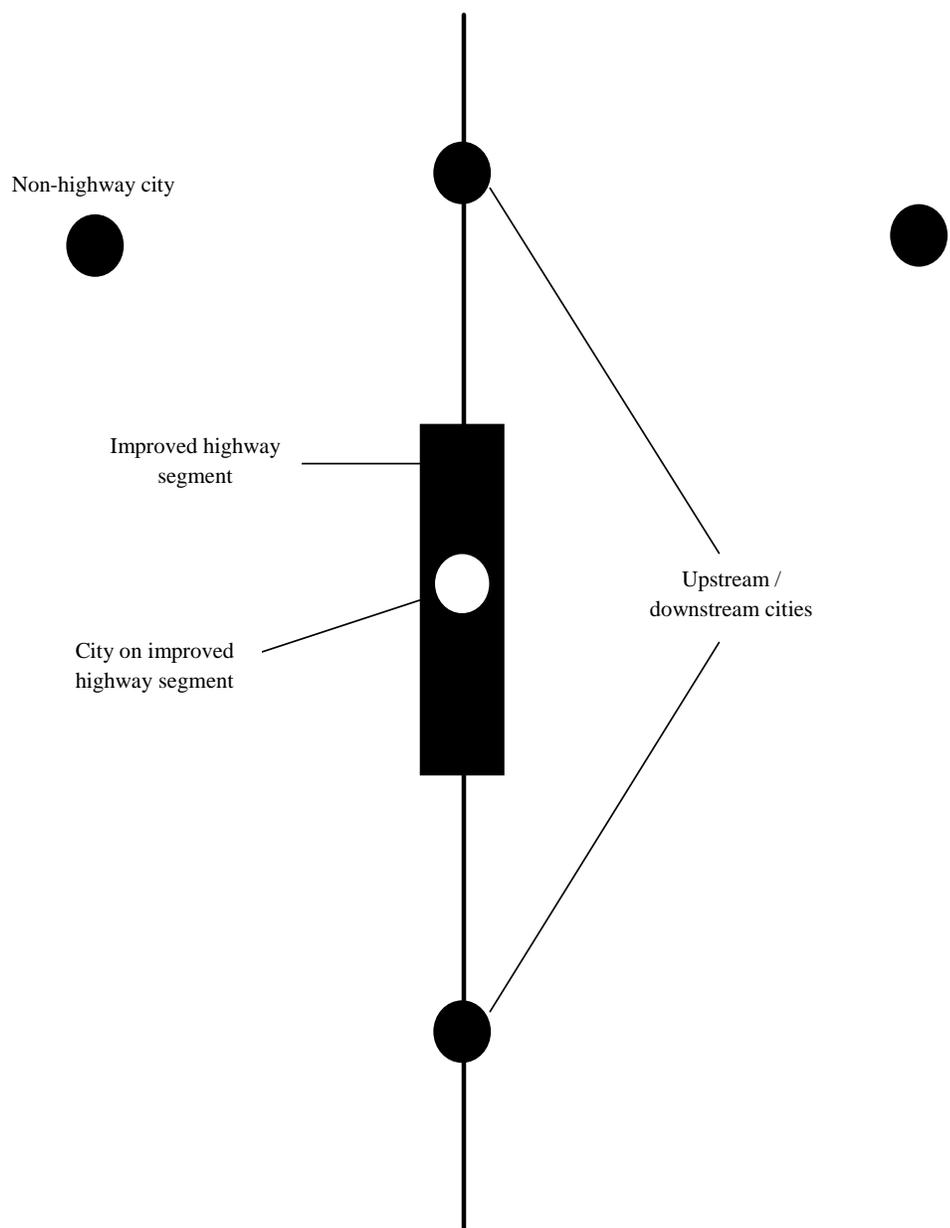


Figure 5.1: Location of cities relative to improved highway segment

relationships between the location of the observed cities and the improved highway are depicted in Figure 5.1.

These space and time-specific characteristics are combined into a set of indicator variables which capture unobserved differences in employment levels (those not attributable to the population and income variables previously mentioned) across locations and before and after the highway improvements of interest. Since there are three location classifications and two time periods, there are a total of six combinations of these variables. We omit one of these time-location combinations, namely the one corresponding to non-highway cities observed before the highway improvement, in order to use it as a reference case against which to evaluate the impacts in other locations and time periods. The use of variables representing “before” and “after” periods allows their comparison to check for statistically significant changes over time.

