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The Economic Impact of Upgrading Roads

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Improvements to transportation networks, especially those in growing areas, tend to have impacts on local land markets. In principle, an improvement to a link in the network will confer economic benefits to adjacent and nearby properties by increasing the utility that the network provides. Traditional methods of economic analysis for highway improvement projects have focused primarily on user benefits and sought to quantify them through the estimation of reductions in travel delay or user cost. However, urban economic theory suggests that many of these benefits are capitalized into local property values, yielding a localized spillover effect. Accordingly, it should be possible to develop rough estimates of the value of the benefits from a highway project by estimating the response of local land markets to the improvement. This report explores the nature and magnitude of benefits accruing to nearby properties that arise from major highway construction or reconstruction projects, more precisely those that add capacity to an existing highway. Highway projects in three Minnesota counties (Hennepin, Jackson, and Olmsted) form the basis for our analysis.

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The Economic Impact of Upgrading Roads

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Executive Summary

Improvements to transportation networks, especially those in growing areas, tend to have impacts on local land markets. In principle, an improvement to a link in the network will confer economic benefits to adjacent and nearby properties by increasing the level of accessibility that the network provides. Traditional methods of economic analysis for highway improvement projects have focused primarily on user benefits and sought to quantify them through the estimation of reductions in travel delay or user cost. However, urban economic theory suggests that many of these benefits are capitalized into local property values. Accordingly, it should be possible to develop rough estimates of the value of the benefits from a highway project by estimating the response of local land markets to the improvement. This report explores the nature and magnitude of benefits accruing to nearby properties that arise from major highway construction or reconstruction projects, specifically those that add capacity to an existing highway.

In this study we select three Minnesota counties as case studies for further analysis. Hennepin County contains the city of Minneapolis and is the most populous county in the state, with a population of more than 1.1 million. It represents a large, growing urban county in the Twin Cities metropolitan area, and contains a number of examples of recent major highway construction projects that have added capacity to existing links. Our analysis also extends to two outstate counties, one primarily urban and the other rural. The urban county is Olmsted County, which is located in southeastern Minnesota and contains the city of Rochester, with a population of over 100,000. Rochester is also the location of the "ROC 52" project, a major multi-year reconstruction project on 11 miles (17.7 km) of U.S. Highway 52 which expanded the freeway from four to six lanes. The rural outstate county we examine is Jackson County in southwestern Minnesota. Jackson is a less populous county with a more stable population and no large urban centers, thus providing a contrasting case to the other counties in the study. The construction project examined in this case is the expansion of Minnesota Trunk Highway 60 from a two-lane rural highway to a four-lane divided highway through the northwestern part of the county, between the towns of Windom and Worthington.

The results of the analyses of highway projects in the three counties vary from location to location. In addition to differences in project size and scope, the case studies employ different data sources and methods, with the availability of data being an important factor in determining the level of sophistication of the methods applied. Furthermore, in cases where greater amounts of data are available it is possible to analyze effects of highway improvements on multiple types of property, including some non-residential property types. In some cases where residential properties are the focus of the analysis, we also attempt to separate out the effects of proximity to the highway itself (which we believe to be negative) from the effect of proximity to a highway access point (which we believe to be positive). To highlight these influential factors and to synthesize the results of the different case studies, we summarize the research findings in Table 1. The results from each county are also described in greater detail below.

Hennepin County

The analysis of highway improvements in Hennepin County differs from those in the other two counties in that multiple projects were evaluated simultaneously in order to make greater use of the available data on highway improvements and property sales. A special home sales data set was available for Hennepin County from the Minnesota Multiple Listing Service (MLS) and was employed in the analysis of house prices. This data set contained a more detailed set of housing characteristics, which improved the accuracy of the statistical models that were used to estimate the price effects of locations near upgraded highways. The use of the MLS data set restricted the period of observation of property sales to four years, 2001 through 2004, the only years for which these data were available. Separate estimates for the effect of location near an upgraded highway were obtained for each year from 2002 through 2004. The basic results of the analysis of residential properties were as follows:

- Proximity to the upgraded highway itself was associated with a reduction in sale price for homes within one mile of the highway. This effect varied from around 5 percent for homes within 1/4 mile (400m) of the highway to less than 2 percent for homes between 3/4 mile and 1 mile from the upgraded highway. There was no discernable trend in these values over time, indicating that this effect likely existed prior to the highway improvements considered here.
- Sale prices for homes fall by an estimated 1.2 percent for every 1/4 mile from the nearest access point on the upgraded highway segments. Again, there is no statistically significant trend in this value over time, indicating that the effect cannot be uniquely attributed to the highway upgrade projects.

Analysis of some non-residential property types was also feasible due to the availability of parcel-level land use data which could be matched to the property sales data. The analysis of non-residential property sales, which were separated into commercial, industrial, and office property types, indicated that:

- No statistically significant positive effect on sale price was found for properties located near an upgraded highway, after controlling for general highway access and a number of other external factors that influence commercial and industrial property values. This finding was partly influenced by the relatively small sample sizes of property sales for commercial, industrial and office properties relative to those available for residential properties.

Jackson County

The analysis of Jackson County residential property sales data also reveals no effect of the upgrade of Highway 60 to a four-lane facility. Here, the effect of proximity to the upgraded highway was shown to be moderately negative, though the source of this effect is difficult to confirm. One possibility is that the variable used to measure proximity to the highway also appears to capture proximity to an active freight rail line, which may also depress residential property values. Also, we note that in this case many of the observations of properties near the upgraded highway are drawn from the town of Heron Lake, and that the reconstructed highway bypasses the town with few residential properties close enough to be substantially affected by the new highway alignment.

Olmsted County

The reconstruction of U.S. Highway 52 provides perhaps the best example of a large highway upgrading project. The ROC 52 project provided a large, multi-year project where impacts could be examined most effectively over time. The analysis of the ROC 52 project made use of Department of Revenue sales data from 2000 through 2007 and split the analysis into three periods corresponding to a period before construction, a period during major construction, and a post-construction period, during which the most substantial construction activity was complete. Residential property sales were analyzed, with estimates of the value of location near the upgraded highway and its access points obtained for each of the three time periods. Results indicated that:

- For home sales within 1 mile of the upgraded segment of Highway 52, prices were 0.5 to 2.0 percent higher during the post-construction period, relative to the pre-construction period.
- No additional premium was observed for properties located near access points (interchanges) on the reconstructed segment of Highway 52.

The property sales data for Olmsted County was also large enough to permit some analysis of commercial and industrial properties sold in the county before, during and after the ROC 52 project. The analysis attempted to control for general highway access throughout the county, then to determine whether location near an access point on the upgraded segment of Highway 52 conferred any additional benefit. Results indicated that:

- General highway access is highly valued, with commercial/industrial property sales prices declining, on average, by around 9 percent for each 1/4 mile from the nearest highway.
- A small premium is attached to location near an access point on the reconstructed segment of Highway 52, with prices declining by 0.3 to 0.6 percent for each 1/4 mile from the nearest access point on the upgraded highway segment.

The results of the analysis suggest a need for improved methods and data for analyzing the effects of transportation improvements. Our results indicate that the effects of highway improvements on property values may vary by location (e.g. urban/rural), property type, and by the size of the project under consideration. The ROC 52 project was the largest single project considered in our analysis, and accordingly it showed the clearest indication of effects on land values. However, variations in data quality also unquestionably affected the results. Further research should focus on standardizing methods of analysis across locations and finding suitable data sources that can facilitate the replication of these methods in different environments.

Table 1: Summary of Research Findings

County	**Project**	**Property Type**	**Data Set**	**Method**	**Highway Access Effect**	**Highway Proximity Effect**
Hennepin	Several	Residential	Multiple Listing Service (2001-04)	Estimated year-specific effects	Sale prices fall by 1.2 percent for every 1/4 mile (400m) from the nearest highway access point; no significant change in magnitude over time	Proximity to highway reduces sale price within 1 mile. Effect declines from around 5 percent within 1/4 mile to less than 2 percent between 3/4 mile and 1 mile.
Hennepin	Several	Commercial	Dept. of Revenue (1999-2007)	Before and after (split data into two periods)	Not estimated	Positive effect for highway proximity generally, but no *specific* effect of being near an upgraded highway
Hennepin	Several	Office	Dept. of Revenue (1999-2007)	Before and after (split data into two periods)	Not estimated	Positive effect for highway proximity generally, but no *specific* effect of being near an upgraded highway
Hennepin	Several	Industrial	Dept. of Revenue (1999-2007)	Before and after (split data into two periods)	Not estimated	No significant effect of highway proximity
Jackson	MN Highway 60	Residential	Dept. of Revenue (1999-2007)	Before and after (split data into two periods)	Not estimated	No significant effect of highway proximity
Olmsted	US Highway 52	Residential	Dept. of Revenue (2000-07)	Estimated effects for periods before, during, and after construction	No significant effect of highway access	Sale prices higher during post-construction period by 0.5 to 2.0 percent for properties within 1 mile of upgraded highway, relative to pre-construction period
Olmsted	US Highway 52	Commercial/ Industrial	Dept. of Revenue (2000-07)	Estimated effects for periods before, during, and after construction	Not estimated	Sale prices decline 9 percent for each 1/4 mile from nearest highway; prices fall an additional 0.3 to 0.6 percent for each 1/4 mile from the nearest access point on upgraded highway segment

Chapter 1

Introduction

Improvements to transportation networks, especially those in growing areas, tend to have impacts on local land markets. In principle, an improvement to a link in the network will confer economic benefits to adjacent and nearby properties. Depending on the type of improvement (construction of a new link, capacity addition to an existing link, or upgrading an existing link), the benefit could represent a reduction in the time cost of travel or other variable costs, such as fuel consumption or mileage-related vehicle depreciation. It could also represent an improvement to the level of access that a given transportation network provides. Urban economic theory would suggest that these benefits are capitalized into local property values, yielding a localized spillover benefit. This report explores the nature and magnitude of benefits accruing to nearby properties that arise from major highway construction or reconstruction projects, more precisely those that add capacity to an existing highway.

In this study we select three Minnesota counties as case studies for further analysis. Hennepin County contains the city of Minneapolis and is the most populous county in the state, with a population of more than 1.1 million. It represents a large, growing urban county in the Twin Cities metropolitan area, and contains a number of examples of recent major highway construction projects that have added capacity to existing links. Olmsted County in southeastern Minnesota has a population of around 125,000 and contains the city of Rochester, Minnesota's third largest city and home to the world-renowned Mayo Clinic. It provides an example of a smaller, though rapidly growing outstate city. In addition, it recently experienced a major reconstruction project, the "ROC 52" project, which expanded an 11-mile segment of U.S. Highway 52, the major north-south arterial through Rochester, from four to six lanes. The last county to be examined in this study is Jackson County. Located in southwestern Minnesota along the Iowa border, Jackson County has a population of about 11,000, and provides a contrasting case of a slower-growing area within which to evaluate the effects of a highway improvement. The project to be evaluated in this case is the expansion of Minnesota Trunk Highway 60 from two to four lanes between the cities of Worthington and Windom.

The methodological approach to the problem of estimating the contribution of a highway construction or reconstruction project to local property values is to define a period during which one or more major projects took place. We then specify hedonic price models to estimate the determinants of property values in a given location. Depending on the size of the data set available and the length of the time period covered, two different approaches are used. Where data sets are more limited, we adopt a before-and-after technique, estimating models from subsets of the data corresponding roughly to periods before and after completion of the relevant project. Where larger data sets are available and temporal coverage is more complete, a greater number of time slices are defined and variables representing proximity to the upgraded highway are interacted in order to search for changes in location premiums (or discounts) over time due the highway improvement.

We employ several data sets to examine the impacts of highway improvements in each location. In addition to data on major construction and reconstruction projects in Minnesota counties during the period from 1997 to 2007, we employ three sets of data on property sales for the counties of interest. Data on arms-length property sales transactions for each of the counties are provided by the Minnesota Department of Revenue for the period from September 1999 through September 2007. We use data on residential and commercial-industrial sales to test for effects on both residential and commercial types of properties. The sales data are supplemented by parcel data supplied by the counties, which allow for mapping and further analysis, along with providing some additional information about the individual properties. In the case of Hennepin County, an additional set of home sales data collected by the Multiple Listing Service over the period from 2001 through 2004 is used. While somewhat limited in longitudinal scope, these data provide a rich set of structural and location attributes which greatly enhance the empirical models we apply to Hennepin County. While it might be preferable to look specifically at sales of raw land parcels to analyze the impact of transportation improvements, as locational benefits owing to transportation improvements are often hypothesized to be capitalized entirely into the price of land, such occurrences are somewhat rare in our data set. More often, observed property sales reflect the bundled set of land and buildings that are purchased simultaneously as a single product. We thus use the total sale price of a property as the unit of analysis in most cases.

The structure of the report proceeds as follows. In the second section we review several of the methods used previously to analyze the economic effects of highway capacity improvements, including the hedonic method applied in this study. The third section provides an overview of the data sources employed in the analysis and describes the methodological approach in greater detail. The fourth section reports the results of the analysis for the three case study counties and the different property types examined in each one. Lastly, we conclude with some discussion of how our approach might be refined and improved to deal with data availability issues and other unique methodological challenges.

Chapter 2

Review of Economic Impact Methods for Highway Improvements

When confronted with the problem of evaluating proposals for projects involving new highway capacity, public decision makers face a bewildering array of options for anticipating and assessing project-related economic impacts. On one hand, the issue of geographic scale is highly relevant. Local or project-level impacts may be very different from those estimated at regional and multi-regional levels. Another salient issue is that there are many metrics for assessing economic impacts, ranging from direct user benefits and changes in external costs of travel to more aggregate economic indicators, such as employment, income and productivity rates.

Several types of economic benefits arise from transportation improvements:

- reductions in travel costs, [1]
- more efficient supply chains,
- intra-firm scale economy effects (permitting individual firms to through larger scale operations at fewer locations),
- agglomeration (including inter-firm scale effects) whereby clusters of competing and complementary firms perform better than firms in isolation, and
- re-organizational benefits, where firms can reorganize the way they produce output, and improve quality or even the goods that can be produced thanks to new infrastructure, just-in-time production is an example.

All of these benefits relate, and may be fully capitalized into the price of land, property and products. Project-level, disaggregate studies tend to focus on the first of these effects, while more aggregate methods are applied to the next two. Almost no studies consider the longer term agglomeration or reorganization benefits of improved infrastructure [24], and identifying the existence of positive externalities from infrastructure (i.e. gains that are not captured by users) is very difficult.

The economic impacts of transportation improvements have been measured alternatively at either a macro or a micro scale. The former contain much of the theoretical literature underlying the calculation of impacts and can be traced back to early works such as [54]. The latter have become associated with more

[1] Some analysts consider reductions in travel costs a user benefit, not an economic benefit, but we find it hard to see how users are not part of the economy. We do believe that user costs should be quantified distinctly from other benefits and double counting of benefits should be avoided.

general studies of the overall impact of transportation or public capital spending on aggregate measures of output.

The development of methodological approaches to economic impact measurement has since evolved to fit more practical applications, and these have mostly been carried out at smaller scales, taking the form of benefit-cost analyses for particular projects [53], regional or corridor investment analyses [22, 1] , or studies of the impact of specific projects on local property values.

This section reviews several strands of relevant literature that aim to assess the basic issue of the economic impact of highways. It begins with a discussion of traditional, project-based economic analysis methods, based on microeconomic foundations and benefit-cost analysis methods. Some attention is paid to the specific topic of induced demand, since this issue presents unique difficulties for microeconomic analysis methods. Then, the discussion turns to regional and macroeconomic methods, including input-output and econometric modeling. The final section summarizes the previous discussion and offers some prospective ideas about evaluating the impacts of transportation improvements.

2.1 Software Tools for Impact Analysis

The majority of economic impact studies for highway capacity projects are undertaken using conventional methods. These methods tend to focus on the direct user impacts of individual projects in terms of travel costs and outcomes, and compare sums of quantifiable, discounted benefits and costs. Inputs to benefit-cost analyses can typically be obtained from readily available data sources or model outputs (such as construction and maintenance costs, and before and after estimates of travel demand, by vehicle class, along with associated travel times). Valuation of changes in external, somewhat intangible costs of travel (e.g., air pollution and crash injury) can usually be accommodated by using *shadow price* estimates, such as obtained from FHWA-suggested values, based on recent empirical studies.

The primary benefits included in such studies are those related to reductions in user cost, such as travel time savings and vehicle operating costs (e.g. fuel costs, vehicle depreciation, etc.). Additional benefits may stem from reductions in crash rates, vehicle emissions, noise, and other costs associated with vehicle travel. Project costs are typically confined to expenditures on capital investment, along with ongoing operations and maintenance costs.

A number of economic analysis tools have been developed under the auspices of the Federal Highway Administration (FHWA) permitting different forms of benefit-cost analysis for different types of projects, at different levels of evaluation. Several of these tools are prevalent in past impact analyses, and are described here. However, none identifies the effects of infrastructure on the economy and development.

2.1.1 MicroBENCOST

MicroBENCOST [51] is a sketch planning tool for estimating basic benefits and costs of a range of highway improvement projects, including capacity addition projects. In each type of project, attention is focused on corridor traffic conditions and their resulting impact on motorist costs with and without a proposed improvement. This type of approach may be appropriate for situations where projects have relatively isolated impacts and do not require regional modeling.

2.1.2 SPASM

The Sketch Planning Analysis Spreadsheet Model (SPASM) is a benefit-cost tool designed for "screening" level analysis. It outputs estimates of project costs, cost-effectiveness, benefits, and energy and air quality impacts. SPASM is designed to allow for comparison among multiple modes and non-modal alternatives, such as travel demand management scenarios. The model is comprised of three modules (worksheets) relating to public agency costs, characteristics of facilities and trips, and a travel demand component. Induced traffic is dealt with through the use of elasticity-based methods, where an elasticity of vehicle-miles of travel (VMT) with respect to travel time is defined and applied. Vehicle emissions are estimated based on calculations of VMT, trip length and speeds, and assumed shares of travel occurring in cold start, hot start, and hot stabilized conditions. Analysis is confined to a corridor level, with all trips having the same origin, destination and length. This feature is appropriate for analysis of linear transportation corridors, but also greatly limits the ability to deal with traffic drawn to or diverted from outside the corridor. DeCorla-Souza et al. [15] describe the model and its application to a freeway corridor in Salt Lake City, Utah.

2.1.3 STEAM

The Surface Transportation Efficiency Analysis Model (STEAM) is a planning-level extension of the SPASM model, designed for a fuller evaluation of cross-modal and demand management policies. STEAM was designed to overcome the most important limitations of its predecessor, namely the assumption of average trip lengths within a single corridor and the inability to analyze system-wide effects. The enhanced modeling capabilities of STEAM feature greater compatibility with existing four-step travel demand models, including a trip table module that is used to calculate user benefits and emissions estimates based on changes in network conditions and travel behavior. Also, the package features a risk analysis component to its evaluation summary module, which calculates the likelihood of various outcomes such as benefit-cost ratios. An overview of STEAM and a hypothetical application are given by DeCorla-Souza et al. [16].

2.1.4 SMITE

SMITE (Spreadsheet Model for Induced Travel Estimation) is a sketch planning application that was designed for inclusion with STEAM in order to account for the effects of induced travel in traffic forecasting. SMITE's design as a simple spreadsheet application allows it to be used in cases where a conventional, four-step travel demand model is unavailable or cannot account for induced travel effects in its structure [14]. SMITE applies elasticity measures that describe the response in demand (VMT) to changes in travel time and the response in supply (travel time) to changes in demand levels.

2.1.5 SCRITS

As a practical matter, highway corridor improvements involving intelligent transportation systems (ITS) applications to smooth traffic flow can be considered capacity enhancements, at least in the short term. The FHWA's SCRITS (SCReening for ITS) is a sketch planning tool that offers rough estimates of ITS benefits, for screening-level analysis. SCRITS utilizes aggregate relationships between average weekday traffic levels and capacity to estimate travel speed impacts and vehicle-hours of travel (VHT). Like many other FHWA sketch planning tools, it is organized in spreadsheet format and can be used in situations where more sophisticated modeling systems are unavailable or insufficient.

2.1.6 HERS

In addition to helping states plan and manage their highway systems, the FHWA's Highway Economic Requirements System for states (HERS-ST) offers a model for economic impacts evaluation. In one case, Luskin and Mallard [46] use HERS-ST to conclude that Texas is under-invested in highways particularly urban systems and lower-order functional classes by 50 percent. Combining economic principles with engineering criteria, HERS evaluates competing projects via benefit-cost ratios. Recognizing user benefits, emissions levels, and construction and maintenance costs, HERS operates within a GIS environment and will be evaluated under this project, for discussion in project deliverables. Well established software like HERS offer states and regions an opportunity to readily pursue standardized economic impact evaluations on all projects, a key advantage for many users, as well as the greater community.

2.1.7 Summary of Software Tools

Many analytical tools, like those described above, are favored due to their relative ease of use and employment of readily available or easily acquired data. However, several characteristics limit their effectiveness in evaluating the effects of new highway capacity. First, they are almost always insufficient to describe the full range of impacts of new highway capacity. Such methods deliberately reduce economic analysis to the most important components, resorting to several simplifying assumptions. If a project adds capacity to a particularly important link in the transportation network, its effects on travel patterns may be felt outside the immediate area. Also, the effects of induced travel, in terms of either route switching or longer trips, may not be accounted for in travel models based on a static, equilibrium assignment of traffic. In the longer term, added highway capacity may lead to the spatial reorganization of activities as a result of changes in regional accessibility. These types of changes cannot typically be accounted for in analysis methods.

Second, there is the general criticism of methods based on benefit-cost analysis that they cannot account for all possible impacts of a project. Benefit-cost methods deliberately reduce economic analysis to the most important components and often must make simplifying assumptions. The project-based methods described here generally do not describe the economic effects of a project on different user or non-user groups. Winners and losers from a new capacity project cannot be effectively identified and differentiated.

Third, a significant amount of uncertainty and risk is involved in the employment of project-based methods. Methods that use benefit-cost techniques to calculate B/C ratios, rates of return, and/or net present values are often sensitive to certain assumptions and inputs. With transportation infrastructure projects, the choice of discount rate is often critical, due to the long life of projects and large, up-front costs. Also, the presumed value of travel time savings is often pivotal, since it typically reflects the majority of project benefits. Valuations of travel time savings vary dramatically across the traveler population, as a function of trip purpose, traveler wage, household income, and time of day. It is useful to test several plausible values.

Assessment procedures in the UK and other parts of Europe have moved towards a multi-criteria approach, where economic development is only one of several appraisal criteria. Environmental, equity, safety, and the overall integration with other policy sectors are examined in a transparent framework for decision makers. In the UK, the Guidance on the Methodologies for Multi-Modal Studies provides such a framework [18]. These procedures require a clear definition of project goals and objectives, so that actual effects can be tied to project objectives, as part of the assessment procedure. This is critical for understanding induced travel effects. Noland [58] has argued that this implies that comprehensive economic assessment, including estimation of land valuation effects, is the only way to fully assess the potential beneficial impacts of projects.

2.2 Induced Demand

Since so many assessments of project benefits are based on travel-time savings, the issue of induced or "elastic" demand merits special attention. Since Hansen and Huang [31] provided evidence of an elasticity of 0.9 between road supply (capacity) and the demand for road use (VMT) among California's counties, there has been a great deal of concern over how the provision of new highway capacity might affect travel behavior and whether new capacity policies might be self-defeating. Such findings may have important implications for the long-term economic and social effects of highway capacity provision.

However, there is still a great deal that is not known about the fundamental causal structure underlying the phenomenon of induced demand. Research attempting to decompose the complex issue of induced demand [35, 40] has emphasized that there are both short-run and long-run effects of highway capacity additions. Specifically, in the short run, movements along the demand curve for road use are observed, as travelers may switch routes or substitute destinations. In the longer term, fixed adjustments by travelers and location decisions by households and firms in response to changes in travel time and accessibility may affect levels of overall travel, leading to an overall *shift* in the demand curve. Recent research has only begun to address these issues in practice by substituting micro-level data and methods for macroscopic analyses [25, 42, 55, 60] and addressing the reciprocal relationship between supply and demand [12, 43, 41].

The relationship between road capacity supply and demand is a dynamic process and is difficult to model with conventional models of travel demand. Since project-based microeconomic analysis techniques, including some developed by FHWA, use output from these models as inputs to benefit or cost calculations, their results may be somewhat skewed. Even the elasticity-based techniques provided in models like STEAM are likely to overestimate the response of travel demand to new capacity. The lack of a dynamic element in these analysis tools means that they are likely to overestimate user benefits due to a) an inability to capture short-term behavioral changes as the transportation network evolves toward a new equilibrium and b) an inability to capture the *co-development* process in the long run, whereby infrastructure and land use develop jointly over time in response to each other. While the benefits for individual users may drop in response to induced demand that diminishes the travel time savings, the fact that demand rises when capacity is added is indicative both of gains to users in general (more users take advantage of the facility), and of other economic benefits that this research aims to capture.

2.3 Aggregate Economic and Econometric Methods

An alternative method for exploring the economic impacts of transportation investment is to observe and measure, at a larger scale, the relationship between investment in transportation infrastructure and indices of economic performance. A range of different methods fall under this general category, including the use of regional economic models, aggregate productivity functions, as well as more disaggregate model specifications that allow for measurement at local and regional levels.

2.3.1 Regional Economic Models

One approach to measuring the effects of transportation investment at a regional level is to apply macroeconomic simulation modeling methods to represent the effects of cost savings and productivity enhancements due to transportation infrastructure investment. Economic impacts from such a model are measured in terms of employment, income and value added. A basic method for estimating the impacts of investment in a transportation project would involve estimating user benefits from the project, translating these benefits into economic consequences, allocating benefits to specific economic sectors, and finally estimating the additional impact due to changes in logistics and product markets [75].

Regional input-output models, such as IMPLAN and RIMS II, have seen extensive application in the transportation sector to issues such as the economic impact of highway and bridge construction [4] and regional estimates of commodity flows [73]. Weiss and Figura [77] have noted a more recent shift in economic impact modeling toward the REMI (Regional Economic Models, Inc.) regional economic model [71]. This has been attributed to the fact that while IMPLAN and RIMS II are largely expenditure-driven (implying that, from a local perspective, a larger project is invariably a better project), the REMI model is able to translate the results of an analysis of the transportation impacts of a project into regional economic performance via its effects on business costs and productivity. For example, since trucking costs are an important input to most economic sectors, any cost savings attributable to a project can be traced through the local economy.

One may question though, the extent to which a single transportation project (such as the addition of capacity to a local highway) will register significant economic impacts, especially in larger urban areas.

Since the changes to the transportation network and their associated cost savings are often modeled using static forecasting procedures, as described earlier, it is possible that any erosion of future benefits, due to unanticipated changes in network conditions, would also limit the economic impact forecasted by a regional economic model. Furthermore, the quality of the data on which regional economic forecasts are made can be considered suspect. It is inherently difficult to measure, with a high degree of precision, trade flows between counties or other relevant economic units. This problem is compounded at larger scales of analysis. A final note of caution is that regional economic models, like other types of complex, computer-based analysis tools, are vulnerable to misuse and abuse in order to justify new government projects. Mills [52] identifies some of the more common errors, such as ignoring the need of state and local governments to raise money to finance capital projects and treating construction wages as benefits instead of costs.

2.3.2 Aggregate Production Functions

During the early 1990s, there was a resurgence of interest in research attempting to measure the contribution of public capital to economic productivity, following the publication of work by Aschauer [3] and Munnell [56]. Both of these researchers estimated econometric production functions for national productivity using time series data and treating public capital stocks as a separate input. Both studies found enormous returns to public capital and suggested that declines in spending on infrastructure as a share of GDP during the 1970s and 1980s might have been a cause for the decline in productivity observed during that period. This immediately prompted national debate over whether there was an "infrastructure shortfall", a debate recently re-ignited by the collapse of the I-35W Mississippi River Bridge in Minneapolis. Subsequent research largely dispelled these claims. For example, federal spending on public nonmilitary capital was shown to be roughly constant from 1950 to 1990, while state and local capital stocks (which tend to be much larger), grew considerably [27]. Also, research that focused on industry-specific and state-level production functions, while controlling for unobservable differences in state-specific conditions, found much lower (and in some cases, statistically indistinguishable) rates of return [36, 23].

Nadiri and Mamuneas [57] estimated the benefits of highway investment at the national level between the 1950s and the 1980s and concluded that in the early years returns were as high as 35 percent per year, but that by late in the years of the construction of the Interstate system that contribution had dropped to roughly the same as the return from private capital, about 11 percent.

One of the benefits that has been associated with transportation improvements is the impact that increased accessibility has on agglomeration of urban areas. *Agglomeration economies* are an external benefit that arise from the interaction and co-location of productive factors within an economy, such as infrastructure, suppliers and customers, as well as a pool of labor with the needed skills. This can provide added economic value to an economy. Agglomeration economies are mitigated by various diseconomies, such as congestion, that may also occur. Recent research by Graham [26] has examined these impacts which may affect different industry sectors in different ways.

The flurry of economic research into the role of public capital and, in particular, highway infrastructure capital, shed light on an important way to measure the economic returns from transportation infrastructure investment, albeit at a highly aggregate level. With the aid of time series data, public infrastructure capital can be specified as a factor of production, and its contribution to productivity tracked over time. This information is critically important at a time when the U.S. National Highway System is essentially complete, and marginal improvements to the network must be evaluated. Care needs to be taken, though, in the specification and interpretation of the results from aggregate production function research. Definitions of public capital and other factors of production need to be rigorous (e.g. separating public highway capital from schools, airports, water systems, etc.). Also, the geographic scale of the research (local, state, national) needs to be clearly defined.

2.3.3 Cliometric Methods

Economic historians, utilizing so-called Cliometric methods (after Clio, the muse of history), have assessed the long-term retrospective impacts of major infrastructure investments. Among the more noted of these is the assessment by Fogel [21] of railroads and economic growth in the nineteenth century, which sought to estimate the incremental economic contribution of railroads compared with its precursor system of canals. Fogel concluded that railroads contributed an increment of only 0.4 percent per year of growth in economic output, compared with competing estimates as high as 4 percent per year [20]. Fogel later won a Nobel Prize in Economics for his work.

What is noteworthy about the economic history assessments of infrastructure assessments is that they underscore the profound difficulty of a deep assessment of the impact of major infrastructure system implementations even a century after the fact. Of course, investments at a smaller scale pose less daunting challenges for analysis.

The larger point is that the scale of investment is in many respects inversely proportionate to the difficulty of measuring impacts. Thus, assessing the effects of a Washington Beltway is an order of magnitude more difficult that assessing the impact of adding a single link to an already deployed network.

2.4 Disaggregate Economic and Econometric Methods

2.4.1 Disaggregate Econometric Models

An alternative to using aggregate production functions is to specify econometric models relating levels of highway capital spending to economic indices such as employment, income, or various forms of output. Some of the later production function studies noted that, at smaller geographic scales, the effect of highway capital spending was to redistribute, rather than generate, economic activity [9]. A related finding was that there were spillover effects from the provision of new highway infrastructure [10, 33, 78]. These findings were not necessarily new – previous research had examined spatially-differentiated effects of highway capital spending [68, 69, 67], but they did signal a new direction for econometric research into the economic effects of highway capital.

The contribution of much of the recent research into the relationships between transportation infrastructure provision and economic performance has been to refine methods of analysis. New methodologies aim to correct for potential temporal and/or spatial autocorrelation in data sets [19, 10, 6]. Finally, new conceptualizations of the link between transportation investment and economic performance have been suggested, such as relationships between improved accessibility and employment outcomes [7, 59], firm inventory behavior as a way to measure the returns from highway infrastructure [63], and hybrid economic evaluation approaches that attempt to bridge the project-specific and macroeconomic approaches described herein [76].

It should also be noted that there have been significant advances in methodologies for disaggregate spatial econometric models, including generalized method of moments, maximum likelihood estimation, Prais-Winsten regression, and other techniques for dealing with spatially distributed panel data. These methods are becoming increasingly popular in current empirical research on infrastructure investment.

2.4.2 Hedonic Models for Property Valuation

Hedonic methods to capture the element of property value that is associated with infrastructure accessibility are arguably the most prevalent in the literature. These types of studies have been carried out mostly at local scales and attempt to capture the capitalization of transportation-related benefits (and costs) on nearby properties. The analytical framework that is typically employed is that of least-squares regression, where the value of property can be decomposed into individual attributes of a structure and land value, based on neighborhood attributes that property buyers implicitly value. Recent examples include [8, 66, 34, 70, 28] and [11], which emphasize access to a particular freeway corridor. The application of hedonic modeling has been paralleled by attempts to probe the underlying causal relationship between transportation and land use [44] and specify the relationship within existing models. This line of research has asserted the importance of accessibility as the mechanism linking transportation and land use [48], [49] by lowering the cost of interaction between individuals and various types of opportunities (e.g. work, shopping).

2.4.3 Other Methodologies for Consideration

Of course, not all impacts can be quantified with available data sets. Luskin and Chandrasekaran [45] survey employers near Dallas' new high-five interchange (the largest project of its kind in the State of Texas) reveal a wide variety of fundamental information, including employers' valuations of employee commute time and anticipated, as well as, ultimately, perceived, effects of project construction (on employee and customer access, for example). Handy et al. [30] survey of residents in bypassed Texas towns illuminate a range of meaningful, perceived benefits (including diminished downtown congestion and noise), even in the wake of reduced sales in these same communities [65]. Such details can serve as a priceless supplement to more numeric studies, emphasizing modeled travel time savings, hedonic values, employment levels, and the like.

Chapter 3

Data and Methodology

3.1 Introduction

This section will give an overview of the data sets that will be employed to measure the economic impacts of road network improvements. The analytical framework adopted for this study involves measuring the capitalization of road improvements into local property values. To accomplish this task, we have collected data on road improvements from a set of construction logs maintained by the Minnesota Department of Transportation (Mn/DOT), and three sets of property data which contain information on past property sales. The property data come from county parcel data files, a statewide database of property sales maintained by the Minnesota Department of Revenue, and a database of home sales maintained by the Minnesota Multiple Listing Service (MLS).

3.2 Data

3.2.1 Road Network Improvements

In order to measure the land value response to road network improvements, a set of improved road network links needs to be identified. Within the state of Minnesota, we have identified a set of three counties for which to collect both road network and property sales data. These counties represent a cross-section of the state that includes both metro and outstate counties. Hennepin County is the only county selected from the Twin Cities metropolitan area. The remaining two counties come from southern Minnesota, with one (Olmsted) being primarily urban and faster-growing and one primarily rural and slower-growing (Jackson).

The data on road network improvements are derived from construction logs maintained by Mn/DOT in order to catalog every construction project that takes place on a given segment of road. The logs track construction and maintenance projects going back to the early decades of the 20th century. A multitude of project types are listed in the logs, including projects for the following purposes:

- Addition of acceleration lanes
- Bridge work
- Drainage modifications
- Shoulder improvements
- Interchange construction
- Ramp construction

- Road bed regrading
- Road bed resurfacing (concrete or gravel)
- Roundabout installation
- Signal installation
- Addition of street lighting
- Traffic bypass lane addition
- Turn land additions
- Utility improvements
- Widened lanes, and
- Widened shoulders

The completeness and level of detail of the construction logs are definite strengths, along with the fact that they are available for all Minnesota counties. However, the types of improvements that are of specific interest for this study are projects that provide new capacity or add major new links to the road network. A weakness of the construction log data is that these types of improvements are often not clearly specified, but are rather lumped into one or more of the categories listed above. Thus, some judgement needs to be exercised in order to determine which projects are to be included in the list of improvements for each county. Some clues are provided by log entries, such as roadway width modifications or the addition of new bridges or interchanges. As a measure of redundancy for the metro counties, the lists derived from construction logs were checked against a set of metro area highway improvements for the period from 1980 through 2005. This alternate list was compiled from successive metropolitan Transportation Improvement plans, and was originally used in research by Levinson and Karamalaputi [43].

The construction log data were supplemented by a list of major construction and reconstruction projects maintained by Mn/DOT's Project Management Unit. This data set organizes projects by county and contains information on primary and secondary work types, project cost, and the date the contract for the project was let. Since there did not appear to be any hard-and-fast criteria for classifying projects as major construction or reconstruction, we adopt an informal standard of limiting our study to projects with a total construction cost of more than $10 million.

3.2.2 Property Sales Data

Three types of property sales data have been identified to allow estimation of the value of highway improvements. One of the data sets, from the Minnesota Department of Revenue, contains data for all Minnesota counties, while the other two, the county parcel files and the MLS, are restricted to the metro counties.

Department of Revenue Property Sales

The Minnesota Department of Revenue maintains data on all property transactions within the state. These data are reported by the counties and assembled into a larger, statewide database. These data have been collected for the 16 counties in the current study for the years 2000 through 2007. Attributes of each property listed in the data set include the property sale price, city and county of sale, indicators for the type of water features on each parcel (lakes, rivers, swamps, etc.), tillable acres and an assessment of their value, financing information, and data on enrollment in various conservation programs.

The strength of this data set is that it is statewide in nature, and thus can be used for analysis of outstate counties as well as metro counties. Most counties are large enough that they have hundreds, if not thousands, of records per year. Also, records are provided for a greater time period (seven years) than for the MLS home sales data, enabling more longitudinal analysis. More land attributes are provided in the Department of Revenue data than in the other two property data sets, though not as much information is available about structures built on the land.

A weakness of the data is that it lacks the completeness and detail of the MLS data in describing the features of a property. While not as important for the analysis of rural counties, a detailed account of site and structure features is critical for understanding and estimating urban property values. A related matter is that, unlike the other data sets, the Department of Revenue data is not geographically encoded, and so must be linked to other parcel data files provided by the counties.

Regional Parcel Data

A third source of property data for the metro area is the Regional Parcel Data set maintained by MetroGIS, a consortium of local governments in the Twin Cities region. This data set provides a rudimentary set of property data covering every parcel in each county of the 7-county portion of the Twin Cities. Attributes of this data set include the city and county in which each parcel is located, school district and watershed district membership, year built for structures, estimated market value for land and buildings, tax exempt status and structure type. An additional feature of the data is that it contains the date of the most recent sale of the property, along with the associated sale value. This last feature is rather valuable, in that fairly large samples are available for each year dating back to around 1992.

The major strengths of the regional parcel data are that they are complete, covering every parcel in the metro counties, and that they provide historical sales data over a longer period than either the MLS or the Department of Revenue property data. A weakness is that the data are mostly restricted to parcel features and omit many of the structure characteristics that are provided in the MLS data. Also, the regional parcel data are restricted to the metro counties. It is doubtful that non-metro counties maintain the same level of detail in their parcel files.

Multiple Listing Service (MLS)

The Minnesota Multiple Listing Service maintains a database of all home sales in the Twin Cities region which provides a higher level of detail than is found in the other two property data sets. Since it is a real estate database, it contains data on many features that are of interest to potential homebuyers, such as the number of bedrooms, bathrooms, garage stalls, finished square footage, age and other features such as fireplaces. Structure characteristics are supplemented with land data on parcel acreage, water features such as lake frontage or lake views and location information such as school district identification.

The MLS is the most complete set of data among those described here, and so provides the best basis for estimating models of property values. However, our data set is restricted to the metro counties and thus cannot be applied to analysis of outstate counties. Also, only a limited number of years' worth of data are available, making longitudinal analysis of changes to transportation networks difficult. Thus, it may be important to use the other two sets of property data as checks on estimates derived from the MLS data. Currently, MLS home sales data are available for the years 2001 through 2004, which provide a database of over 130,000 sales transactions in the metro counties. Hennepin County, the largest county in the region, accounts for over 66,000 sales in the region during this period. This data set will be discussed further in the next section.