The formal specification of the empirical model is described in Equation 5.1:

$$\ln(e_{it}) = \alpha + \beta_1 \ln(P_{it}) + \beta_2 \ln(I_{it}) + \sum_{j=1}^5 \gamma_j (\text{Highway}_i) + \epsilon_{it} \quad (5.1)$$

where:

$\ln(e_{it})$ = natural log of total private sector employment in city i at time t

$\ln(P_{it})$ = natural log of population in county i at time t

$\ln(I_{it})$ = natural log of real per capita income (in 2009 dollars) in city i at time t

Highway_i = indicator variables representing location and time-varying characteristics of city i

ϵ_{it} is an error term, and

$\alpha, \beta_1, \beta_2,$ and γ_i are parameters to be estimated

As noted, the continuous variables in the model are transformed into their natural logarithms to allow for direct elasticity estimates. The set of time and location-specific indicator variables are collectively referred to as Highway_i . These variables will be described in more detail in the next section.

5.2 Results

5.2.1 Basic Employment Model

Table 5.1 displays the results of the basic employment regressions, predicting total private sector employment for each of the cities in the three case study areas. The models are fit using ordinary least squares estimation. The time and location-specific indicator variables are given names which correspond to their location. For example, the “H” variable represents cities located along the improved segment of highway. The “before” and “after” subscripts denote the time aspect of these variables, and correspond to the periods before and after completion of the highway improvement. For the variables in each of the estimated equations, the table contains the parameter estimates, standard errors, and associated t-statistics. We discuss the results of each of the case studies individually.

Table 5.1: Private-sector employment regressions for US 71/TH 23, TH 371, and US 53 improvements

Variable	US71/TH23			TH371			US53		
	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value
$\ln P_{it}$	0.926	0.011	84.88	0.921	0.012	78.44	0.912	0.008	115.35
$\ln I_{it}$	0.660	0.013	49.24	0.822	0.019	42.42	0.710	0.029	24.64
O_{after}	0.002	0.028	0.07	-0.014	0.036	-0.38	-0.042	0.075	-0.56
H_{before}	0.528	0.045	11.60	0.126	0.067	1.89			
H_{after}	0.524	0.041	12.90	0.152	0.070	2.16			
U_{before}	-0.267	0.045	-5.91	0.036	0.060	0.59	0.155	0.038	4.09
U_{after}	-0.176	0.038	-4.69	-0.006	0.065	-0.09	0.133	0.055	2.43
A_{before}							-0.155	0.040	-3.83
A_{after}							-0.113	0.072	-1.57
Constant	-6.769	0.140	-48.48	-7.959	0.181	-43.98	-6.859	0.237	-28.92
Adjusted R^2	0.995			0.979			0.987		
N	121			295			247		

US71/TH23 Expansion

We first examine the case of the set of improvements to US Highway 71 and Minnesota Trunk Highway 23, including the Willmar Bypass, in Kandiyohi County. The summary results of the model in the first few columns of Table 5.1 indicate that the model provides a good overall fit to the panel data on total employment. As should be expected, employment appears to scale with population, with a one percent increase in population being associated with greater than a 0.9 percent increase in employment. Local per capita incomes are also strongly associated with employment levels, though the effect is somewhat smaller.

Looking at the variables representing the time and location, there appears to be no evidence of the completion of the highway improvement on employment in non-highway cities. The O_{after} variable, which measures the residual effect of being located in a non-highway (or “off-highway”) city after the completion of the highway improvement (relative to being in the same location before the improvement), has a very small coefficient which is not statistically different from zero at any reasonable level of significance.

Likewise, there seems to be no statistically significant difference in the variables representing cities located on the improved highway segment before and after the improvement. The H_{before} variable, representing the residual difference in employment levels between cities located on the improved highway segment prior to completion of the improvement and non-highway cities during the same period, is fairly large, indicating that the cities located along the improved highway already had high employment levels relative to their populations prior to the highway improvement. The cities in the “highway” class include the three largest cities in the county (Willmar, New London and Spicer), which likely serve as higher-order trade centers, accounting for much of this difference. However, it is important to note that the *difference* between the coefficients of the H_{before} and H_{after} variables, which measure the change in the residual difference between highway cities (both before and after the improvement) and the baseline case (non-highway cities observed before the improvement), is very small and not statistically significant, indicating that the effect of location did not improve as a result of the highway expansion. Stated differently, the advantage of being located on the improved highway segment (relative to location in a non-highway city) did not change as a result of the completion of the highway improvement.

Lastly, we also consider the variables representing cities located upstream or downstream from the improved segment of highway. We include in this class all cities located on either US 71 or TH 23 that are not within the improved segment of highway (the Willmar Bypass or the expanded stretch of TH 23). The difference between the U_{before} and U_{after} coefficients is about 9 percentage points and in the positive direction, indicating that there may be some change in employment for cities in this class relative to those in the non-highway class due to the highway improvement. We can formally test for equality of the two coefficients using Welch’s t-test to determine whether or not the observed difference in coefficients is likely due to chance variation. The test statistic generated for the null hypothesis of equality of the two coefficients was -1.56, which corresponds roughly to a $p < .12$ level of significance. This is not particularly strong evidence against the null hypothesis that the two coefficients are equal, hence we cannot confidently state that the observed difference resulted from the effect of the highway improvement, as opposed to simply chance variation in the data.