3.3 Methodology

The method we will use to model home prices and estimate the effects of road network improvements is called *hedonic regression*. Hedonic regression models seek to estimate the price of housing by decomposing it into the bundle of services it provides (attributes), then estimating the implicit values that consumers place on each attribute. This method works best when it is possible to identify a larger number of attributes, as is the case with the MLS data. The base estimating equation is the standard hedonic price function [50]:

$$lnP_{it} = \alpha_t + \delta_t U_i + \boldsymbol{\beta' X_i} + e_{it} \tag{3.1}$$

where lnP_{it} represents the natural logarithm of the price of house i at its sale at time t, α_t is an indicator variable for houses that sold during time period t, U_i is an dummy variable indicating that house i is within a given distance of an upgraded road segment, and e_{it} is a disturbance term for house i at time t. The way we choose to identify the influence of road segments is to construct buffer zones around upgraded segments of roads, then identify houses within these buffer zones with the indicator variable, U_i.

Variations of this model will be estimated in the subsequent section. In cases where a large sample is available, the full model will be estimated with interactions between location and time period of sale. In many of the cases, particularly those where non-residential properties are being analyzed, a more limited, before-and-after approach will be applied to effectively deal with issues of limited sample size. As most of the data sets represent relatively heterogeneous, cross-sectional samples of property sales, we will use OLS with heteroskedastic-consistent standard errors to estimate the models.

Chapter 4

Results

4.1 Introduction

In the previous section, we introduced some of the data sets that will be employed in the analysis of the economic impact of upgrading roads. Also, the methodological approach was introduced. In this section, we apply the approach to residential and commercial property sales in Hennepin, Jackson and Olmsted Counties.

Each of the three counties will be introduced in turn, with analysis presented for residential and non-residential properties. Hennepin County will be covered first, with the analysis of residential property sales followed by the estimation of separate models for commercial, office and industrial properties. The analysis of property sales in Jackson County will combine residential and commercial/industrial property types, due to a limited number of observations. In this case, a before-and-after approach to estimating the impacts of road improvements is employed, with the data set divided into two subgroups, corresponding roughly to periods before and after the completion of major elements of construction on the upgraded highway (MN Highway 60). Lastly, results will be presented for analysis of residential and commercial-industrial properties in Olmsted County. This analysis will correspond to the “ROC 52” project, a major multi-year highway expansion project along an 11-mile stretch of U.S. Highway 52 in Rochester, MN.

4.2 Hennepin County

The first of the three counties to be studied is Hennepin County, the state’s most populous county (estimated at 1.15 million as of 2007), and one of the seven core metropolitan counties under the jurisdiction of the Metropolitan Council. Hennepin County’s large population, well-developed highway network and dynamic growth over the past two decades make it an ideal location to study the effects of highway improvements on local real estate markets.

We will first look at residential property sales, which make use of home sales data from the Minnesota Multiple Listing Service (MLS) for the period from 2001 to 2004. While this is a somewhat limited time period, the richness of the data set allows for a more detailed analysis than is possible with the other data employed here. Then, analysis is conducted on commercial, office and industrial properties using property sales data from the Minnesota Department of Revenue (DoR). These sales records were mapped using parcel-level geographic information system (GIS) data from Hennepin County, then spatially joined to specific land uses using land use data from the Metropolitan Council. Specifically, the sales records that were mapped using GIS were all identified as Commercial-Industrial properties by the Department of Revenue, and then were assigned a specific use (commercial, office, or industrial), based on the land use that the parcel centroid corresponded to in the regional land use data file. Of the 7,388 records initially identified as Commercial-Industrial in the DoR data set, about 4,400 were able to be effectively joined to the county’s parcel data files and mapped. Of these remaining records, just under 2,000 were joined to a commercial, office or industrial land use type. After cleaning these remaining records, there were 1,095 commercial sales records, 244 office property sales and 558 industrial properties. These three data sets are used for analysis of non-residential properties.

The highway improvement projects in Hennepin County correspond roughly to the period from 1997 to 2007, and represent major construction and reconstruction on Interstate Highways 94 and 494, U.S. Highways 12 and 212, and Minnesota Trunk Highways 55, 100 and 610. All of these projects involved construction of a new facility or addition of capacity on an existing highway, and involved total capital outlays of more than $10 million.

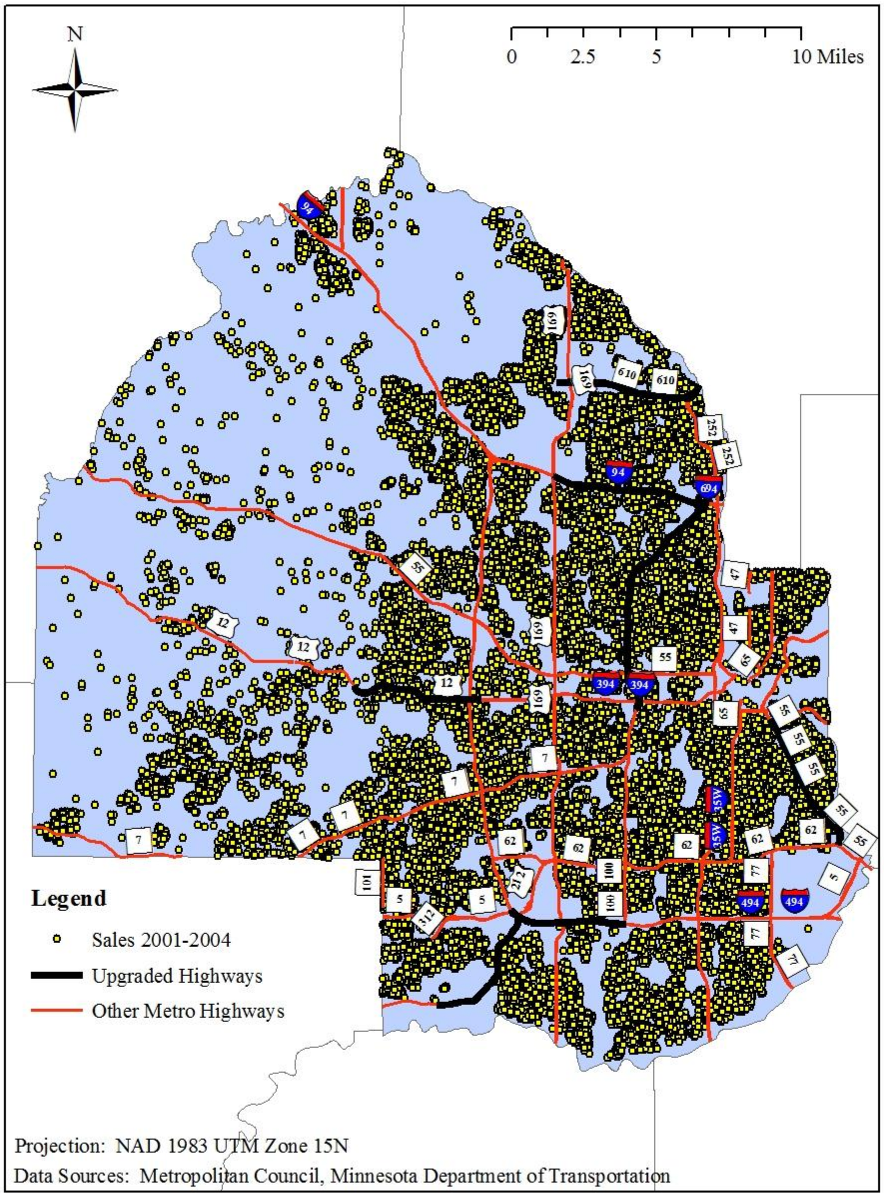
4.2.1 Residential

We analyze the impact of highway improvements on residential properties in Hennepin County by making use of MLS home sales data for the period from 2001 to 2004. This was a particularly vigorous period of sales activity in the Twin Cities real estate market, with median home sale prices in Hennepin County increasing by more than 24 percent (from $177,000 to $220,000) in nominal terms in just three years. The data set includes more than 66,000 sales and contains information about the characteristics of the structure and the land on which the structure sits (e.g. acreage, lake frontage, etc.). The location of each of the sales is plotted in Figure 1.

The characteristics provided by the MLS data were supplemented with variables representing neighborhood characteristics (e.g. income, school quality) and location. The latter included both variables identifying a location near an upgraded highway and variables representing regional accessibility, defined as accessibility to employment and population by auto in the year 2000. The accessibility measure is a *cumulative opportunity* type of measure that calculates the number of jobs and people that can be accessed within 30 minutes via the highway network. Based on research into the effects of accessibility considering competition [32, 72], we would expect that consumers would value increased access to employment, but would receive disutility from greater access to other competing resident workers (here, measured simply as population). Dummy variables are included for both the year and month of sale. The former are used to control for seasonality in home sales and associated price impacts, while the latter are used to identify longer-term, secular trends in prices. The year-specific variables may be seen as tracing out an index of sale prices over time, since they control for most relevant qualitative attributes. Table 1 provides list of variables to be included in the analysis of the MLS home sales data. Descriptive statistics for each of the variables (mean, standard deviation, median, minimum and maximum values) in the MLS home sales data are presented in Table 2.

Multiple variables were defined for the purpose of measuring the impact of highway capacity improvements. At the most basic level, distance bands are defined around upgraded highway segments in quarter-mile intervals, up to a distance of one mile. The choice of one mile as a threshold beyond which highway improvements are assumed to have little measurable effect is somewhat arbitrary, though reviews of previous empirical work on the topic find several examples of this threshold [62], and the results described below suggest it is a reasonably good fit. The effect of distance from an improved highway is assumed to be nonlinear and of indeterminate form, making the approach of using a series of dummy variables all the more appealing. These locational dummies are interacted with the variables representing individual years, allowing for the impact of the highway improvement (and perhaps also disruption during major construction periods) to vary over time. Another type of location variable was also defined for the Hennepin County example. This variable interacts the sale year dummy with a measurement of the distance from the home to the nearest highway access point (in meters). This distance is also limited to a one-mile (1.6km) radius. The use of this term is designed to represent the possibility that two separate effects of proximity to an improved freeway might be present. First, the location dummy represents linear distance to the facility itself, and may uncover externalities associated with locating near a freeway (e.g. noise, air pollution), which are anticipated to have

Figure 4.1: Location of MLS home sales in Hennepin County, 2001-2004



negative effects [37, 17, 38]. Secondly, proximity to a highway access point may yield additional accessibility benefits, which may to some degree offset the effect of proximity to the facility itself. It is hoped that the introduction of this variable will help to isolate separate proximity effects in certain cases, such as when a home is located near a highway, but does not enjoy the benefit of a convenient, nearby access point.

Output from the estimation of the hedonic price model for home sales in Hennepin County are provided in Table 3. The table lists estimates for the various model parameters, their associated standard errors, t-values and levels of statistical significance. Overall, the model provides a good fit to the home sales data. The large sample ensures that most of the variables are statistically significant, in many cases strongly so. Results indicate that, at the sample mean, an additional bathroom adds about 7.5 percent to the price of a home. An additional fireplace adds 6 percent, while each additional garage stall adds roughly 5.5 percent. The effect of age is nonlinear, as expected, and is captured by adding a squared term to the age variable. We can interpret the coefficients as meaning that for each one year increase in the age of a house, there is a 0.6 percent decline in price, and for each 100 unit increase in the *squared* age of a house, there is a 0.5 percent *increase*. This explains the observation that newer houses tend to be more valuable, as are very old houses which tend to be of higher quality, attract more investment in preservation and rehabilitation, and are less likely to be torn down and replaced.

Variables relating to land are also shown to be highly significant. We estimate that each additional acre of land adds around 3.1 percent to the sale price of a home [1]. Also, homes located on or near water features command a premium. We identify separate effects for lakefront homes, homes with a lake view, riverfront homes, homes with a river view, and homes with a pond or creek on their property. Lakefront homes have the largest effect, on average adding 49 percent to the sale price of a home [2]. Homes with a lake view (but no frontage) sell for about 15 percent more than those with no water feature nearby. Likewise, riverfront homes command a premium of about 28.9 percent, while homes with a river view sell for prices about 24.2 percent higher than comparable homes with no water features. Creeks and ponds also have positive and statistically significant impacts on the sale price of a home, though the effects are demonstrably smaller.

Neighborhood variables also add some explanatory power to the model. Of particular importance are measures of local school quality. We measure this by adding two variables related to school performance at the school district level. The first, average school scores on comprehensive tests, shows a strong, positive effect. The test score, measured as mean 5th grade student comprehensive scores on the Minnesota Comprehensive Assessment, has a large coefficient. A one percent increase in test scores in a given school district is associated with a 1.25 percent increase in home sales price. The second education variable, school graduation rate, has a negative sign and small magnitude, likely indicating that there is little residual effect of graduation rates after controlling for other measures of school quality. The percent of population in a Census tract that is non-white is associated with lower home sales prices, and the median household income in the tract in which a home is sold appears to have no significant effect on its sale price.

Of greatest interest are the effects of the transportation-related variables in the model. Employment accessibility appears to be highly valued by households, as the variable representing year 2000 employment within a 30-minute drive of a household's home is significantly positive. A ten percent increase in this measure raises the sale price of a home by about 2.3 percent. Conversely, population access within the same travel shed, the measure of competing resident workers, is shown to be negatively associated with home sale price. The coefficient on this variable indicates that a ten percent increase in competing resident workers is associated with a roughly one percent decline in sale price.

The variables representing time-varying effects of proximity to an upgraded highway show mixed re-

[1] We ignore qualitative differences in types of land. While the MLS data set contains separate variables for wooded and tillable acres, these variables are rarely observed. Presumably, little information would be added by incorporating them separately, as opposed to a single acreage variable

[2] The actual effect is likely larger. Halvorsen and Palmquist [29] show that a better approximation to the marginal effect of a dummy variable in a semilogarithmic equation is given by $e^{\beta} - 1$, implying a premium of closer to 63 percent for lakefront homes

Table 4.1: List of variables included in Hennepin County models

Variable Name	Description
ln SalePrice	Natural logarithm of sale price
Bedrooms	Number of bedrooms
Bathrooms	Number of bathrooms
Age	Age of housing unit or other structure
AgeSq	Age of structure squared
ln FinishedSq	Natural logarithm of finished square feet
Fireplace	Number of fireplaces
GarageStall	Number of garage stalls
Acres	Acres of land
Creek	Dummy variable representing creek frontage
Lakefront	Dummy variable representing lakefront property
LakeView	Dummy variable representing lake view
Riverfront	Dummy variable representing river frontage
RiverView	Dummy variable representing river view
Pond	Dummy variable representing pond on property
ln IHMed	Natural logarithm of Census tract-level median household income
NonWhite	Percent of population non-White (measured at Census tract level)
ln MCA5Comp	Natural logarithm of school district mean comprehensive score among 5th grade students on Minnesota Comprehensive Assessment (MCA) tests
Graduation	School district graduation rate (percent)
ln EmpAcc30	Natural logarithm of jobs accessible within 30 minutes
ln PopAcc30	Natural logarithm of population accessible within 30 minutes
2002	Dummy variable representing sale in year 2002
2003	Dummy variable representing sale in year 2003
2004	Dummy variable representing sale in year 2004
Feb	Dummy variable representing sale in month of February
March	Dummy variable representing sale in month of March
April	Dummy variable representing sale in month of April
May	Dummy variable representing sale in month of May
June	Dummy variable representing sale in month of June
July	Dummy variable representing sale in month of July
August	Dummy variable representing sale in month of August
September	Dummy variable representing sale in month of September
October	Dummy variable representing sale in month of October
November	Dummy variable representing sale in month of November
December	Dummy variable representing sale in month of December
1/4Mile	Dummy variable for location within 1/4 mile of upgraded highway
1/2Mile	Dummy variable for location within 1/2 mile of upgraded highway
3/4Mile	Dummy variable for location within 3/4 mile of upgraded highway
Mile	Dummy variable for location within 1 mile of upgraded highway
1/4Mile02	1/4Mile dummy * 2002 dummy
1/4Mile03	1/4Mile dummy * 2003 dummy
1/4Mile04	1/4Mile dummy * 2004 dummy
1/2Mile02	1/2Mile dummy * 2002 dummy
1/2Mile03	1/2Mile dummy * 2003 dummy
1/2Mile04	1/2Mile dummy * 2004 dummy
3/4Mile02	3/4Mile dummy * 2002 dummy
3/4Mile03	3/4Mile dummy * 2003 dummy
3/4Mile04	3/4Mile dummy * 2004 dummy
Mile02	Mile dummy * 2002 dummy
Mile03	Mile dummy * 2003 dummy
Mile04	Mile dummy * 2004 dummy
AccDist02	Distance to nearest freeway entrance ramp on upgraded highway link * 2002 dummy
AccDist03	Distance to nearest freeway entrance ramp on upgraded highway link * 2003 dummy
AccDist04	Distance to nearest freeway entrance ramp on upgraded highway link * 2004 dummy

Table 4.2: Descriptive statistics for Hennepin County residential sales data

Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	12.309	0.487	12.223	9.568	15.538
Bedrooms	3.038	0.943	3	0	10
Bathrooms	2.106	0.943	2	0	11
Age	46.484	28.671	45	4	158
AgeSq	2,981	3,130	2,025	16	24,964
ln FinishedSq	7.438	0.430	7.433	5.298	9.999
Fireplace	0.593	0.790	0	0	6
GarageStall	1.759	0.831	2	0	12
Acres	0.124	1.055	0	0	110
Creek	0.011	0.105	0	0	1
Lakefront	0.018	0.133	0	0	1
LakeView	0.018	0.134	0	0	1
Riverfront	0.002	0.043	0	0	1
RiverView	0.003	0.053	0	0	1
Pond	0.037	0.189	0	0	1
ln IHMed	10.838	1.671	10.977	-9.210	12.125
NonWhite	11.346	15.989	6.600	0	91.700
ln MCA5Comp	8.450	0.068	8.457	8.360	8.565
Graduation	76.343	20.189	88.000	46.000	99.000
ln EmpAcc30	13.847	0.388	14.007	10.794	14.159
ln PopAcc30	14.244	0.366	14.372	12.337	14.630
2002	0.231	0.422	0	0	1
2003	0.251	0.433	0	0	1
2004	0.295	0.456	0	0	1
Feb	0.051	0.219	0	0	1
March	0.068	0.252	0	0	1
April	0.081	0.272	0	0	1
May	0.095	0.293	0	0	1
June	0.112	0.315	0	0	1
July	0.107	0.309	0	0	1
August	0.113	0.316	0	0	1
September	0.090	0.286	0	0	1
October	0.089	0.285	0	0	1
November	0.075	0.264	0	0	1
December	0.069	0.254	0	0	1
1/4Mile	0.036	0.188	0	0	1
1/2Mile	0.057	0.231	0	0	1
3/4Mile	0.062	0.241	0	0	1
Mile	0.056	0.230	0	0	1
1/4Mile02	0.009	0.092	0	0	1
1/4Mile03	0.009	0.095	0	0	1
1/4Mile04	0.010	0.099	0	0	1
1/2Mile02	0.014	0.116	0	0	1
1/2Mile03	0.015	0.120	0	0	1
1/2Mile04	0.015	0.123	0	0	1
3/4Mile02	0.013	0.115	0	0	1
3/4Mile03	0.016	0.127	0	0	1
3/4Mile04	0.019	0.135	0	0	1
Mile02	0.013	0.113	0	0	1
Mile03	0.014	0.118	0	0	1
Mile04	0.017	0.129	0	0	1
AccDist02	44.729	218.477	0	0	1609.191
AccDist03	48.567	227.393	0	0	1609.227
AccDist04	56.891	245.861	0	0	1608.767
N = 66,420					

Table 4.3: Hedonic price model for home sales in Hennepin County, 2001-2004

Variable	Coefficient	S.E.	t-value	Sig.
Bedrooms	-0.016	0.002	-9.46	***
Bathrooms	0.075	0.002	37.23	***
Age	-0.006	0.0002	-37.54	***
AgeSq	5.64E-05	1.47E-06	38.27	***
ln FinishedSq	0.632	0.006	105.27	***
Fireplace	0.064	0.002	38.83	***
GarageStall	0.055	0.002	35.61	***
Acres	0.031	0.004	7.02	***
Creek	0.078	0.010	7.46	***
Lakefront	0.489	0.012	40.40	***
LakeView	0.138	0.008	16.66	***
Riverfront	0.254	0.029	8.75	***
RiverView	0.217	0.024	9.10	***
Pond	0.021	0.005	4.49	***
ln IHMed	-0.0007	0.0007	-0.98	
NonWhite	-0.007	8.70E-05	-83.18	***
ln MCA5Comp	1.246	0.033	37.99	***
Graduation	-0.006	0.0001	-49.66	***
ln EmpAcc30	0.230	0.013	17.20	***
ln PopAcc30	-0.099	0.015	-6.40	***
2002	0.129	0.003	46.51	***
2003	0.154	0.003	60.01	***
2004	0.110	0.003	38.65	***
1/4Mile02	-0.051	0.009	-5.94	***
1/4Mile03	-0.024	0.008	-3.00	***
1/4Mile04	-0.061	0.008	-7.62	***
1/2Mile02	-0.015	0.008	-2.02	**
1/2Mile03	0.005	0.007	0.81	
1/2Mile04	-0.064	0.007	-9.29	***
3/4Mile02	-0.021	0.007	-2.91	***
3/4Mile03	-0.001	0.007	-0.23	
3/4Mile04	-0.043	0.006	-6.77	***
Mile02	-0.005	0.008	-0.62	
Mile03	0.028	0.007	3.99	***
Mile04	-0.015	0.007	-2.11	**
AccDist02	-3.17E-05	4.34E-06	-7.30	***
AccDist03	-4.61E-05	4.02E-06	-11.47	***
AccDist04	-3.20E-05	3.69E-06	-8.67	***
Constant	-4.462	0.292	-15.29	***
N = 66,420				
Adjusted R^2 = 0.784				

Notes:
Dependent variable is the natural logarithm of SALEPRICE
* = variable is statistically significant at $p < 0.1$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

sults. Most are statistically significant and negative in sign. Regardless of year, properties closest to the upgraded highway show a negative effect which appears to taper off with distance, tracing out the gradient for proximity to the highway itself. Values for all of the coefficients are larger in 2003 than in 2002, but also are more negative in 2004.

The second set of variables relating to location near an upgraded highway, measuring the interaction of time and distance from the nearest access point, also show mixed results. The coefficient for the variable representing distance from the nearest access point is negative and statistically significant in each case, as expected, indicating a benefit to having good access to an upgraded highway. The coefficient for distance from the nearest access point in 2002 is (-0.0000317), with the interpretation that a 100 meter increase in distance from the nearest access point on an upgraded highway link is associated with a decline of 0.3 percent in home sale price, up to a distance of one mile. However, there is no discernable trend in the value of this coefficient over the three years for which this effect is measured (relative to 2001). Most likely, this rather short period during which the data are available are not sufficient to capture the locational adjustments in local real estate markets that might be expected to occur in response to a highway improvement, to the extent that they exist.

the marginal effect of the road upgrade on nearby property values in this particular model specification is the sum of the coefficients for the two highway proximity variables described above.

Lastly, the estimated coefficients for the years 2002, 2003 and 2004 dummies have values of 0.142, 0.164 and .115, respectively, indicating that all else equal, houses sold for about 13, 15 and 11 percent more in these years than in 2001. These large increases are fairly consistent with the run-up in prices experienced during the early part of this decade, though the slightly smaller coefficient for 2004 than for the previous two years is a bit puzzling. Note also that parameters were estimated for month-specific dummy variables, with January assigned as the omitted category. These coefficients were suppressed from Table 3 for the sake of brevity, though all of the variables, except the one representing sales in the month of February, were significant at the $p < 0.01$ level. The impact of the month-specific variables was uniformly positive and in the range of 3 to 9 percent (relative to January sales), with the highest values being recorded during the summer months (June through September).

4.2.2 Commercial

The process of matching the plotted commercial-industrial property sales to a specific land use, in this case commercial, yielded a set of 1,095 property sales records that could be further analyzed. Due to the limited number of observations available on properties near the major construction projects identified in the previous section, a simpler model structure was adopted for the commercial property analysis. A before-and-after method, where the data set is split into two smaller sub-groups and used to estimate the same model, is applied. We divide the data into two groups of equal length, with Group 1 representing sales from October 1999 through September 2003, and Group 2 covering sales between October 2003 and September 2007. As in the analysis of residential properties, we define variables for quarter-mile distance bands around the improved sections of highway. If there is a particular benefit to being located within one (or more) of these bands, we should expect to see the coefficient values associated with these variables take on larger values for the second group of data, indicating the emergence of a location premium.

Our models take on a semilogarithmic (semilog) form, where the dependent variable, the natural logarithm of sale price, is expressed as a linear combination of the independent variables. We hypothesize that the price of a commercial property is primarily a function of building characteristics, a set of location variables that describe regional and local access, and a limited set of macroeconomic influences, such as regional income and interest rates. Several of these variables were introduced in the analysis of residential properties. Others that were not include:

- *RegInc*, regional per capita income for the Twin Cities metropolitan region. We hypothesize that rising incomes will increase consumption and the demand for space (e.g. for retail outlets).

- *FedRate*, an index of the federal funds rate compiled for each month during the study period. Closely linked to other key interest rates, we hypothesize that lower interest rates will be associated with increased demand for physical capital, and thus with increases in commercial property prices.
- *PopAccess*, a measure of regional access to population. Firms in locations with high regional accessibility will be expected to have greater access to labor markets and to potential customers, which should be capitalized into the property's value. The accessibility measure that is used is a cumulative opportunity-type measure which calculates the size of the population that can be access by car within a 30-minute travel shed.
- *EmpAccess*, a measure of regional employment access. In the current context, it is a measure of the degree to which commercial firms value locating near other centers of employment.
- *Hwy1000*, a measure of distance to the nearest highway, expressed in increments of 1000 feet (304 m). Property values are anticipated to decline with distance from the nearest highway.
- *HwySq*, a squared term for the *Hwy1000* variable.
- *LandOnly*, a dummy variable identifying raw land sales. Unimproved land parcels are expected to have lower values than those that have previously been developed.

Table 4 provides a statistical summary of the two groups of commercial property sales data. Figure 2 maps the location of all of the sales in Hennepin County during the study period.

Table 4.4: Descriptive statistics for Hennepin County commercial property sales data

Group 1					
Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	12.901	1.229	12.816	8.006	17.862
RegInc	36,428	1,460	36,830	33,046	37,834
FedRate	3.379	2.090	2.090	1.010	6.540
PopAccess	1,827,375	422,107	1,960,906	228,089	2,255,461
EmpAccess	1,212,427	254,506	1,320,058	130,121	1,406,077
Age	51.087	30.562	48	0	124
AgeSq	3,542	3,497	2,304	0	15,376
Hwy1000	3.052	3.511	2.096	0.069	21.800
HwySq	21.624	61.114	4.395	0.005	475.249
Acres	0.740	1.583	0.302	0.018	18.175
LandOnly	0.087	0.281	0	0	1
1/4Mile	0.081	0.274	0	0	1
1/2Mile	0.076	0.266	0	0	1
3/4Mile	0.046	0.209	0	0	1
1Mile	0.051	0.220	0	0	1
N = 589					

Group 2					
Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	13.473	1.203	13.384	9.210	18.040
RegInc	40,836	1,995	40,998	37,834	44,237
FedRate	3.145	1.645	3.040	0.980	5.260
PopAccess	1,809,326	404,117	1,898,779	415,890	2,255,461
EmpAccess	1,207,389	248,833	1,294,233	248,218	1,406,077
Age	48.611	28.074	48	0	128
AgeSq	3,150	3,249	2,304	0	16,384
Hwy1000	2.870	3.094	1.974	0.080	22.714
HwySq	17.791	50.894	3.898	0.006	515.940
Acres	0.809	1.514	0.334	0.022	14.506
LandOnly	0.115	0.319	0	0	1
1/4mile	0.071	0.257	0	0	1
1/2mile	0.071	0.257	0	0	1
3/4mile	0.038	0.190	0	0	1
1mile	0.051	0.221	0	0	1
N = 506					

Table 5 presents the commercial property models fitted to the two groups of sales data. Two models are fitted to each group of data, with the second model in each group containing the additional squared term for distance from the nearest highway. Taking a look at the first model in the Group 1 data, we see that most of the estimated coefficients have the expected sign and general magnitude. The population access variable has the expected positive sign and is statistically significant. The estimated coefficient can be interpreted as indicating that for every additional 100,000 people within a 30-minute travel time (roughly a 5 percent increase from the mean), the value of a property increases by about 16 percent. The coefficient on the employment access variable is also significant and about twice as large as the population access variable, indicating that commercial firms seek to cluster near other centers of employment. This should be especially true for retail and office activities. The variable measuring distance from the nearest highway in Model 1 also has the expected negative sign. We interpret from this model that for each additional 1,000 feet (304 m) from the nearest highway, a parcel declines in value by about 3.3 percent. In Model 2, the squared term is added to the distance variable, though it is not significant. It also appears to weaken the significance of the linear distance variable, indicating that it adds little to the model and can be safely omitted in favor of the simpler specification.

Beyond the benefit conferred by general highway proximity however, there does not appear to have been any additional premium associated with location near one of the upgraded highway links. The variables indicating proximity to the upgraded highway links all have negative signs and fairly large magnitudes. Lastly, the coefficient on the acreage variable is just over 0.35, indicating that each additional acre of land adds about 35 percent to the value of a property. This coefficient is fairly large relative to those estimated for residential properties in urban and rural areas, as well for commercial properties in Olmsted County (detailed in a later section), indicating the higher values for commercial land generally, as well the effect of city size.

The results from the model fitted to the second group of data show largely the same result. One exception is that the value associated with regional accessibility to population is slightly lower, as the coefficient for the *PopAccess* variable indicates, and the employment access variable becomes insignificant. Also, the effect of highway proximity seems to be slightly larger. The coefficient on the *Hwy1000* variable indicates that the same increment of distance from the nearest highway (1,000 feet or 304 meters) was associated with a decline of more than 3 percent in the value of a property during the period from 2003 to 2007. Interestingly, in Model 2 the squared distance term becomes significant and the linear distance term increases significantly, to a value of -0.117. This result contrasts with the model estimated from the Group 1 data and suggests a greater premium for location near the highway network.

Again, there does not appear to be any special benefit conferred on properties near the upgraded highways. The coefficients for the distance band variables are again all negative and have nearly the same magnitudes, with the exception of the variable representing the 1/2 to 3/4 mile (0.8 to 1.2 km) distance band, which shows an inexplicably large negative effect. Lastly, the value of an additional acre of land is estimated to be higher for the second group of data, adding about 40 percent, on average, to the value of a property.

The evidence gathered from the two models offers some insight to the value of location for commercial property owners in a large urban area. Access matters, both at the regional level (as indicated by the access to population and employment variables) and at the local level (as the highway proximity variable indicates). Our evidence on location near the set of upgraded highways does not indicate the presence of any additional land value benefit owing to this location. In fact, our evidence suggests the opposite, though this finding is difficult to explain. These findings should be accepted tentatively, as the methods they use are rather coarse. The process of deriving a set of commercial property data by matching the DoR records to land use classifications is limited in that retail properties cannot be distinguished from other types of commercial properties that may have different location and transportation requirements. Also, we have not been able to obtain a commercial property data set that will allow us to control for the square footage of buildings on a given property, a particular problem for properties in densely-developed areas.

Figure 4.2: Location of commercial property sales in Hennepin County, 1999-2007

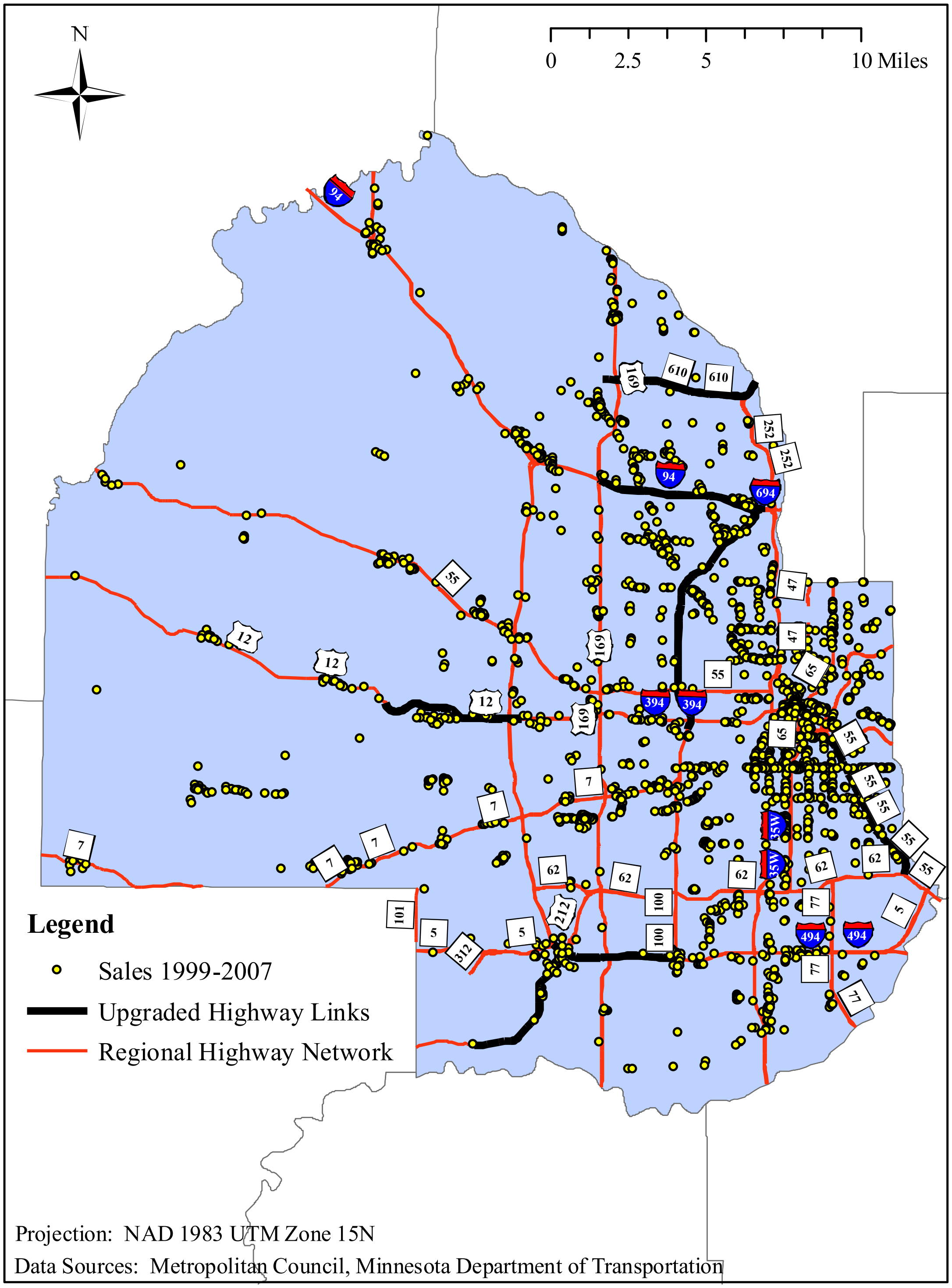


Table 4.5: Hedonic price models for commercial property sales in Hennepin County, 1999-2007

Group 1								
	Model 1				Model 2			
Variable	Coefficient	S.E.	t-value	Sig.	Coefficient	S.E.	t-value	Sig.
RegInc	-4.55E-05	5.62E-05	-0.81		-4.80E-05	5.62E-05	-0.85	
FedRate	-0.101	0.040	-2.53	**	-0.101	0.040	-2.54	**
PopAccess	1.66E-06	6.38E-07	2.60	***	1.51E-06	6.30E-07	2.40	**
EmpAccess	3.49E-06	8.53E-07	4.90	***	3.38E-06	7.17E-07	4.71	***
Age	-0.037	0.007	-5.53	***	-0.037	0.007	-5.47	***
AgeSq	0.00025	0.00005	4.63	***	0.00025	0.00005	4.62	***
Hwy1000	-0.025	0.012	-1.96	**	-0.044	0.030	-1.48	
HwySq					0.0013	0.0014	0.91	
Acres	0.357	0.071	5.03	***	0.357	0.071	5.04	***
LandOnly	-1.497	0.258	-5.81	***	-1.494	0.258	-5.79	***
1/4mile	-0.251	0.134	-1.88	*	-0.274	0.136	-2.01	**
1/2mile	-0.402	0.149	-2.70	***	-0.409	0.149	-2.75	***
3/4mile	-0.354	0.211	-1.68	*	-0.353	0.210	-1.68	*
1mile	-0.237	0.186	-1.27		-0.239	0.185	-1.29	
Constant	19.236	2.998	6.42	***				
N = 589								
Adjusted R^2	0.338				0.339			

Group 2								
	Model 1				Model 2			
Variable	Coefficient	S.E.	t-value	Sig.	Coefficient	S.E.	t-value	Sig.
RegInc	0.00014	0.00006	2.26	**	0.00014	0.00006	2.27	**
FedRate	-0.074	0.075	-0.98		-0.70	0.075	-0.93	
PopAccess	1.40E-06	6.88E-07	2.03	**	1.73E-06	6.96E-07	2.48	**
EmpAccess	-4.74E-09	6.49E-07	-0.01		-1.79E-07	6.47E-07	-0.28	
Age	-0.014	0.007	-2.10	**	-0.013	0.007	-1.90	*
AgeSq	0.00008	0.00005	1.53		0.00007	0.00005	1.32	
Hwy1000	-0.031	0.013	-2.47	**	-0.117	0.033	-3.48	***
HwySq					0.006	0.002	2.86	***
Acres	0.417	0.057	7.37	***	0.414	0.056	7.39	***
LandOnly	-0.647	0.209	-3.10	***	-0.655	0.205	-3.20	***
1/4mile	-0.269	0.179	-1.50		-0.355	0.183	-1.94	*
1/2mile	-0.443	0.153	-2.90	***	-0.460	0.151	-3.04	***
3/4mile	-0.719	0.275	-2.61	***	-0.685	0.276	-2.48	**
1mile	-0.200	0.258	-0.77		-0.211	0.253	-0.83	
Constant	7.498	2.406	3.12	***	7.508	2.394	3.14	***
N = 506								
Adjusted R^2	0.359				0.370			

Notes:
Dependent variable is the natural logarithm of sale price
* = variable is statistically significant at $p < 0.10$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

4.2.3 Office

A data set containing sales of office properties as a subset of all commercial-industrial properties in the DoR data set was generated using the method described in the introduction to the analysis of Hennepin County projects. Sales observations classified as office properties are those from the DoR data set originally classified as commercial-industrial and matched by location with the "office" land use classification in the regional parcel-level land use data set administered by the Metropolitan Council. According to this definition of office land use, the office category contains land (and associated buildings) that is used "predominantly for administrative, professional, or clerical services". Of note, this definition excludes hospitals and government office buildings, but may include government offices that are housed on a privately-owned parcel (leased office space). In additional to parcels classified strictly as office space, the data set also contains properties matched to "mixed-use commercial" and "mixed-use residential" land uses. The resulting data set contains 244 sales observations, which are split nearly evenly among the two four-year periods that comprise the data set, October 1999 through September 2003 and October 2003 through September 2007. Table 6 provides a descriptive summary of the variables in the data set, while Figure 3 displays the location of the office property sales in Hennepin County.

The model specification we adopt for the office property sales data is identical to the one chosen for the commercial property sales, with the exception that we add a higher-order term for the effect of distance to the nearest highway (*HwySq*) in order to test a more flexible form for the effect of proximity to the highway network. The model is estimated twice for each of the two groups of data, with one model including the squared distance term and the other omitting it. We also test for a more simple specification of the effect of building age by estimating one of the models with only a linear term for the effect of age, and the other with the squared term added.

The results of the models fitted to the commercial property sales data are provided in Table 7. Most of the variables in the models have the correct sign, but do not appear as statistically significant. With respect to the transportation and location variables in the model, access to population appears to be the most imporant determinant of office property values. It is statistically significant in each of the models, though the coefficient value is larger in the models fitted to the group 2 data. This is to be expected, as many office functions, especially in certain industries (e.g. finance, legal, insurance, real estate), tend to gravitate toward high-accessibility locations within the region (central business districts, "edge" cities, or the intersections of major regional highways). One might also expect office activities to be near other concentrations of employment, as many of the industries just described require high levels of face-to-face contact and interaction with customers or suppliers. However, the evidence for this is mixed, as the employment access variable is positively correlated with sale price in the Group 1 data, but negatively correlated in the model based on the Group 2 data. The variable representing distance to the nearest highway has the correct sign in each of the models, but is only significant in the second model fitted to the Group 2 data. In this case, the coefficient on the distance variable is much larger, implying a steeper distance gradient in terms of highway proximity. On one hand, this might be an indication that a linear specification for distance to the nearest highway is incorrect, at least for this type of property. However, this finding must be tempered by the fact that the same specification leads to statistically insignificant results when applied to the Group 1 data.