TH 371 Expansion

The second case study we consider is the the expansion of TH 371 between Little Falls in Morrison County and the Brainerd/Baxter area of Crow Wing County, including the Brainerd Bypass. As described previously, this project expanded TH 371 between the two locations to four lanes in each direction, adding several new interchanges and the bypass around the central business district of Brainerd. This case study contains the largest sample of the three case studies fully analyzed in this section. This is due to the fact that we include both Crow Wing and Morrison Counties in the sample, as the improved highway traverses significant parts of both counties. We estimate the impacts of this project in the same manner that we did the US71/TH23 case study.

The results in Table 1 again indicate a good overall fit for the model, with the population and income variables both having the expected sign and level of significance. The coefficient of the population variable is very similar in magnitude to the one estimated in the US71/TH23 case, though the coefficient of the income variable is somewhat larger. The variable representing non-highway cities shows no indication of a change in employment as a result of the completion of the highway improvement. The coefficient for the variable representing the cities located on the improved highway (Baxter, Brainerd, Camp Ripley and Little Falls) after completion of the improvements is slightly larger in magnitude than the variable for the same set of cities observed before completion of the highway improvement. However, the magnitude of this difference is small relative to the estimated standard errors of the coefficients, indicating that this difference is well within the error bands of the two coefficients and unlikely to represent a statistically significant effect. The same is true of the variables representing the cities located upstream and downstream from the improved segment of TH 371. The difference in the estimated coefficients is small, both in absolute terms and, more importantly, relative to their respective standard errors. Therefore we have no evidence from this case study that the highway improvement had a statistically significant effect on employment levels.

US 53 Expansion

The context for our third case study, the expansion of US Highway 53 north of Virginia, Minnesota in St. Louis County, is slightly different than the previous two and thus requires a modification to our empirical approach. The improvements to US Highway 53 that are the focus of this case study are an expansion to four lanes of an 11-mile segment of the highway between the towns of Virginia and Cook. Unlike the previous two case studies, the improved segment of US 53 in this case does not pass through any cities. Thus, we cannot define the location characteristics of the cities in the sample in the same way that we treated the previous cases. As an alternative, we retain the variables representing cities upstream and downstream from the improved highway (in this case including all cities in St. Louis County along US 53) and add a classification for cities not located immediately along the highway, but within 10 miles of it. These are the variables labeled *A* in Table 5.1 to indicate their adjacency to the improved highway. The definition of non-highway cities is adjusted accordingly to include all cities not within 10 miles of US 53. The definition of cities in the “adjacent” class allows us to account for the unique geographic clustering of several mining towns near US 53 in the Iron Range region of the county.

The results of the model for the US 53 improvements in Table 5.1 show similar findings to those in the previous two case studies. Population and income variables have similar signs and

magnitudes to those included in the other models. Again, employment in non-highway cities do not appear to have been affected by the completion of the improvements. The coefficient for the U_{after} variable, indicating the effect on employment in cities located on Highway 53 after the completion of the expansion project, is smaller than the corresponding variable for the pre-improvement period, though again this difference is too small to register as statistically significant. The same is true for cities located within 10 miles of the highway, as indicated by the adjacency variables. Overall, the model results appear to reject the notion of statistically significant employment impacts due to the expansion of the highway.

5.2.2 Employment Change Model

As a check on the results produced by our basic employment model, we also estimated a separate set of models for the three case studies using the year-over-year change in employment as the dependent variable. Our previous employment regressions assumed that population could be considered an exogenous predictor of employment. One can imagine instances where this might not hold. For example, if a highway improvement project impacted employment indirectly, via induced changes to the population of an affected city, then the dummy variables used to capture the effect of time and location relative to the improved highway on employment would underestimate the employment impacts. In our models of employment change, we drop population as an explanatory variable and use only statewide employment change as a control for macroeconomic fluctuations. The resulting model can be written as:

$$\Delta e_{i,(t-1)-(t)} = \alpha + \beta_1(\Delta E_{i,(t-1)-(t)}) + \sum_{j=1}^5 \gamma_j(Highway_j) + \epsilon_{it} \quad (5.2)$$

where:

$\Delta e_{i,(t-1)-(t)}$ = percentage change in total private sector employment in city i between time $t - 1$ and time t

$\Delta E_{(t-1)-(t)}$ = percentage change in total statewide private sector employment between time $t - 1$ and time t

$Highway_j$ = indicator variables representing location and time-varying characteristics of city i

ϵ_{it} is an error term, and

$\alpha, \beta_1, \beta_2,$ and γ_j are parameters to be estimated

The employment change model is fitted to the same three case study locations using the panel correction techniques described in the previous section. Of note, the sample size of each of the locations is reduced slightly due to the differencing of the observations in the data set. The results of the models are displayed in Table 5.2.

Table 5.2: Private-sector employment change regressions for US 71/TH 23, TH 371, and US 53 improvements

Variable	US71/TH23			TH371			US53		
	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value	Coeff.	S.E.	t-value
$\Delta E_{(t-1)-(t)}$	0.293	1.150	0.25	0.038	0.778	0.05	1.567	0.428	3.66
O_{after}	2.872	4.591	0.63	-1.615	3.214	-0.50	2.090	3.229	0.65
H_{before}	8.279	3.230	2.56	11.187	5.292	2.11			
H_{after}	3.271	4.073	0.80	-3.813	5.328	-0.72			
U_{before}	22.681	9.332	2.43	0.725	5.292	0.14	2.285	2.197	1.04
U_{after}	-0.399	7.532	-0.05	-3.799	5.328	-0.71	2.618	2.526	1.04
A_{before}							5.147	1.990	2.59
A_{after}							4.281	3.530	1.21
Constant	-4.397	3.843	-1.14	3.289	2.268	1.45	-2.345	1.382	-1.70
ρ	0.023			N/A			0.070		
Wald $\chi^2(6)$	14.71			7.30			496.48		
Adjusted R^2	0.094			0.027			0.064		
N	110			263			224		

The first thing to notice about the employment change regressions is the weaker fit of the models. While differenced models generally tend to provide a poorer fit than models estimated with the variables in level form, the change in fit between the employment level and change regressions are substantial, even with the panel correction. At least two factors seem to contribute to this. First, the absence of a population variable, which showed up as highly significant in each of the employment regressions. Second, the use of percentages instead of absolute values (in order to make the change in employment at local levels compatible with those measured at the state level) introduces a larger amount of variance in the data. Due to the fact that many cities in the various samples have small population and employment bases, even relatively minor economic events can yield large changes (measured in percentage terms) in employment.

The state-level employment variable, $\Delta E_{(t-1)-(t)}$, has the expected sign in each of the case study regressions but is only statistically significant in the model for the US Highway 53 case study. Looking at the pairs of variables related to the highway improvements, some of the pairs reveal sizeable differences between the before and after periods of the highway improvements. However, the large estimated standard errors of these variables cast doubt on their statistical significance. Among the three case studies, there appear to be two instances in which estimated growth rates changed in response to the completed highway improvement in magnitudes which approach reasonable levels of statistical significance. In the US71/TH23 case study, the variables representing cities located upstream or downstream from the improved highway segment had coefficients which differed by about 23 percentage points before and after the completion of the highway improvements (relative to the baseline of non-highway cities observed prior to the completion of the improvements). The large estimated variances for these coefficients suggest that more information is needed to determine their level of significance. Applying the Welch's t-test used in the previous case study for the US71/TH23 expansion, we find that the difference between the two coefficients is significant at the $p < 0.06$ level. Note, however, that in this case the change in the estimated coefficient is in the *negative* direction, suggesting that these cities' employment growth rates were lowered to a level roughly equal to those for non-highway cities prior to the highway improvement. This also appears to be case for the variables representing cities located along the improved segment of highway in the TH 371 expansion case study. The change between the periods before and after completion of the highway is fairly large and negative in sign. A formal test of the difference between the two coefficients reveals them to be statistically significant at the $p < 0.05$ level.

With the exception of these two instances, none of the other pairs of variables representing time and location in the three case studies show evidence of significant effects due to the timing of the completion of the highway improvements. We view this as generally supporting the results from the previous set of employment regressions, that there is little evidence of measurable employment impacts due to the completion of these highway improvements.

5.2.3 Opportunity Drive Interchange

The fourth case study of interest is the Opportunity Drive (CSAH 75) interchange on Interstate 94 in the city of St. Cloud, Minnesota. The interchange was completed in the summer of 2004, providing direct access to the interstate near a site undergoing development into an industrial park (I-94 Industrial Park). Proponents of this project, including the city itself, expected that the freeway access provided by the interchange would provide a strong incentive for commercial/industrial development in the new business park.

The interchange project presents a particularly difficult case to evaluate, due to the localized nature of the benefits derived from the improvement. It is unlikely that such a project would have larger spillover effects, as in the case of a corridor highway improvement, which might spread to other nearby cities. This point is furthered by the fact that the project is in a location that already has reasonably good highway access. Prior to completion of the interchange at Opportunity Drive, the nearest freeway access point was just two miles away. Further complicating matters, the city of St. Cloud already has a fairly large and diverse economy, meaning that projects of this scope would be unlikely to register impacts which would be highly noticeable in trends in the region's economy.