The variables designating location relative to the improved highway links in quarter-mile distance bands show inconclusive results. The estimated coefficients have mixed signs which do not appear to show a pattern with respect to distance. Also, none of the variables show up as statistically significant in any of the models. In most cases, the associated t-statistics for these variables have an absolute value of less than one, indicating that we little evidence to reject the hypothesis that the coefficients of each of these variables is zero. These findings might in part be attributed to small sample size for the office property sales data. Another important consideration is that the different office properties that comprise the data set are a mix of properties that are single-use office properties and mixed-use properties with residential and office uses

Figure 4.3: Location of office property sales in Hennepin County, 1999-2007

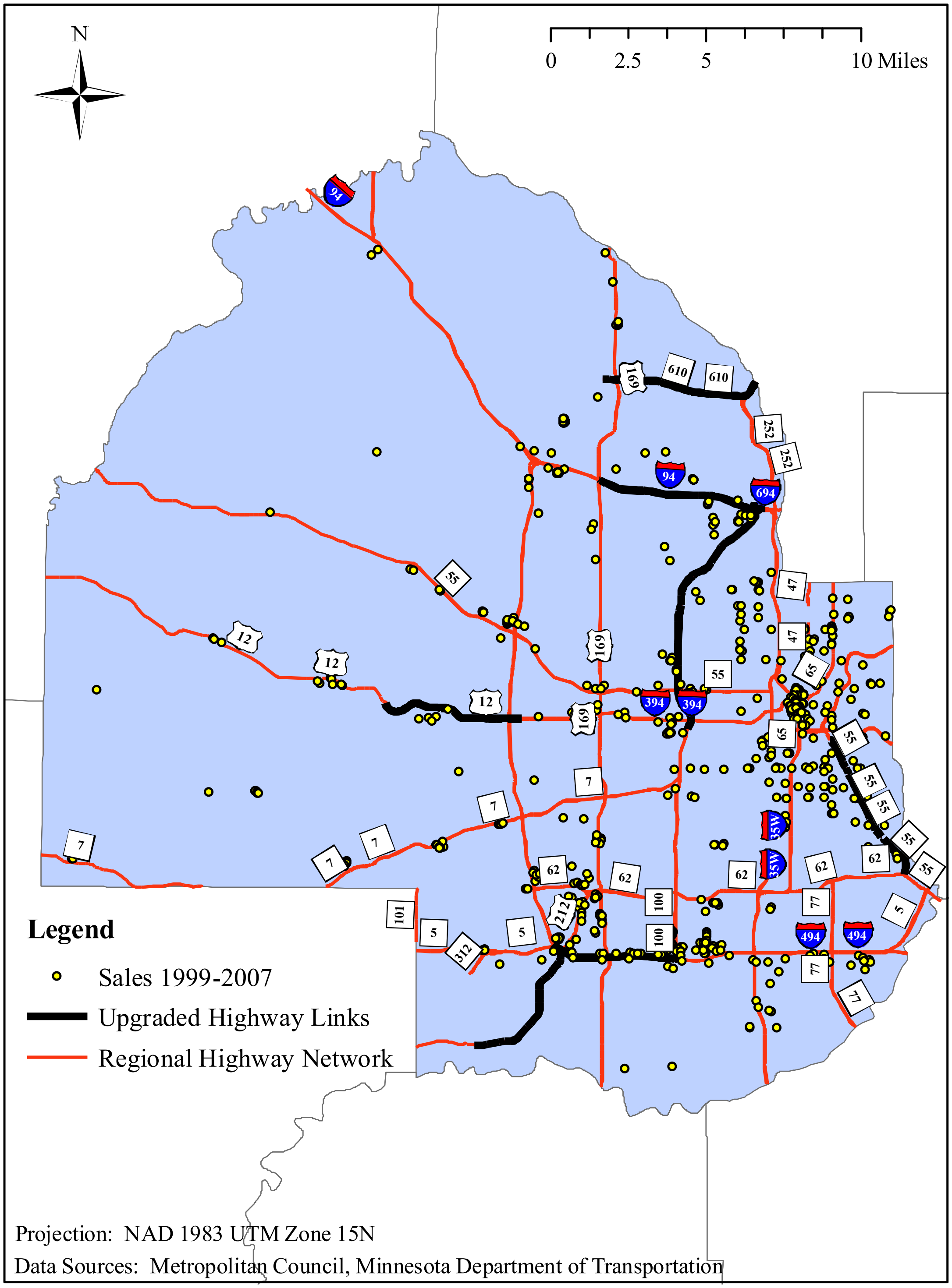


Table 4.6: Descriptive statistics for Hennepin County office property sales data

Group 1					
Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	13.409	1.483	12.921	10.488	18.956
RegInc	36,617	1,452	37,359	33,046	37,834
FedRate	3.292	1.491	3.500	1.000	5.260
PopAccess	460,765	145,019	455,592	149,894	728,532
EmpAccess	370,815	151,224	364,911	61,027	606,158
Age	42.317	36.904	27	0	120
AgeSq	3,142	4,238	729	0	14,400
Hwy1000	1.914	1.889	1.277	0.180	10.675
HwySq	7.201	15.393	1.631	0.032	113.965
Acres	1.146	2.517	0.194	0.032	21.693
LandOnly	0.089	0.287	0	0	1
1/4Mile	0.073	0.261	0	0	1
1/2Mile	0.073	0.261	0	0	1
3/4Mile	0.073	0.261	0	0	1
1Mile	0.081	0.274	0	0	1
N = 123					

Group 2					
Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	13.648	1.692	13.136	8.517	19.252
RegInc	41,050	1,768	40,998	38,819	44,237
FedRate	3.292	1.491	3.500	1.000	5.260
PopAccess	429,922	162,294	439,717	39,198	731,499
EmpAccess	332,755	174,317	350,663	11,058	616,427
Age	38.388	34.166	29	0	108
AgeSq	2,631	3,641	841	0	11,664
Hwy1000	3.910	3.365	2.854	0.174	18.263
HwySq	26.518	45.449	8.143	0.030	333.524
Acres	0.835	1.665	0.143	0.031	9.104
LandOnly	0.099	0.300	0	0	1
1/4mile	0.066	0.250	0	0	1
1/2mile	0.091	0.289	0	0	1
3/4mile	0.033	0.180	0	0	1
1mile	0.066	0.250	0	0	1
N = 121					

Table 4.7: Hedonic price models for office property sales in Hennepin County, 1999-2007

Group 1								
	Model 1				Model 2			
Variable	Coefficient	S.E.	t-value	Sig.	Coefficient	S.E.	t-value	Sig.
RegInc	0.00014	0.00020	0.71		0.00014	0.00020	0.71	
FedRate	0.069	0.110	0.62		0.069	0.114	0.61	
PopAccess	4.80E-06	2.27e-06	2.12	**	4.93e-06	2.24e-06	2.20	**
EmpAccess	6.58E-07	2.48e-06	0.27		6.10e-07	2.41e-06	0.25	
Age	-0.020	0.021	-0.95		-0.022	0.006	-3.63	***
AgeSq	-0.00002	0.00014	-0.17					
Hwy1000	-0.003	0.065	-0.05		-0.056	0.286	-0.20	
HwySq					0.007	0.043	0.16	
Acres	0.280	0.152	1.84	*	0.282	0.151	1.87	*
LandOnly	-1.005	0.542	-1.85	*	-1.048	0.510	-2.06	**
1/4mile	0.144	0.433	0.33		0.133	0.447	0.30	
1/2mile	-0.261	0.296	-0.88		-0.252	0.302	-0.83	
3/4mile	-0.614	0.580	-1.06		-0.622	0.586	-1.06	
1mile	0.119	0.288	0.41		0.103	0.286	0.36	
Constant	6.388	7.626	0.84		6.416	7.646	0.84	
N = 123								
Adjusted R^2	0.567				0.568			

Group 2								
	Model 1				Model 2			
Variable	Coefficient	S.E.	t-value	Sig.	Coefficient	S.E.	t-value	Sig.
RegInc	-0.00022	0.00021	-1.01		-0.00025	0.00021	-1.18	
FedRate	0.310	0.246	1.26		0.322	0.244	1.32	
PopAccess	1.20E-05	4.02e-06	2.99	***	1.42e-05	4.35e-06	3.25	***
EmpAccess	-8.62E-06	4.12e-06	-2.09	**	-1.08e-05	4.47e-06	-2.42	**
Age	-0.007	0.006	-1.10		-0.005	0.006	-0.88	
AgeSq								
Hwy1000	-0.0004	0.065	-0.01		-0.213	0.110	-1.93	*
HwySq					0.016	0.010	1.66	*
Acres	0.580	0.110	5.25	***	0.549	0.104	5.26	***
LandOnly	-1.174	0.560	-2.10	**	-1.148	0.560	-2.05	**
1/4mile	0.177	0.499	0.35		0.010	0.511	0.02	
1/2mile	-0.074	0.474	-0.16		-0.208	0.501	-0.41	
3/4mile	-0.894	0.605	-1.48		-0.933	0.596	-1.57	
1mile	0.028	0.324	0.09		-0.117	0.342	-0.34	
Constant	19.079	7.710	2.47	**	20.718	7.724	2.68	***
N = 121								
Adjusted R^2	0.539				0.566			

Notes:
Dependent variable is the natural logarithm of sale price
* = variable is statistically significant at $p < 0.10$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

housed in the same building. These are likely to represent different classes of office space for which the tenants may have different needs regarding transportation and location, and hence for which they may have differing willingness to pay.

4.2.4 Industrial

The third type of non-residential property to be analyzed using the DoR data for Hennepin County is industrial property. In striving for uniformity among the analyses of non-residential properties, we adopt the same classification technique for the property sales observations and a similar model structure to those used in the analysis of commercial and office properties. Industrial properties were identified as being matched with the land use classifications for "industrial and utility" and "mixed-use industrial" uses. The former classifies industrial uses rather broadly and includes land used for activities such as manufacturing, transportation, construction, communications, utilities or wholesale trade. Certain specialized uses are included, such as warehouses, automotive junk yards, and radio and TV stations. The latter classification is designed to classify properties that are predominantly industrial, but that also contain some commercial or office use (though not residential). The resulting data set yielded 558 observations of industrial property sales over the eight-year study period, again split rather evenly among the four-year "before" and "after" periods. Figure 4 shows the location of each of the industrial property sales in Hennepin County. Table 8 provides a set of descriptive statistics for the variables used in the analysis of the industrial property data.

The analysis of industrial properties employs a model similar to the one estimated for commercial and office properties. Previous research into the determinants of industrial land and property values has identified a set of factors which might be expected to influence these values. These include local and national macroeconomic factors (employment, output, etc.), building characteristics, parcel size, certain financial indicators (e.g. interest rates, capitalization rates), utilities or other urban services, time or date of sale, and location factors [61, 2, 39, 64]. Since our data set has only limited information about the building characteristics for each industrial property we focus mostly on the locational aspects of the properties that are associated with variations in sale prices. As in the previous analyses, we include access to jobs and workers (population) as important macro-level locational factors. We assume that industrial firms, like those in other sectors, value access to potential employees. Employment access is also tested as a control variable, as some industrial firms may value access to other firms that provide critical inputs. This is implicitly a test of agglomeration effects for industrial firms. Distance to the nearest highway is included as before, along with a squared term for highway distance which appears in a second model. In addition to highway distance, we also include a variable for distance to the nearest railroad and its squared term, as some industrial firms, particularly those involved in heavy manufacturing, may require rail access for accessing raw materials or for shipping bulky finished goods. All other variables are as specified before.

The fitted models for the industrial property sales are shown in Table 9. As the model output shows, only a handful of variables appear to be statistically significant. In each of the models, access to population appears to be negatively correlated with sale price, while access to employment shows a positive association. The latter variable appears as statistically significant in the models estimated from the Group 2 (2003 to 2007) data, though not the Group 1 data. Neither the highway distance or the rail distance variables appear to be statistically significant in either model, with the exception of the rail distance variable in Model 1 using the Group 1 data, though in this case the estimated coefficient has an incorrect (positive) sign. None of the dummy variables measuring proximity to the improved highway links consistently appear as statistically significant in the different models. The estimated coefficients fail to show any smooth distance effect.

The results from the industrial property sales models offer little evidence of an effect of proximity to an improved highway link on the value of industrial property. While this finding is not terribly surprising by itself, the finding that none of the highway or rail proximity variables were significant either requires some interpretation. There are at least three possible explanations for this finding. First, the sample size was

Figure 4.4: Location of industrial property sales in Hennepin County, 1999-2007

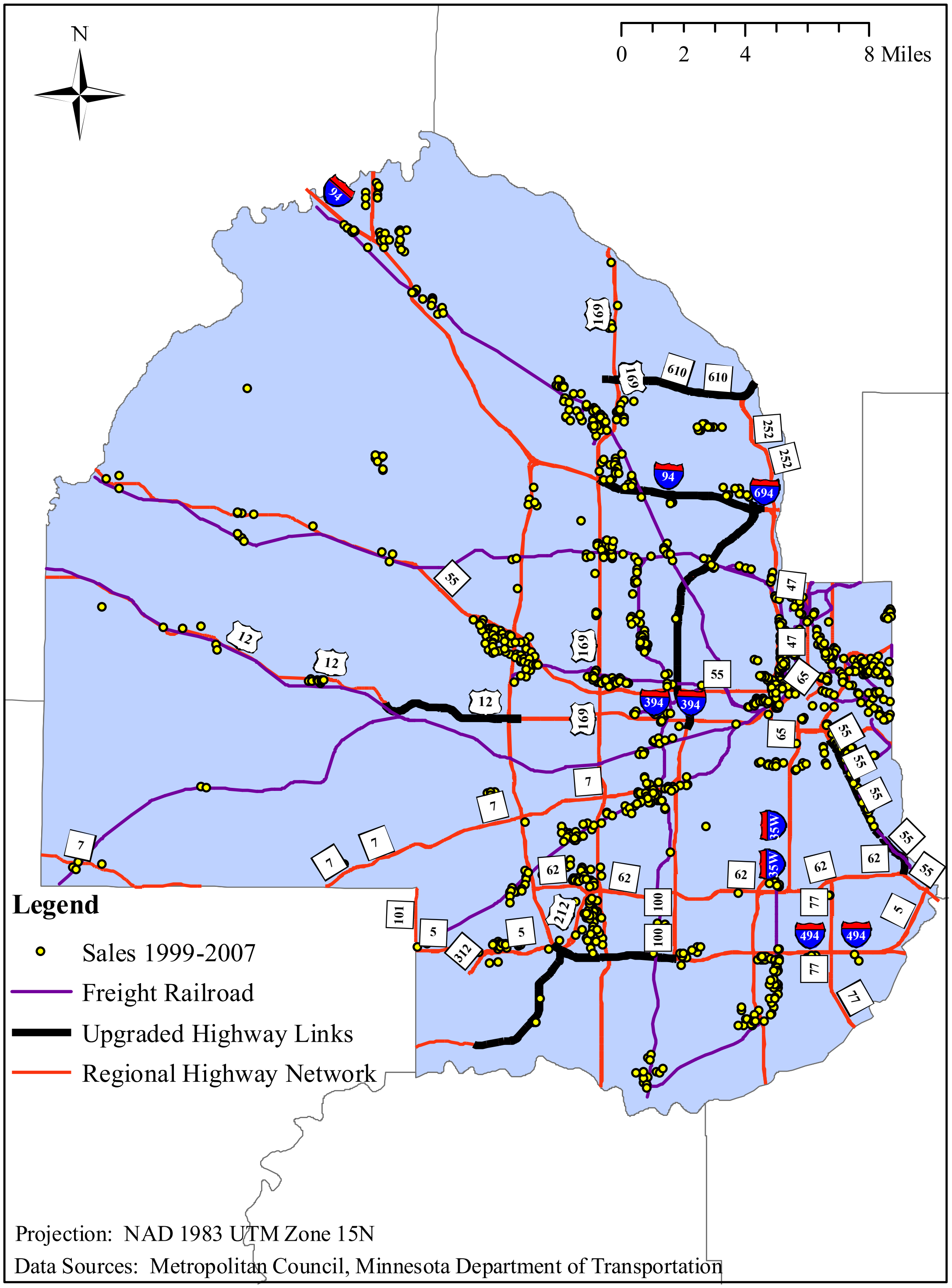


Table 4.8: Descriptive statistics for Hennepin County industrial property sales data

Group 1

Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	13.402	1.225	13.500	8.824	17.183
RegInc	36,147	1,624	36,830	33,046	37,834
FedRate	3.651	2.144	3.650	1.010	6.540
PopAccess	470,269	155,670	469,775	34,328	809,615
EmpAccess	372,928	157,462	363,148	11,058	625,659
Age	38.442	21.689	37	0	123
AgeSq	1,947	2,100	1,369	0	15,129
Hwy1000	2.558	2.463	1.764	0.091	20.020
HwySq	12.586	35.290	3.112	0.008	400.802
Rail1000	2.030	3.271	0.638	0.009	15.850
RailSq	14.782	39.472	0.408	0	251.209
Acres	2.166	3.147	1.237	0.036	38.180
LandOnly	0.065	0.247	0	0	1
1/4Mile	0.054	0.226	0	0	1
1/2Mile	0.061	0.240	0	0	1
3/4Mile	0.025	0.157	0	0	1
1Mile	0.011	0.104	0	0	1
N = 278					

Group 2

Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	14.017	1.121	14.028	10.127	17.859
RegInc	40,955	2,069	40,998	37,834	44,237
FedRate	3.223	1.681	3.380	0.980	5.260
PopAccess	474,306	152,736	464,953	34,328	720,963
EmpAccess	384,163	155,994	389,092	11,058	600,262
Age	41.400	22.120	39	0	116
AgeSq	2,201	2,404	1,521	0	13,456
Hwy1000	2.768	2.721	1.844	0.127	20.230
HwySq	15.042	40.887	3.399	0.016	409.267
Rail1000	2.187	3.046	0.803	0.006	15.338
RailSq	14.031	33.173	0.644	0.000	235.248
Acres	2.601	3.239	1.367	0.045	23.000
LandOnly	0.018	0.133	0	0	1
1/4mile	0.057	0.233	0	0	1
1/2mile	0.032	0.177	0	0	1
3/4mile	0.029	0.167	0	0	1
1mile	0.025	0.156	0	0	1
N = 280					

Table 4.9: Hedonic price models for industrial property sales in Hennepin County, 1999-2007

	Group 1							
	Model 1				Model 2			
Variable	Coefficient	S.E.	t-value	Sig.	Coefficient	S.E.	t-value	Sig.
RegInc	0.00011	0.00006	1.75	*	0.00011	0.00006	1.81	*
FedRate	0.049	0.055	0.89		0.050	0.052	0.95	
PopAccess	-3.96E-07	1.01e-06	-0.39		-4.81e-07	9.48e-07	-0.51	
EmpAccess	6.48E-07	1.18e-06	0.55		7.27e-07	1.12e-06	0.65	
Age	-0.007	0.013	-0.57		-0.007	0.013	-0.56	
AgeSq	0.00006	0.00011	0.54		0.00006	0.00011	0.57	
Hwy1000	0.006	0.031	0.18		0.073	0.068	1.07	
HwySq					-0.005	0.005	-0.98	
Rail1000	0.035	0.019	1.82	*	0.079	0.054	1.46	
RailSq					-0.003	0.005	-0.70	
Acres	0.202	0.114	1.77	*	0.200	0.114	1.74	*
LandOnly	-2.118	0.499	-4.24	***	-2.073	0.499	-4.15	***
1/4mile	-0.113	0.233	-0.48		-0.055	0.232	-0.24	
1/2mile	0.305	0.279	1.09		0.302	0.294	1.03	
3/4mile	0.444	0.420	1.06		0.436	0.428	1.02	
1mile	-0.348	0.298	-1.17		-0.343	0.284	-1.21	
Constant	8.987	2.555	3.52	***	8.842	2.421	3.65	***
N = 278								
Adjusted R^2	0.502				0.509			
	Group 2							
	Model 1				Model 2			
Variable	Coefficient	S.E.	t-value	Sig.				
RegInc	0.00004	0.00008	0.47		0.00002	0.00008	0.31	
FedRate	0.007	0.010	0.07		0.018	0.101	0.18	
PopAccess	-1.30E-06	8.56e-07	-1.52		-1.42e-06	8.68e-07	-1.63	
EmpAccess	2.57E-06	8.56e-07	2.90	***	2.64e-06	9.18e-07	2.87	***
Age	-0.043	0.009	-4.64	***	-0.042	0.009	-4.48	***
AgeSq	0.00032	0.00007	4.24	***	0.00031	0.00008	4.12	***
Hwy1000	-0.020	0.019	-1.02		0.031	0.040	0.77	
HwySq					-0.0038	0.0030	-1.25	
Rail1000	0.023	0.015	1.50		0.037	0.056	0.65	
RailSq					-0.0007	0.0057	-0.13	
Acres	0.224	0.034	6.63	***	0.221	0.034	6.51	***
LandOnly	-1.573	0.491	-3.20	***	-1.522	0.481	-3.16	***
1/4mile	0.044	0.229	0.19		0.096	0.242	0.39	
1/2mile	-0.145	0.388	-0.37		-0.145	0.398	-0.37	
3/4mile	0.408	0.179	2.28	**	0.434	0.174	2.50	**
1mile	0.019	0.560	0.03		0.031	0.576	0.05	
Constant	12.724	2.853	4.46	***	13.054	2.896	4.51	***
N = 280								
Adjusted R^2	0.502				0.506			

Notes:
Dependent variable is the natural logarithm of sale price
* = variable is statistically significant at $p < 0.10$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

rather small. With fewer than 300 observations in each of the groups of data, only a handful of which were located near the highway links under study (as Table 8 indicates), it is not surprising that the estimated effects were small relative to their associated variances. Second, the regional highway network used in the analysis does not include several county and state highways along which some of the industrial properties might be located. For example, from Figure 3 it is apparent that some of the properties are located along CSAH 10 in the northwestern portion of the county. While this highway may provide the access services that industrial firms require, it is not part of the regional network, meaning that distances to the nearest highway will be calculated instead to Trunk Highway 55 or Interstate 94. Third, the sample of industrial properties in the data set are likely to come from a heterogeneous group of firms with different transportation requirements. Some manufacturers or utilities may value rail freight services and locate next to a rail line, while other activities classified as industrial, such as warehousing, may have little need for such services. The resulting mixture of these different types of firms in the industrial data likely lead to higher variance estimates and to conflicting estimates of the value of proximity to highway or rail networks.