Nonetheless, we attempt to ascertain whether there have been any distinct effects on employment growth due to the project. Using the same QCEW data set, we measure employment changes at the smallest available geographic unit. The data extraction tool provided by DEED allows for the disaggregation of employment and wage totals among some of the state's larger cities into smaller, sub-city units, often based on ZIP codes. Since the St. Cloud city limits now encompass parts of three separate counties, the city is disaggregated into parts corresponding to each of the counties in which they are located. We focus only on the part of the city that is located in Stearns County, which contains the location of the interchange.

We previously identified a framework for understanding the principal sources of growth effects from transportation improvements. These included productivity improvements from more intensive use of existing inputs, increases in the scale of operations by expanding firms, and attraction of new resources or productive inputs. It is difficult to directly measure productivity in this case due to the absence of firm-level data. However, we can get a sense for what is happening in terms of the latter two effects, firm expansion and attraction of new businesses, from the attributes of the QCEW data. We therefore use data on employment levels and the disaggregate components of employment change to examine this case study. Aggregate private employment, as well as employment in three of the industries we considered in the analysis of private earnings (construction employment data was not available for the Stearns County portion of St. Cloud) form the basis of the analysis.

Aggregate Employment

A summary of the aggregate employment data for St. Cloud is provided in Figure 5.2, which shows changes in employment levels for both St. Cloud and the state of Minnesota (as a point of reference).

The other two panels of the figure show trends in net job gains and losses due to firm expansion/contraction and firm openings/closings, along with trends in average firm size for all private establishments in this portion of the city. Note again that the interchange project was completed in mid-2004, so any growth effects of this project would be likely to appear after this point in the time series.

The graph of employment growth in Figure 5.2 indicates that there was little employment growth overall during the first half of the first half of the decade, and that city growth rates were lagging the statewide growth rate. St. Cloud then saw a couple of years of employment growth that outpaced the state's performance before plunging into recession. The most recent period shows both the city and the state emerging from recession at about the same rate.

The second panel of Figure 5.2 shows the net employment gains and losses attributable to firm expansions or contractions and firm openings or closings. The relationship between these quantities can be described as follows:

$$\text{Net employment gain} = (\text{net gain from expansion}) + (\text{net gain from openings})$$

where:

$$\text{Net gain from expansion} = (\text{job gains from firm expansions}) - (\text{job losses from firm contractions})$$

and

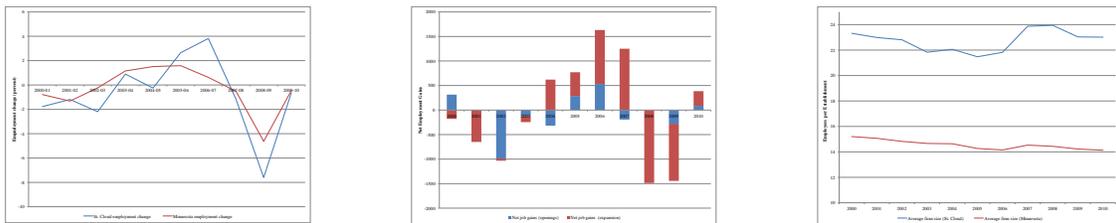
$$\text{Net gain from openings} = (\text{job gains from firm openings}) - (\text{job losses from firm closings})$$

The data on total employment change due to openings and expansion follow the same cyclical trend overall, but the changes appear to come from different sources at different points in time. With the exception of 2002 and 2002, it appears that employment changes due to expansion and contraction drive the overall changes in employment. The middle years of the decade showed relatively strong employment gains from firm expansion, but most of these gains were lost during the recession years. In contrast, there were relatively few gains from new firm openings during this period.

The third panel of Figure 5.2 shows a time trend of data of firm size for both St. Cloud and Minnesota. The statewide data show a longer-term trend of modest declines in average firm size, from just over 15 workers per establishment in 2000 to around 14 in 2010. The data for St. Cloud, while not showing a monotonic trend of decline over the course of the decade, nonetheless indicate a slightly smaller average firm size at the end of the decade than at the beginning. It is interesting to note, however, that the average firm size in 2010 is somewhat higher than the middle of the decade, when the project was completed.

Industry Employment

Beyond the aggregate employment data, we can examine the performance of some of the individual industries. Figure 5.3 depicts the same summary of employment data for the manufacturing industry. The first panel shows the rate of growth in manufacturing employment at both the city and state levels. These data illustrate the longer-term trend toward declining employment in manufacturing, both at the city and statewide levels. While St. Cloud experienced a slight period of