4.3 Jackson County

The results presented in the previous section provide estimates of the effects of highway improvements in a large and growing urban county in Minnesota's largest metropolitan area. The next sections will provide comparable estimates for the effects of highway improvements in rural and smaller, outstate urban areas. The rural county we will analyze is Jackson County.

Jackson County is located in southwestern Minnesota, along the Iowa border. Its county seat is the town of Jackson, which lies about 175 miles southwest of the Twin Cities and about 90 miles east of Sioux Falls, SD at the junction of Interstate 90 and U.S. Highway 71. Interstate 90 is the primary east-west highway through the county, crossing the southernmost tier of counties in Minnesota, while U.S. Highway 71 is the primary north-south route. As of 2007, the population of Jackson County was estimated to be just under 11,000, a slight decline since the 2000 Census.

The most recent major construction project in Jackson County was the reconstruction of Minnesota Trunk Highway 60, a state highway that cuts diagonally through the northwestern portion of the county. Highway 60 serves as a trade corridor, connecting to Sioux City, IA to the southwest and Mankato, MN to the northeast. Within Jackson County it runs through the towns of Heron Lake and Wilder. The reconstruction project widened the highway from two lanes to four within Jackson County, from the county's western border to the town of Wilder near its northern edge. Also, a new bypass was built around the town of Heron Lake. Work on the construction project commenced in late 2001 and finished in the fall of 2003. The total of cost of the construction project exceeded $20 million.

In order to gauge the impact the new highway may have, we again designated an area of influence within 1 mile of the improved highway, demarcated by a set of contiguous, quarter-mile buffer zones. Data on residential property sales within Jackson County were extracted from the Department of Revenue property sales data set. These included properties classified as Residential (with less than four units), Rural Residential (farms with buildings but less than 35 acres of land) and Residential Land (raw land sales). Commercial and Industrial properties were removed from the data set on the grounds that there were too few sales to conduct a separate analysis of these properties, and that the statistical analysis of the residential property sales would benefit from the use of a more homogeneous set of properties.

Between October 1999 and September 2007 there were just under 2,000 residential property sales in Jackson County. Given the much smaller sample size for the Jackson County data and that most of the sales in the county occurred in locations not near the improved section of Highway 60, it was not possible to estimate models with interaction terms for location and year variables, as was done with the MLS data for Hennepin County. Instead, the data were split into two groups, with one representing the period from 1999 to 2002, and the other covering the period from 2003 to 2007. Separate models were estimated with the two data sets and the estimated coefficients were compared to test for any changes in the effect of proximity to the improved highway. Before any analysis was conducted, the data needed to be matched to the county's GIS-based parcel file in order to construct several of the location-based variables. In addition, the sales records themselves needed to be thoroughly cleaned in order to weed out records that contained faulty data or that represented non-arms-length transactions (e.g. bank foreclosure sales), as these would not adequately reveal prices for housing and land. The net effect of these matching and data cleaning procedures was to reduce the size of the two sample groups to 633 observations for the first group (1999 to 2002), and 777 observations for the second group (2003 to 2007). The geographic distribution of the sales data for each of the two groups is described in Figures 5 and 6.

Figure 4.5: Location of residential property sales in Jackson County, 1999-2002

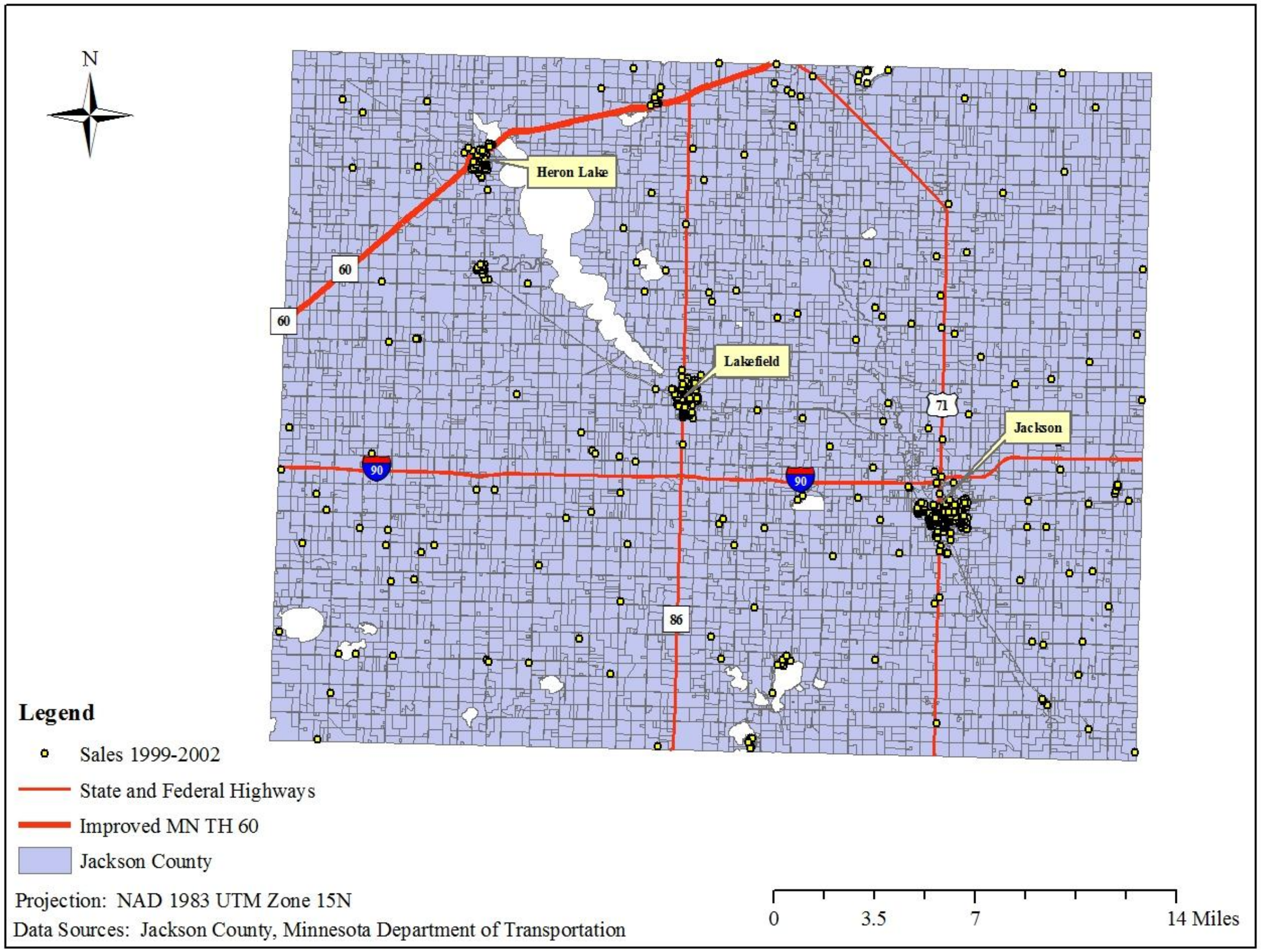


Figure 4.6: Location of residential property sales in Jackson County, 2003-2007

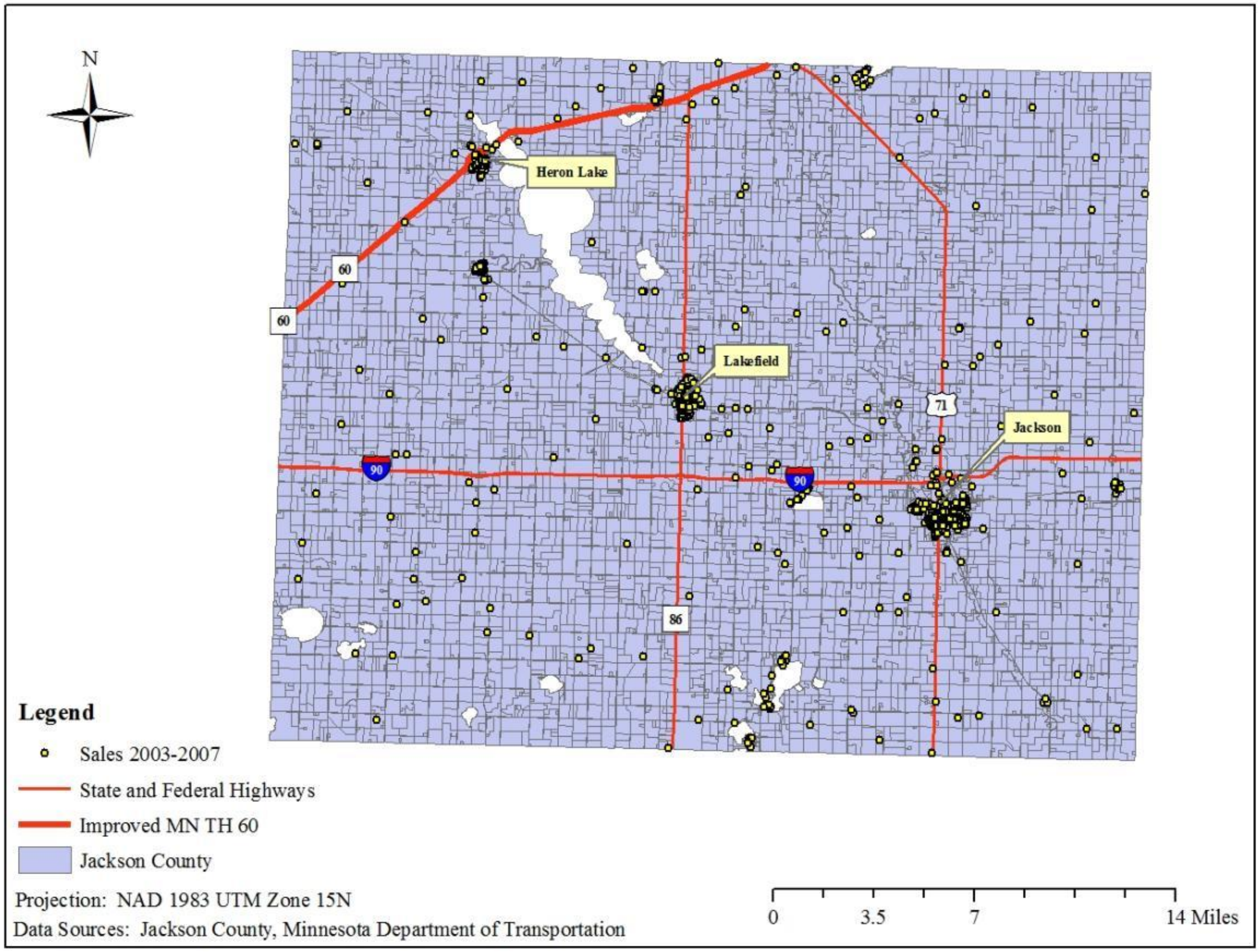


Table 10 includes a list of the variables included in the two models estimated for residential property sales in Jackson County. In addition to the variables designated to capture the influence of location relative to the upgraded highway, there are a set of control variables to account for parcel size, location, age of housing, amenities (e.g. lake frontage), and any time-varying, exogenous factors, as are captured by year-specific dummy variables. The variable for parcel size is split into urban and rural acreage, as urban land is expected to command a higher price per acre. Some additional variables were tested, rejected, and left out of the final specification. These included an interest rate variable, capturing monthly movements in the federal funds rate which might be expected to influence the demand for real property, the distance of a parcel to some of the larger towns in the county, distance to freight rail tracks, the presence of streams or rivers within a parcel, and dummy variables for sales within towns other than Jackson, which is the largest town in the county. Descriptive statistics for the variables used in estimation are presented in Table 11.

The fitted hedonic price models for sales of residential properties in Jackson County are presented in Table 12. The table is split into two parts to display the separate models fitted to the two groups of data. The first point to note is that the two models estimated from the Jackson County data do not fit the data nearly as well as the models estimated from the MLS data for Hennepin County. The models based on the Jackson County data explain only about one quarter of the variance in sales prices, whereas the MLS data explained more than three quarters of the variance. This finding is primarily the result of two factors. One is sample size from which the models were estimated. The Hennepin County MLS sales data represent a cross-section with more than 66,000 observations, while the two groups of data from which the Jackson County models were estimated each represent a sample size of less than 800. Second, and perhaps most important, the completeness of the data for Jackson County cannot match that of the MLS sample. The MLS data set contains a rather complete set of structural attributes, whereas the data obtained for Jackson County only contains observations on the age of the structure, with no other major attributes. We will see in the next subsection, where data from Olmsted County are used, how important certain of these attributes (in particular, building square footage) are.

Nonetheless, the fitted models in Table 12 do allow for some inferences into the determinants of sale prices in the Jackson County data. Nearly all of the estimated coefficients have the expected sign in the two models, though only about half of them in the model estimated from the Group 1 data (1999 to 2002) show statistical significance at the $p < 0.10$ level or greater. The decision to separate the land acreage variable into urban and rural acreage appears to be well-founded, as the two types of land have significantly different values per acre. An additional acre of urban land is estimated to add about 15 percent to the value of a parcel based on the Group 1 data, and about 10 percent based on the Group 2 data. Likewise, an additional acre of rural land is estimated to add about two percent to the value of a parcel based on the Group 1 data, and about four percent based on the Group 2 data. For each of the data sets, an additional year of age of housing is associated with a decrease of about 0.4 percent in the sale price of the property. Both data sets also show that properties classified as Rural Residential (that is, farms with less than 35 acres of land) are worth significantly more than other residential properties, while sales prices for raw land are often much lower than for sale of residential properties that include both land and buildings [3]. This is another indication of the importance of structural attributes of a property in estimating hedonic price models. Lake frontage again appears to be an important determinant of land value. The two coefficients for lake frontage have quite similar values, and indicate a premium of between 65 to 70 percent on the sale price of a property. Additionally, there seems to be an upward trend over time in the price of residential properties in Jackson County. While it is not as clear from the coefficient estimates in the model based on the Group 1 data, the Group 2 data, covering the period from 2003 to 2007, show a clear and consistent upward trend in sale prices with properties selling in 2007 for about 40 percent more than in 2003.

[3] According to the model, once all other variables are controlled for, and using the adjustment for the interpretation of dummy variables in semilogarithmic equations described in the previous section, the discount for raw land sales in the range of 75 to 78 percent of the sale price of the parcel

Table 4.10: List of variables included in Jackson County models

Variable Name	Description
ln SalePrice	Natural logarithm of sale price
UrbAcre	Urban land acreage
RurAcre	Rural land acreage
Age	Age of house (if present)
RuralRes	Dummy variable representing rural residential property type
ResLand	Dummy variable representing land-only property sale
Jackson	Dummy variable representing sale in town of Jackson
Lake	Dummy variable representing lakefront properties
2000	Dummy variable representing sale in year 2000
2001	Dummy variable representing sale in year 2001
2002	Dummy variable representing sale in year 2002
2004	Dummy variable representing sale in year 2004
2005	Dummy variable representing sale in year 2005
2006	Dummy variable representing sale in year 2006
2007	Dummy variable representing sale in year 2007
1/4mile	Dummy variable for location within 1/4 mile of upgraded highway
1/2mile	Dummy variable for location within 1/2 mile of upgraded highway
3/4mile	Dummy variable for location within 3/4 mile of upgraded highway
1mile	Dummy variable for location within 1 mile of upgraded highway

Lastly, we turn our attention to the estimated effects of the upgraded section of Highway 60 on residential property sale prices. The coefficient estimates for the dummy variables representing distance from the improved highway in the model estimated from the Group 1 data indicate that all properties within one mile of the new highway sold for less, on average, than other properties not near the highway. There does not appear to be a clear effect of distance in these estimates, as the largest negative coefficient is registered for the variable representing location between 1/2 and 3/4 of a mile of the improved highway. It should be noted though, that while the signs on these coefficients might be expected, none of the coefficients appear to be highly statistically significant.

The estimates based on the Group 2 data are able to draw on a slightly larger sample size, and here the effect of distance from the improved highway becomes a bit more clear. The estimated coefficients for the variables representing location within 1/4 of a mile of the improved highway and between 1/4 and 1/2 mile of the improved highway are very similar in magnitude, with the variables representing greater distances from the highway showing a negative, but declining effect of distance. In contrast to the Group 1 data, three of the four coefficient estimates here are at least moderately statistically significant ($p < 0.10$ level). The tentative conclusion then from the Jackson County data is that residential properties near an expanded highway (i.e. two to four-lane rural highway) are discounted slightly in price, relative to other properties further from the highway. It is unclear from the data however, whether the effect of proximity to the highway changed over time as a result of the highway construction. The sample of properties near the improved highway is too small to reveal any statistically significant differences.