(a) Total employment change

(b) Net job gain from openings/expansion

(c) Firm size

Figure 5.2: Aggregate employment trends, St. Cloud

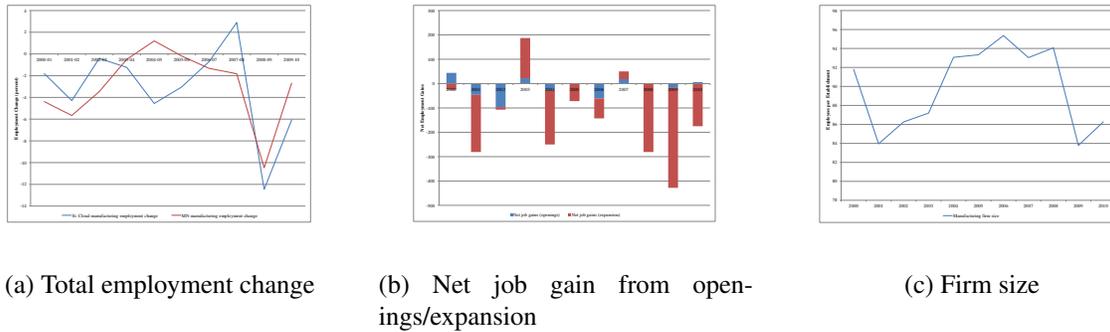
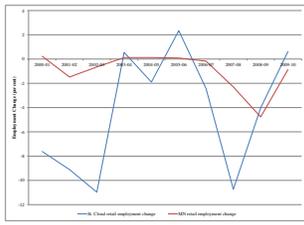


Figure 5.3: Manufacturing industry employment trends, St. Cloud

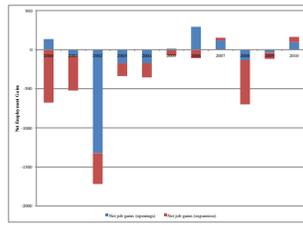
growth in manufacturing employment between 2007 and 2008, this was followed by a sharp loss of employment during the recession. The second panel of Figure 5.3, which shows the gains and losses in employment due to openings and expansions, indicates that most of this loss was due to contraction of existing firms. The third panel of Figure 5.3 shows the trend in average firm size for manufacturers in St. Cloud. The trend appears to closely follow macroeconomic conditions, with a decline during the first couple of years of the decade followed by a period of expansion, and punctuated by another large decline during the recession of 2008-09. As a result, the average manufacturing firm was about six percent smaller at the end of the decade than at the beginning.

Retail industry employment data are displayed in Figure 5.4. The first panel indicates that, while there was almost no growth in employment statewide in the industry during this decade, the retail sector in St. Cloud was even weaker in terms of employment growth. A brief period of employment growth from 2005 to 2006 was followed by a sharp contraction at the onset of the recession. Since the retail sector is particularly vulnerable to changes in consumer spending, it tends to get hit harder during recessions. While there was a slight uptick in retail employment in St. Cloud at the end of the period, this seems to be more or less in line with the statewide trend. The second panel of Figure 5.4 indicates that most of the retail employment losses during the first half of the decade were due to the contraction of existing firms, with the exception of 2002. Between 2005 and 2007 there were positive net employment gains from new firm openings in each year, though in 2005 and 2006 they were at least partially offset by net losses due to contractions from existing retail firms. Figure 5.4 also shows the long-term trend in firm size, which indicates a pattern of consolidation, rather than expansion. Changes in average firm size have been modest since 2003 and show no pattern of consistent expansion or contraction.

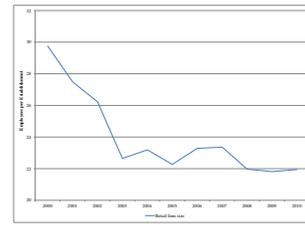
The last industry we look at is the wholesale industry. Unlike the previous two industries we examined, data on wholesale employment is only available through 2009 for the Stearns County portion of St. Cloud. The first panel of Figure 5.5 shows the city and statewide employment trends in this industry. While the statewide trend in employment in the wholesale industry between 2000 and 2009 was one of modest growth, wholesale employment in St. Cloud appeared not to grow much at all during the decade. The components of employment change indicate that some net job gains due to expansion occurred between 2004 and 2007, although they were more or less matched by losses from contractions in the adjoining years. Likewise, modest gains and losses from firm openings and closings occurred at irregular intervals during the decade. The data on firm



(a) Total employment change



(b) Net job gain from openings/expansion



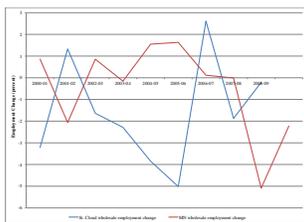
(c) Firm size

Figure 5.4: Retail industry employment trends, St. Cloud

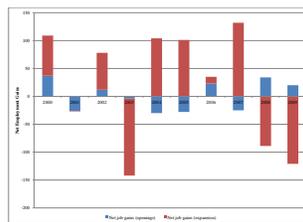
size indicate a decline in average firm size during the middle of the decade, followed by a sharp rebound in 2007 prior to the onset of recession. Overall, the average wholesale establishment had about one fewer employee in 2009 than in 2000, a decrease of roughly four percent.