Table 4.11: Descriptive statistics for Jackson County residential property sales data

Group 1					
Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	10.473	0.898	10.538	7.984	13.816
UrbAcre	0.410	1.345	0.182	0	15
RurAcre	1.613	4.345	0	0	63
Age	58.373	27.149	59	0	136
RuralRes	0.111	0.314	0	0	1
ResLand	0.054	0.226	0	0	1
Jackson	0.392	0.489	0	0	1
Lake	0.036	0.187	0	0	1
2000	0.336	0.473	0	0	1
2001	0.302	0.460	0	0	1
2002	0.266	0.442	0	0	1
1/4mile	0.049	0.216	0	0	1
1/2mile	0.043	0.204	0	0	1
3/4mile	0.018	0.132	0	0	1
1mile	0.001	0.037	0	0	1
N = 633					

Group 2					
Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	10.846	0.835	10.951	8.006	13.422
UrbAcre	0.335	1.193	0.181	0	23
RurAcre	1.611	3.822	0	0	30
Age	71.043	28.092	72	0	154
RuralRes	0.100	0.301	0	0	1
ResLand	0.045	0.208	0	0	1
Jackson	0.421	0.494	0	0	1
Lake	0.035	0.183	0	0	1
2004	0.222	0.415	0	0	1
2005	0.201	0.401	0	0	1
2006	0.173	0.379	0	0	1
2007	0.149	0.357	0	0	1
1/4mile	0.029	0.168	0	0	1
1/2mile	0.047	0.212	0	0	1
3/4mile	0.023	0.149	0	0	1
1mile	0.002	0.046	0	0	1
N = 777					

Table 4.12: Hedonic price models for residential property sales in Jackson County, 1999-2007

Group 1				
Variable	Coefficient	S.E.	t-value	Sig.
UrbAcre	0.149	0.021	7.22	***
RurAcre	0.020	0.016	1.26	
Age	-0.004	0.001	-2.61	***
RuralRes	0.354	0.123	2.87	***
ResLand	-1.395	0.170	-8.23	***
Jackson	0.205	0.073	2.80	***
Lake	0.528	0.192	2.75	***
2000	0.059	0.117	0.50	
2001	0.202	0.120	1.69	*
2002	0.163	0.122	1.33	
1/4mile	-0.236	0.199	-1.18	
1/2mile	-0.168	0.141	-1.19	
3/4mile	-0.317	0.275	-1.15	
1mile	-0.217	0.133	-1.62	
Constant	10.496	0.158	66.59	***
N = 633				
Adjusted R^2	0.204			

Group 2				
Variable	Coefficient	S.E.	t-value	Sig.
UrbAcre	0.100	0.057	1.73	*
RurAcre	0.041	0.010	4.19	***
Age	-0.004	0.001	-3.65	***
RuralRes	0.383	0.110	3.48	***
ResLand	-1.541	0.124	-12.38	***
Jackson	0.150	0.061	2.44	**
Lake	0.504	0.110	4.57	***
2004	0.204	0.073	2.78	***
2005	0.278	0.078	3.55	***
2006	0.317	0.085	3.75	***
2007	0.398	0.089	4.45	***
1/4mile	-0.364	0.181	-2.02	**
1/2mile	-0.371	0.169	-2.19	**
3/4mile	-0.256	0.135	-1.89	*
1mile	-0.152	0.427	-0.36	
Constant	10.770	0.097	111.41	*
N = 777				
Adjusted R^2	0.275			

Notes:
Dependent variable is the natural logarithm of sale price
* = variable is statistically significant at $p < 0.10$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

4.4 Olmsted County

The third Minnesota county we will use as a case study to estimate the effects of highway improvements on nearby property values is Olmsted County. Olmsted County is located in southeastern Minnesota, about 75 miles southeast of St. Paul via U.S. Highway 52. As of 2000, the county had a population of just under 125,000 with most of these residents living the county's largest city, Rochester. Rochester's year 2000 population was reported as 85,806 by the U.S. Census Bureau, and has more recently been estimated to be close to 100,000. As an outstate city that has experienced considerable population growth in recent years, Rochester and its surrounding county present a useful study area for examining the link between highway improvements and changes in property values.

The other major consideration in choosing Rochester and Olmsted County as a study area is that it presents an opportunity to evaluate the effects of a major, multi-year highway construction project in an outstate urban area. The reconstruction of an 11-mile section of U.S. Highway 52 in Rochester took place between 2003 and 2005. Known as the "ROC 52" project, this construction project rebuilt and expanded Highway 52 from four to six lanes between U.S. Highway 63 south of Rochester to 85th Ave. NW on the north end. While the project primarily involved reconstruction of an existing facility, patterns of access were altered as a result of the construction, and a new interchange was added along the rebuilt section. The total cost of the project was around $240 million, making it the single largest highway construction project in Minnesota history.

4.4.1 Residential

To evaluate the effects of the Highway 52 reconstruction on residential property values, we will employ the property sales data from the Department of Revenue and augment the data with some additional information on building characteristics which, as we will see, will prove quite valuable.

The property sales data are again available for the period from October 1999 to September 2007, with a total of more than 38,000 property transactions recorded during this period. Of the 38,000 records, about 26,600 are residential providing a potentially large sample for estimation. As with the Jackson County data, parcel shapefiles were obtained from Olmsted County in order to map the location of the parcels. Along with the necessary parcel data, additional building characteristics were collected, providing information on important variables such as square footage, number of bedrooms and bathrooms, and heating/cooling systems. The property sales files were first joined to the parcel data, then to the building characteristics. The process of joining the sales data to the parcel files resulted in the loss of a large number of records, including all of the 1999 records and most of the 2000 records. About 15,100 records were successfully joined. The second step, joining the building characteristics, resulted in the loss of about 150 additional records. Finally, some cleaning was done to the data, in order to try to identify sales that represented errors or non-arms-length transactions. The cleaning that was performed on the Olmsted County data was not as thorough as was applied to the Jackson County data, mostly because the much larger sample size assures that the effect of outliers will be much less critical. In all, about 60 additional records were removed from the sample. The final sample that was used for estimation contained 14,900 observations.

Figure 7 displays the location of the residential property sales in Olmsted County. It is apparent from the map that most of the sales in the county during this period are clustered around the city of Rochester. The large number of sales causes the location of some observations to be obscured. To provide more detail, Figure 8 centers the map view on the city of Rochester and identifies the reconstructed section of Highway 52, along with a set of buffer rings around the reconstructed highway at 1/4 mile intervals.

The approach we will adopt to estimate the effect of the highway improvement on residential property values will differ from those adopted for the Hennepin and Jackson County residential property analyses. The MLS data for Hennepin County were limited in terms of their longitudinal nature, whereas the property sales data for Jackson County were limited in terms of their sample size and location relative to the upgraded highway of interest. With the residential property sales data set available for Olmsted County, we can effectively address both of these issues.

Our data set is divided into three periods, organized around the period coinciding with the major construction work on the ROC 52 project. A pre-construction period is comprised of sales occurring prior to April 2003. Sales from between April 2003 and September 2005 are identified as construction period observations, and any sales following this period are considered post-construction observations. We then adapt our original approach to create variables that designate location relative to the upgraded section of Highway 52 and also identify the period of sale. Thus, we can identify whether the effect of the location of property relative to the highway changes over time during the three periods.

We also extend the approach to consider the possibility that proximity to the highway may generate both positive and negative externalities. The prior approach of looking at the location of properties near an improved highway implicitly assumed that all external effects would be captured by the coefficients on the location variables. Other hedonic analyses, primarily those concerned with the effect of proximity to rail transit stations, have attempted to separate the positive effects of access to the improved network (e.g. stations) from the nuisance effects that the network infrastructure itself generates (e.g. noise, pollution) [13]. To operationalize this concept, we keep the variables representing sales within various distance bands of the improved highway to serve as proxies for the nuisance effects of the highway. We also create new variables that measure network distance to the nearest access point (interchange) on the improved section of Highway 52, essentially a measure of local accessibility to the upgraded highway. This variable is also split into temporal intervals, coinciding with the pre-, post-, and under construction periods of the ROC 52 project, to determine if the value of highway access changes over time. Thus, the marginal effect of the highway improvement is the net effect of the positive and negative externalities (access versus nuisance effects).

Table 13 provides a list of the variables used in the analysis of residential property sales. In addition to those listed in the table, we also include dummy variables for month and year of sale. The month of sale variables again use January as the reference category. The year-specific indicators are defined for 2001 through 2007, leaving the period from October 2000 to the beginning of 2001 as the point of reference. Also of note, a variable is defined representing distance to the central business district (CBD) of Rochester. This variable is a proxy measure for regional employment accessibility, as comparable measures to those used in the Hennepin County analysis were not available. The CBD distance measure is seen as an acceptable proxy, as most of Rochester's major employers, including the Mayo Clinic, are located there. A set of descriptive statistics for the residential property sales data is provided in Table 14 [4].

Results of the fitted model for the residential property sales data are presented in Table 15. The fitted model explains more than two-thirds of the variation in residential property prices using a limited set of structural attributes, some variables representing location and amenities, and the transportation attributes of interest. The coefficient on the bedroom variable is negative indicating that, controlling for the square footage of a residential unit, an additional bedroom has no value, though it should be noted that the estimated coefficient is small and not statistically significant. The bathroom variable is significant, with an additional bathroom adding about 2.8 percent to the value of a house. This value is considerably smaller than the estimate obtained from the Hennepin County home sales model. Both the age and age squared variables are

[4] Note in Table 14 the summary of the access distance variables. Distances were calculated only for properties within three miles of an access point, a distance beyond which the localized access effect was assumed to disappear. All properties beyond this distance were assigned an arbitrary value of 30 miles, implying that, given the specification of the model, the effect of the new highway would be zero or only nominally positive. This modification was undertaken to prevent the access distance variable from being correlated with the CBD distance variable, a factor which is shown in the estimated model to be significant

Figure 4.7: Location of residential property sales in Olmsted County, 2000-2007

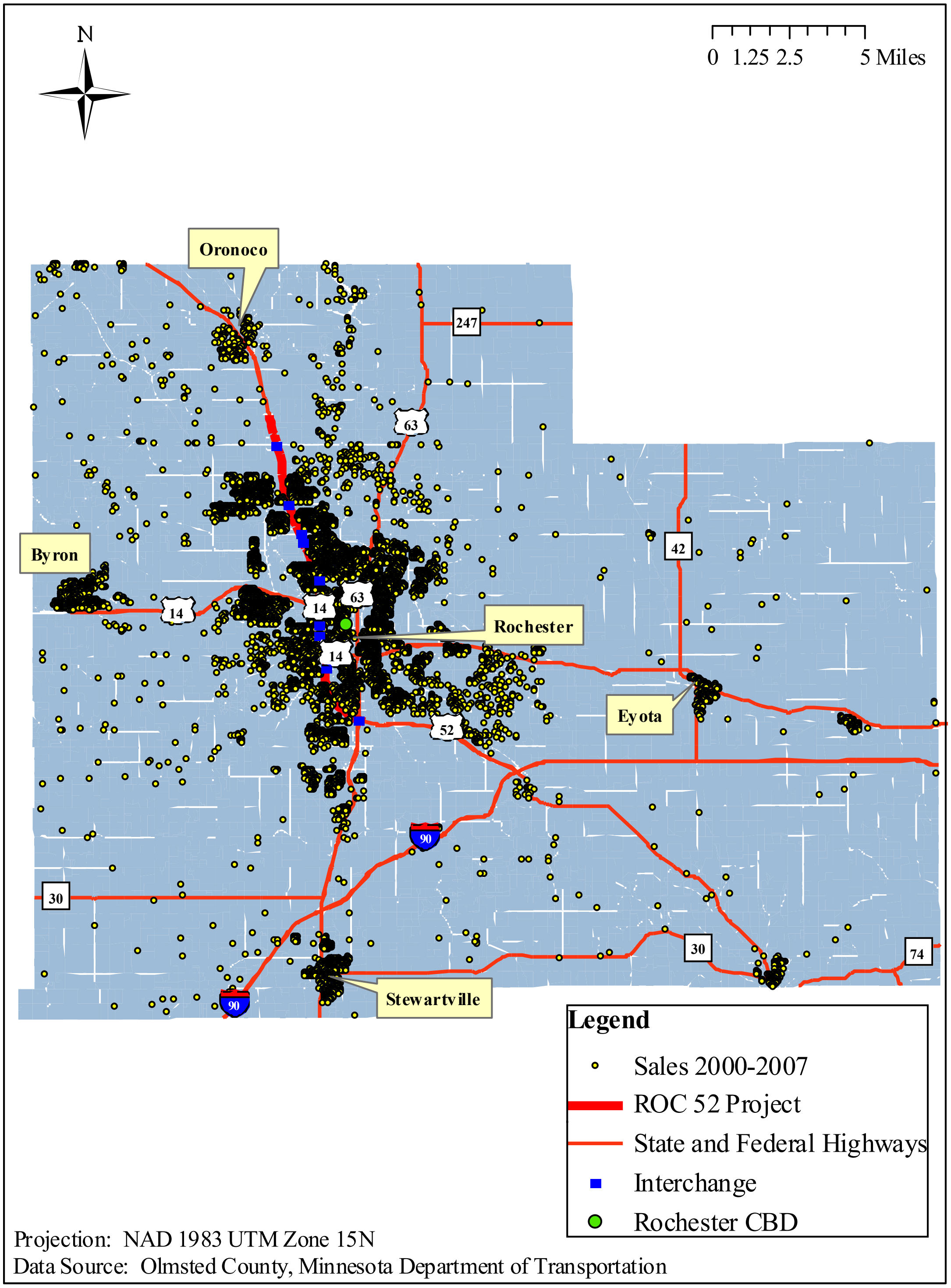


Figure 4.8: Location of ROC 52 project and residential property sales in Rochester, 2000-2007

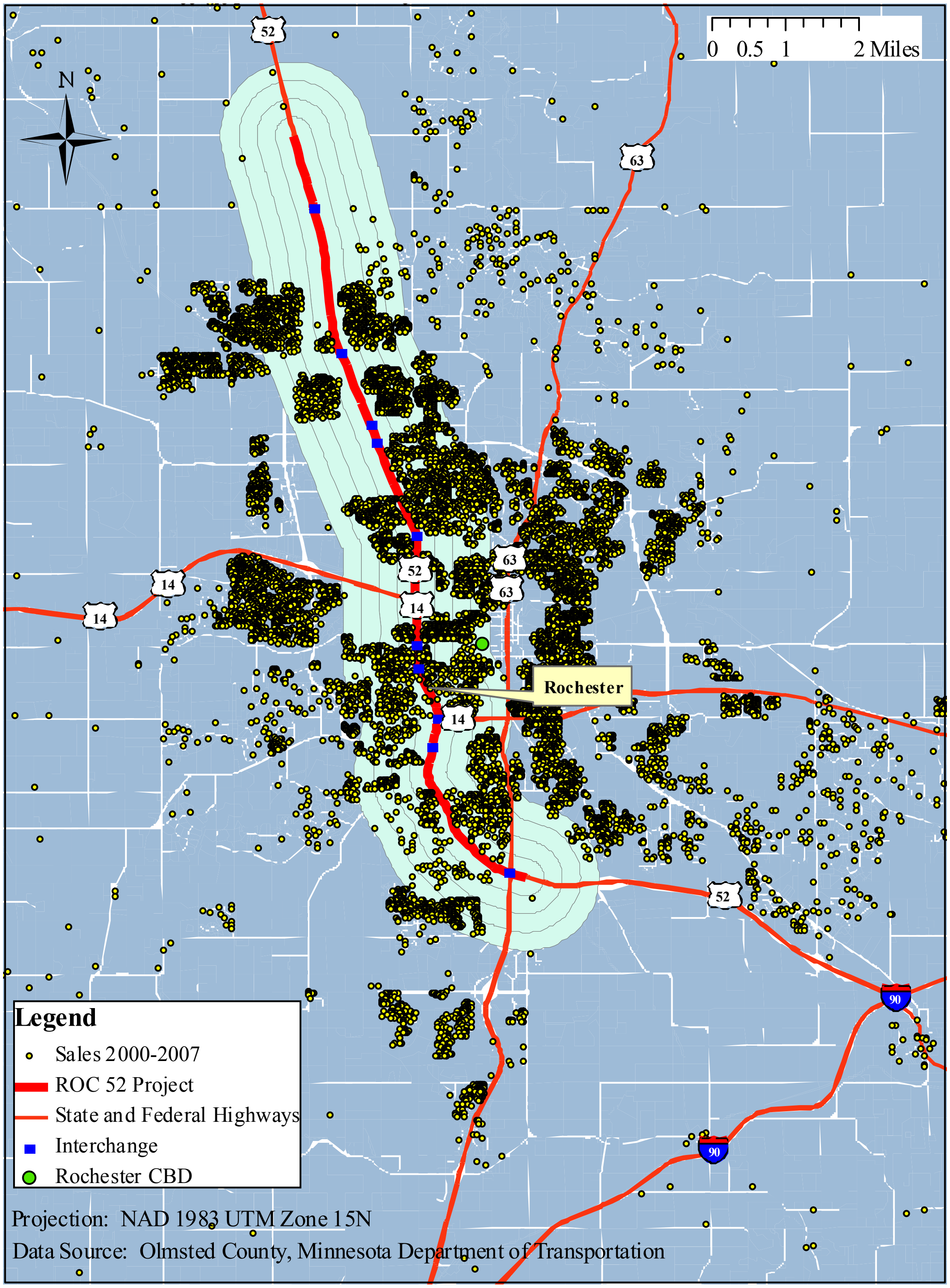


Table 4.13: List of variables included in Olmsted County residential sales model

Variable Name	Description
ln SalePrice	Natural logarithm of sale price
Bedrooms	Number of bedrooms
Bathrooms	Number of bathrooms
Age	Age of house
AgeSq	Age of house squared
FinishedSqFt	Square feet of house
AirCond	Dummy variable representing houses with air conditioning
River	Dummy variable representing house with river frontage
Condo	Dummy variable denoting housing unit as a condominium
TillAcre	Tillable acres of land
NTAcre	Non-tillable acres of land
CBDdist	Distance from Rochester CBD
1/4Mile	Dummy variable for location within 1/4 mile of upgraded highway
1/2Mile	Dummy variable for location within 1/2 mile of upgraded highway
3/4Mile	Dummy variable for location within 3/4 mile of upgraded highway
1Mile	Dummy variable for location within 1 mile of upgraded highway
Pre	Dummy variable for pre-construction period (up to April 2003)
Con	Dummy variable for major construction period (April 2003 to September 2005)
Post	Dummy variable for post-construction period (after September 2005)
1/4MilePre	1/4Mile * Pre
1/4MileCon	1/4Mile * Con
1/4MilePost	1/4Mile * Post
1/2MilePre	1/2Mile * Pre
1/2MileCon	1/2Mile * Con
1/2MilePost	1/2Mile * Post
3/4MilePre	3/4Mile * Pre
3/4MileCon	3/4Mile * Con
3/4MilePost	3/4Mile * Post
1MilePre	1Mile * Pre
1MileCon	1Mile * Con
1MilePost	1Mile * Post
AccPre	Network distance to nearest access point (pre-construction)
AccCon	Network distance to nearest access point (during construction)
AccPost	Network distance to nearest access point (post-construction)

Table 4.14: Descriptive statistics for Olmsted County residential property sales data

Variable	Mean	S.D.	Median	Min	Max
ln SalePrice	12.027	0.468	11.967	9.210	16.244
Bedrooms	1.855	1.643	2	0	11
Bathrooms	1.486	1.231	2	0	9
Age	31	28	22	1	149
AgeSq	1761	2841	484	1	22,201
FinishedSqFt	1630	575	1,472	70	12,432
AirCond	0.807	0.395	1	0	1
River	0.001	0.028	0	0	1
Condo	0.007	0.085	0	0	1
TillAcre	0.040	1.083	0	0	71
NTAcre	0.503	2.504	0	0	234
CBDdist	4.168	3.505	3.070	0.142	20.087
2001	0.099	0.299	0	0	1
2002	0.029	0.167	0	0	1
2003	0.148	0.355	0	0	1
2004	0.161	0.368	0	0	1
2005	0.208	0.406	0	0	1
2006	0.193	0.395	0	0	1
2007	0.140	0.347	0	0	1
Feb	0.054	0.226	0	0	1
March	0.074	0.262	0	0	1
April	0.084	0.278	0	0	1
May	0.112	0.315	0	0	1
June	0.146	0.353	0	0	1
July	0.100	0.299	0	0	1
August	0.103	0.304	0	0	1
September	0.081	0.273	0	0	1
October	0.078	0.268	0	0	1
November	0.067	0.251	0	0	1
December	0.058	0.235	0	0	1
1/4MilePre	0.010	0.100	0	0	1
1/4MileCon	0.026	0.158	0	0	1
1/4MilePost	0.020	0.141	0	0	1
1/2MilePre	0.017	0.129	0	0	1
1/2MileCon	0.047	0.212	0	0	1
1/2MilePost	0.038	0.190	0	0	1
3/4MilePre	0.017	0.130	0	0	1
3/4MileCon	0.047	0.211	0	0	1
3/4MilePost	0.034	0.181	0	0	1
1MilePre	0.016	0.125	0	0	1
1MileCon	0.038	0.191	0	0	1
1MilePost	0.032	0.176	0	0	1
AccPre	26.430	9.422	0	0	30
AccCon	20.904	13.270	0	0	30
AccPost	22.415	12.557	0	0	30
N = 14,900					

significant, indicating that the desirability of a house (as indicated by its selling price) declines with age, though the rate of decline decreases as age increases. The square footage variable, which is used here largely as a statistical control, has a coefficient of 0.0005. This may be interpreted to mean that a 100 square foot increase in the floor space of a house is associated with a five percent increase in its value. The presence of air conditioning is also estimated to add about six percent to the value of a house. Properties identified as condominiums sell for about 15 percent less than comparable detached units.