Considering the evidence on employment changes, both at the level of individual industries and in the aggregate, it is difficult to find evidence of employment growth trends that may be attributable to the interchange project. While the aggregate employment data indicate some growth, mostly via firm expansion from 2004 to 2007 (the three years following the completion of the interchange), the fact that these data include many service-oriented industries unlikely to be greatly affected by the project, which is located at the city’s periphery, indicates that the project probably had little effect on employment growth.

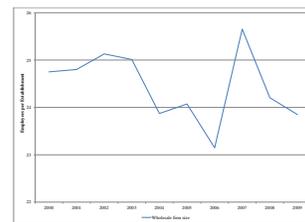
Looking at the individual industries and decomposing the sources of employment change is more instructive. Considering that the interchange project and the adjacent business park were built on a “greenfield” site far from the contiguously developed parts of the city, they were likely to be marketed to new prospective tenants rather than existing local businesses. Thus, it seems probable that any (positive) employment changes associated with this project would be more likely to appear in the data on job growth from new firm openings. Since relatively few of the employment gains observed during this period, especially in the manufacturing, retail and wholesale industries, were the result of new firm openings, it seems unlikely that the project had a measurable impact



(a) Total employment change



(b) Net job gain from openings/expansion



(c) Firm size

Figure 5.5: Wholesale industry employment trends, St. Cloud

on employment. One possible exception to this finding would be if some the new occupants of the business park were branches of existing firms already established within the city. In this case, the job gains would be classified as due to firm expansion from the perspective of the entire of the city.

5.3 Summary

While the evidence from the St. Cloud employment data was not as clear-cut with respect to conclusions about employment growth effects, it seems likely that the impacts were on par with those observed in the other three case studies. The use of MCD-level employment data allowed us to add some additional spatial resolution and examine whether the highway improvement projects that comprise the set of case studies had any redistributive or reorganization impacts independent of the growth effects we studied in the previous section. The results appear to indicate that neither type of effect was observed at any level of practical significance. In concluding section that follows, we discuss what these findings might mean for practitioners involved in transportation and economic development projects, as well as future studies designed to evaluate the economic impacts of transportation improvements.

Chapter 6

Conclusions

Transportation investment remains a popular strategy for promoting economic development at the state and local level. Yet if it is to continue to be used for this purpose, state departments of transportation and other public authorities responsible for the provision of transportation will need to be judicious in terms of how they allocate scarce resources to transportation. The empirical analysis of the case study projects contained in this research study found no convincing evidence of statistically significant effects on private earnings and employment in the locations where these projects were implemented. We believe these findings point to some important implications about the relationship between transportation investments and economic development, both from the perspective of designing policy to promote economic development through transportation improvement and from the perspective of technical issues involved in the design and use of methods to evaluate the impacts of such projects. We address these in turn, beginning with technical issues.

6.1 Technical Analysis Issues

The findings of no statistically significant impacts on earnings and employment from the two sets of empirical analysis at the core of this study, while consistent, do require some caveats. First, we note that in both of the empirical applications there were relatively few years in the time period following the construction of the highway improvement in each of the case studies. This was especially true for the analysis of the employment data, where only 11 years were available, and thus the period of analysis was somewhat compressed. Likewise, in both cases the latter years in the sample corresponded to a fairly deep depression, from which most US states are continuing to recover. Thus, it may be useful to continue to track the economic growth paths of the case study locations for several years following the completion of this study and, if necessary, to update the analysis.

Second, an important assumption in the empirical models of earnings and employment was the exogeneity of population change in each of the case studies. Other published studies have suggested the possibility of multiple paths of influence from highways of population change [30, 29]. To the extent that population growth may have been endogenous to (determined by) the transportation improvements in each location, our results may understate the impacts of the projects on economic growth. Yet from looking at recent decennial census population counts for each of the counties studied, three of the five counties (Kandiyohi, Morrison, and St. Louis) grew at rates slower than

the statewide average between 2000 and 2010, and those that grew faster (Crow Wing County and the city of St. Cloud) than average generally grew at rates significantly lower than the previous decade. It seems then that for the set of case studies under study here, the assumption of exogenous population change is an acceptable one.

If longer time series data sets were available, especially with more annual observations of post-construction outcomes, an alternative approach would be to relax the exogeneity assumption and allow for the simultaneous determination of population and employment [25] or population, employment and income [38] within a structural framework. These approaches, however, tend to be better suited to more systematic and large-scale analyses of growth, as opposed to the more location-specific case study approach adopted here.

Third, another important limitation of the case study approach is that it is difficult to establish a “treatment effect” of the highway improvements that are comparable across cases. While three of the four projects considered here were generally of the same type (expansion projects on outstate, non-interstate trunk highways), they varied somewhat in terms of size and scope. Further confounding these differences is the fact that the highway improvements under study generally occurred in response to previous traffic growth, thus making it difficult to identify the separate contribution of the project itself. Identification of the treatment effect of an improvement in these types of studies is often a difficult yet important task. Some of the previous studies we reviewed previously found creative ways of managing this issue. The studies by Chandra and Thompson [27] and Michaels [89] focused on effects of interstate highways on rural counties, effectively treating the introduction of an interstate as part of a natural experiment since the interstates were planned to connect large cities, with the intervening rural areas often being incidental to their location. Likewise, the study by Rephann and Isserman [102] used quasi-experimental matching techniques to identify “control” groups against which impacted counties along new highways could be compared. These methods may represent potentially useful points of comparison for the panel regression techniques applied here.

Fourth, we note that the three highway improvement case studies analyzed here are all components of larger, interregional corridors being developed to link outstate trade centers to one another. To the extent that there are any network effects to the incremental completion of these links, it may be worthwhile to study them, including the case study locations covered here, at some future date when they are more substantially developed.

6.2 Policy Toward Transportation and Economic Development

Our findings with respect to economic impacts of highway improvements also help to illustrate some key points regarding policies which use transportation investment to promote economic development.

In an earlier chapter, we reviewed and synthesized much of the available evidence on the contribution of transportation infrastructure, non-transportation infrastructure, and other non-transportation factors to economic development. Our general conclusion that the importance of transport costs, and hence transportation infrastructure, is diminishing relative to other non-transportation factors such as human capital, taxation, and quality of life factors seems to be confirmed. Indeed, these other factors seem to figure prominently in determining the growth potential of the case study areas included here. Crow Wing County, the fastest-growing county in our study, has benefitted from an

abundance of natural amenities which give it distinct advantage as a potential residential location relative to other non-metropolitan counties. In contrast, St. Louis County, which has experienced the slowest growth among our case study locations, has been limited by multiple factors. Its colder climate (in particular, its harsh winters) diminishes its attractiveness to households and firms, while its economic structure has been marked by the presence of an unfavorable industry mix, including greater concentrations of employment in certain declining or slow-growth sectors such as mining and manufacturing. These factors are generally outside the control of public policy and are unlikely to be affected by modest changes to the transportation network.

The results produced in this study also correspond with our earlier suggestion from the review of evidence on transportation and economic development that highway networks in the United States are substantially mature, and thus subject to diminishing returns to new investment. Outside of large cities, there are few major highway links that have yet to be built which would provide extranormal rates of return. The set of projects that this study examined were generally expansions to interregional corridors connecting smaller urban areas in outstate Minnesota, with two of them also providing bypasses of traditional central business districts. These projects should be expected to provide some travel time savings to users and respond to growing needs in locations with increasing traffic volumes, yet they seem unlikely to represent major catalysts to economic development by themselves.

We do not interpret the results of the study as necessarily providing *prima facie* evidence that the projects in question were not cost-effective or economically viable. Rather, we suggest that projects like these should continue to be evaluated based on their ability to deliver benefits to users. Travel time savings, safety benefits, and other types of measurable social benefits, such as reductions in pollutant emissions, are the core justification for undertaking improvements to highways and other transportation networks. Moreover, focusing only on jobs created or local income effects may cause analysts to lose sight of the fact that for highway improvement projects like those covered in this study, many of the benefits may be diffuse and accrue to non-local users of the highway. The focus on user benefits seems particularly appropriate in light of the fact that there are few projects that could not pass a standard cost-benefit test, yet also be expected to provide sizable economic development benefits.

Lastly, we return to the issue of scale in evaluating the economic development effects of transportation investment. As we noted previously in our review, several empirical studies of highway investment have found evidence that the effects of these projects were not merely generative, but also tended to redistribute activity across locations [51]. Studies examining the effects of major public works projects like the Interstate Highway System tended to find the greatest redistributive effects. While our examination of three highway corridor expansion projects found little evidence of this, the case study of the Opportunity Drive interchange is instructive. Since this project provided access to nearby land and enabled the development of a new industrial park, it might rationally be seen as generating new growth from the perspective of local residents and public officials who may be positioned to capture a substantial share of the benefits. Seen from a statewide perspective, however, it is more difficult to substantiate these effects as generative. Doing so would require answering the counterfactual question of whether, and if so, where investment would have taken place in the absence of the interchange. Would the firms who located near the interchange still have chosen to expand? Would they have located somewhere else in the city? Or the state? In cases where the benefits from a project are highly localized, yet there may be some spillover effects to a larger geographic area, it may make sense to pursue cost participation policies that spread the

cost of developing a project across multiple jurisdictions (e.g. state and local) in rough proportion to the anticipated benefits. This approach could ensure that transportation projects which deliver economic benefits at a scale somewhere between statewide and entirely local will still be provided in a manner that it is both efficient and fair.

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