The coefficients on the land acreage variables have the expected sign, but appear not to be significant. River frontage does appear to have a significant effect, with homes with river frontage selling for about 30 percent more than homes without [5]. Location relative to the Rochester CBD also has a significant effect, with each additional mile from the CBD being associated with a one percent decline in the value of a house.

Variables representing month and year of sale also are significant. The month dummies (which are suppressed from Table 15) are all statistically significant with the exception of March. The coefficients exhibit the familiar pattern of increases during the warmer months of the year, with a peak during summer. The year dummies for 2001 through 2007 trace out the upward trend in home prices in Olmsted County throughout the first half of the decade. Prices in 2006 were, on average, nearly 21 percent higher than in 2000, controlling for all of the variables entered into the current model.

The effects of the upgrade of Highway 52 are reflected in the coefficients of the variables representing time and location, as well as the set of variables measuring access distance to the improved highway during the pre-construction, construction, and post-construction periods. Figure 9 plots the effects of proximity to the improved highway over time, as measured by the dummy variables denoting distance from the highway during specific time periods.

The set of points representing various distances from the improved highway during each time period trace out a rough price gradient for highway proximity. As the figure indicates, houses closest to the highway sold for slightly less than those not near the highway during the pre-construction and construction periods. During the post-construction period, they sold for slightly more (around 1.0 percent). Houses three-quarters of a mile from the improved highway appear to obtain a slight premium during *all* periods, with the largest premium occurring during the post-construction period. In order to attempt to sort out the effects of access to the improved highway, the separate variables representing distance to the nearest highway access point are included. The coefficients on these variables were expected to be negative, indicating that some premium would be placed on having access to the improved highway nearby. As Table 15 indicates, the coefficient representing access distance during the pre-construction period is negative, though very small and not statistically different from zero at the $p < 0.1$ level. The coefficients representing access during the period of major construction and post-construction are both slightly positive, though also statistically insignificant.

Overall, we are unable to detect any premium associated with being located near an access point to the improved highway. Conversely, the dummy variables used to represent proximity to the highway itself do show a slight positive effect at certain distances (0.5 to 0.75 miles). These findings seem to suggest that, at least for residential properties, nuisance effects of being near a highway interact with the effect of the access that the highway provides in subtle ways. This result should, however, be qualified by noting that in each case the magnitude of the effect of the improved highway (whether positive or negative) was quite small, and that only a handful of the variables representing the effects of the highway improvement showed statistically significant (non-zero) effects.

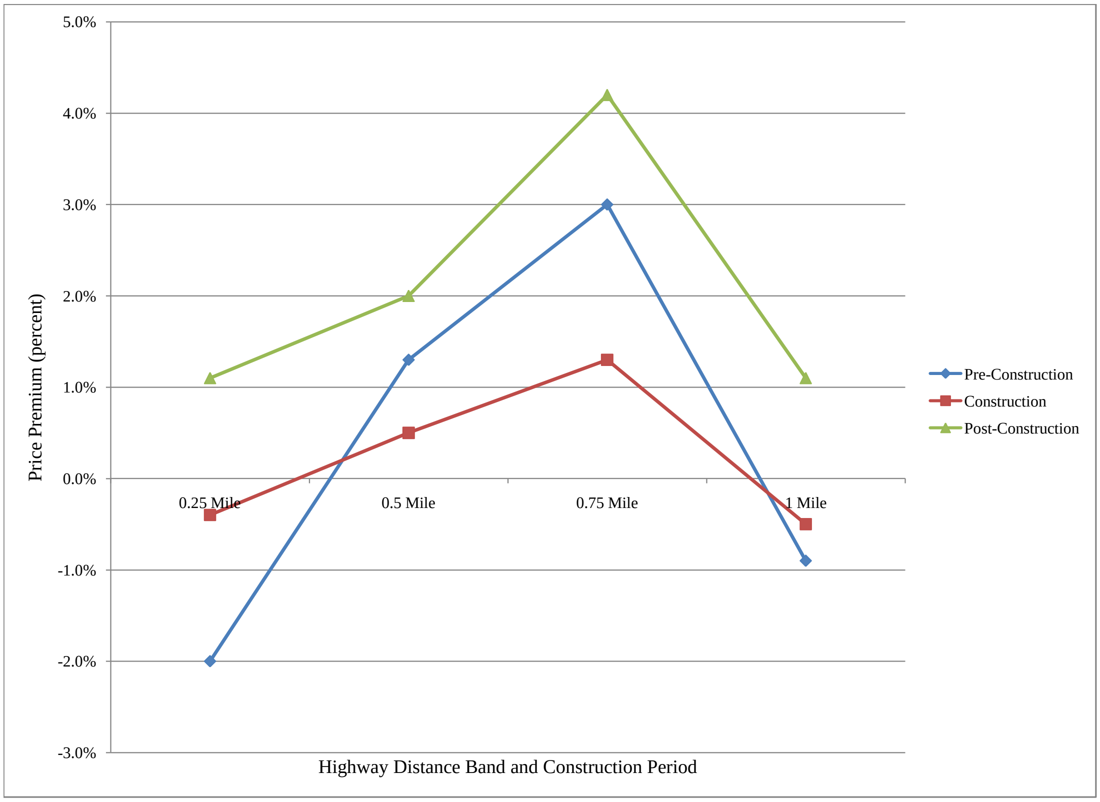
[5] The river frontage variable was drawn from the Department of Revenue sales data set. There were no comparable observations for lake frontage (or a lake or river view), as were found in the MLS data set. This was at least partly due to a classification issue. Olmsted County does have lakes, but none are natural lakes. They are all reservoirs created by dams on local streams and rivers

Table 4.15: Hedonic price model for residential property sales in Olmsted County, 2000-2007

Variable	Coefficient	S.E.	t-value	Sig.
Bedrooms	-0.003	0.002	-1.24	
Bathrooms	0.028	0.006	4.48	***
Age	-0.006	0.0004	-13.06	***
AgeSq	1.47E-05	3.75E-05	3.92	***
FinishedSqFt	0.0005	0.00002	22.55	***
AirCond	0.060	0.008	7.37	***
River	0.316	0.105	3.01	***
Condo	-0.158	0.042	-3.78	***
TillAcre	0.006	0.009	0.65	
NTAcre	0.011	0.019	0.56	
CBDdist	-0.010	0.002	-6.08	***
2001	-0.002	0.019	-0.08	
2002	0.059	0.022	2.69	***
2003	0.119	0.021	5.70	***
2004	0.155	0.022	7.04	***
2005	0.186	0.021	8.65	***
2006	0.209	0.022	9.33	***
2007	0.208	0.023	9.04	***
1/4MilePre	-0.020	0.022	-0.90	
1/4MileCon	-0.004	0.012	-0.35	
1/4MilePost	0.011	0.018	0.63	
1/2MilePre	0.013	0.016	0.81	
1/2MileCon	0.005	0.009	0.50	
1/2MilePost	0.020	0.011	1.82	*
3/4MilePre	0.030	0.014	2.11	**
3/4MileCon	0.013	0.010	1.27	
3/4MilePost	0.042	0.012	3.39	***
1MilePre	-0.009	0.021	-0.41	
1MileCon	-0.005	0.010	-0.47	
1MilePost	0.011	0.014	0.78	
AccPre	-0.001	0.0007	-1.53	
AccCon	0.0002	0.0005	0.33	
AccPost	0.0006	0.0005	1.11	
Constant	11.110	0.047	234.03	***
N = 14,900				
Adjusted R^2	0.679			

Notes:
Dependent variable is the natural logarithm of SALEPRICE
* = variable is statistically significant at $p < 0.10$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

Figure 4.9: Price effects of proximity of residential properties to upgraded U.S. Highway 52



4.4.2 Commercial-Industrial

While the analysis of residential properties in Olmsted County found the impacts of the ROC 52 project on home prices to be small and somewhat unreliable statistically, we might expect to find a more noticeable effect on commercial properties, which have different transportation requirements and do not experience the same nuisance effect that often makes location near a major highway undesirable for residences. The DoR property sales data set for Olmsted County was large enough to permit some analysis of commercial and industrial property values in addition to the more extensive treatment of residential properties.

Between 2000 and 2007, over 1,200 commercial and industrial property sales were recorded in Olmsted County, enough to permit a small-scale analysis of the impact of the ROC 52 project. As with the residential property data, the commercial-industrial sales data needed to be first mapped and then joined to data on building characteristics. The process of matching the sales data to the county's parcel records resulted in a loss of about half of the transactions, leaving 647 observations. Joining these data to a set of building attributes resulted in a loss of an additional 145 records. Finally, the data were cleaned to weed out non-arms length transactions, leaving a total of 471 observations for the analysis. The location of these properties, along with the highway network, is mapped in Figure 10.

The set of attributes of the commercial-industrial properties that could be used to predict property values were somewhat limited, though important features, such as building size and age, were included. More

Table 4.16: Hedonic price model for commercial-industrial property sales in Olmsted County, 2000-2007

Variable	Coefficient	S.E.	t-value	Sig.
Ksqftpr	0.015	0.004	3.81	***
Age	-0.010	0.003	-3.52	***
CBDdist	-0.051	0.020	-2.50	**
HwyDist	-0.367	0.128	-2.87	***
UrbAcre	0.168	0.023	7.17	***
RurAcre	0.019	0.005	3.62	***
2002	0.005	0.199	0.02	
2003	-0.062	0.233	-0.27	
2004	0.468	0.243	1.93	*
2005	0.503	0.233	2.16	**
2006	0.515	0.236	2.18	**
2007	0.543	0.245	2.22	**
AccPre	-0.025	0.009	-2.67	***
AccCon	-0.016	0.007	-2.20	**
AccPost	-0.012	0.007	-1.61	*
Constant	13.823	0.414	33.40	***
N = 471				
Adjusted R^2	0.523			

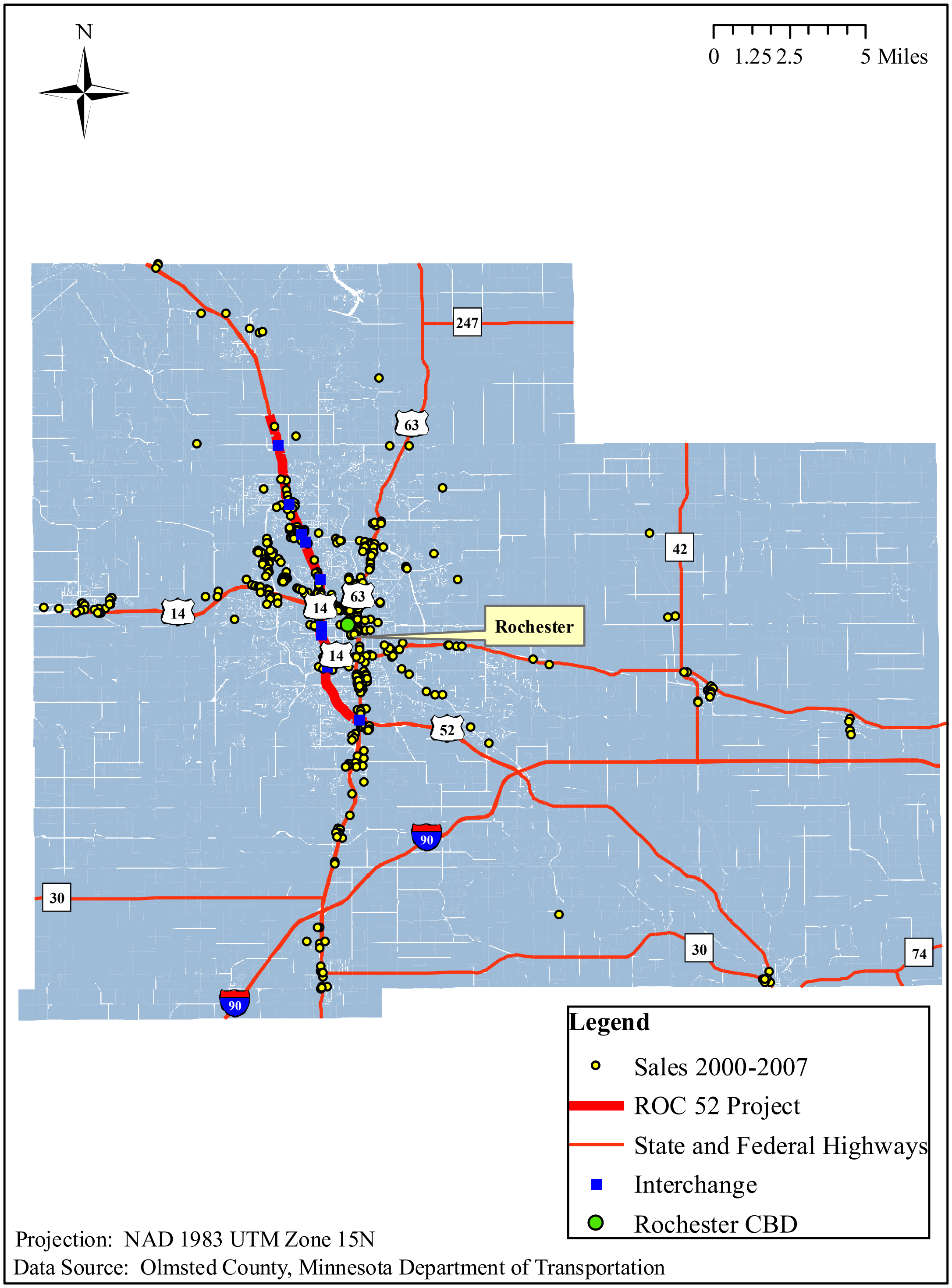
Notes:
Dependent variable is the natural logarithm of sale price
* = variable is statistically significant at $p < 0.10$ level
** = variable is statistically significant at $p < 0.05$ level
*** = variable is statistically significant at $p < 0.01$ level

general location variables were developed, measuring distance from the CBD as well as distance from the nearest highway. Parcel acreage was measured, and was divided into urban and rural acreage, as was done in the analysis of properties in Jackson County. Year-specific dummy variables were again added to attempt to measure any secular trends in prices during the period of observation.

The effects of the upgrade of Highway 52 were measured by defining a variable similar to that used in the residential analysis, in which network distance to the nearest access point on the improved section of highway is measured during specific time periods. The reasons for doing so were basically twofold. First, there was little reason to believe that externalities from highway traffic would have the same effect on commercial and industrial properties as on residential properties. Second, the smaller sample size for the commercial-industrial properties made difficult the method of identifying distance bands around the improved highway, since the number of observations in each location during each specific period were not consistently large enough to permit valid statistical inference. Instead, a continuous approximation is used to represent the relationship between proximity to the improved highway and property values. Since another variable is included in the model accounting for the distance to the nearest highway for all properties in the sample, the distance variable that is specific to the ROC 52 project should be seen as capturing the presence of any premium that is associated solely with the effect of this project.

The model fitted to the Olmsted County commercial-industrial data is shown in Table 16. The coefficient on the square footage variable indicates that each additional 1,000 prime square feet of space adds about 1.5 percent to the price of a commercial-industrial property. Building age is also significant, with each additional year of age being associated with a 1 percent decline in price. The value of commercial-industrial

Figure 4.10: Location of commercial-industrial property sales in Olmsted County, 2000-2007



land is indicated by the coefficient estimates for the two acreage variables. An additional acre of urban land adds about 17 percent to the value of a property, while an acre of rural land (identified as being outside an incorporated town) adds about 2 percent. Distance from the Rochester CBD appears to be significant factor in explaining commercial property values, as it is for residential properties. Here, we find that each additional mile from the CBD is associated with a roughly five percent decline in value. Of note, this price gradient appears to be much steeper than the one estimated for residential properties (about one percent for each mile from the CBD).

The interpretation of the time trend dummy variables does not appear to be as straightforward. The coefficients on the year 2002 and 2003 variables both are fairly small and not statistically significant. While the 2004 through 2007 variables do appear to be significant, there is a large and seemingly unexplainable discontinuity between the 2003 and 2004 variables, where the coefficient estimate jumps from -0.062 to 0.468. The variables for 2004 through 2007 then appear to resume a rather smooth, upward trend. Since these variables do appear to add explanatory power to the model, they are included in our preferred specification.

The variable representing distance to the nearest highway appears to have a rather large influence on property values. On average, property values fall by more than 36 percent for each additional mile from the nearest highway. This finding appears to underscore the importance of highway access for commercial and industrial properties, a finding that is also readily apparent from the location of these properties in Figure 10. Beyond this effect, the variables representing proximity to access points on the reconstructed section of Highway 52 also appear to be significant. The variable representing highway access during the pre-construction period indicates that for every mile of distance from the nearest access point on the rebuilt Highway 52, property values fall by about 2.5 percent. This is *in addition to* the more general effect of proximity to highways for all properties in Olmsted County. The variables representing access distance during the construction and post-construction period have the same sign but a smaller coefficient, indicating that the distance gradient for access to the improved highway may have flattened out over time, with the effect of the improved highway possibly being encountered at further distances from access points following completion of the ROC 52 project. On one hand, this may be evidence of a real, accessibility-related improvement due the reconstruction project. On the other hand, the estimated standard errors for each of the three coefficients on the access variables are large enough that we may not rule out the possibility that there is no real difference between the true value of the three coefficient estimates, and that the differences observed in our model are due to chance variation. Nonetheless, our evidence suggests that the effect of the ROC 52 access distance variable is non-zero, meaning that the project resulted in at least some increment in property values for commercial and industrial properties.

4.5 Discussion

As many of the results of the analyses show, obtaining accurate and statistically meaningful results from the procedures employed here can be difficult in many cases. That many of the types of projects we are interested in (major construction and reconstruction) are by definition large and may span multiple years suggests that a data set with some longitudinal scope may be necessary. This presents tradeoffs between the different data sets available. As we have seen, home sales data from the Multiple Listing Service (MLS) provides a rich set of structure attributes that can be very helpful in analyzing price variations among units. However, the availability of only four years' worth of observations makes inferences on a number construction projects difficult (if not impossible). The property sales data from the Department of Revenue provides a longer period over which observations can be made, but lacks the richness of the MLS data in terms of property attributes. It must therefore be combined with whatever data on property attributes is available from county records, as in the case of Olmsted County.

Looking forward, there are at least two other possible methods that could be employed to overcome some of the difficulties encountered in the present analysis. In the case of urban counties such as Hennepin, the Department of Revenue data could be analyzed using the hedonic methods described here, with an emphasis on raw land sales rather than those including structures. Since many factors, including the hypothesized effects of highway upgrades and other neighborhood attributes, are theoretically captured in the price of land, this approach should yield more accurate results (certainly for residential properties). This method should reduce the need for extensive attribute data and should provide the greater longitudinal coverage available in the Department of Revenue data. Further, we recommend analyzing major projects separately in large, urban counties in order to reduce problems associated with a lack of concurrency among project impacts. Still, greater availability of structural attributes for properties in the parcel level data set, especially in Hennepin County, would be highway desirable. These data appear to be in the development stages, and could be applied to the type of analysis undertaken here in the near future.

The second alternative method that could be considered is the method of repeat sales index construction [5, 74]. This method involves analyzing trends in house prices or growth rates over a given period, based on the set of properties that sell at least twice over the study period. While this method is typically employed to study price trends in entire market areas, it could just as easily be applied to submarkets within the same study area, with one submarket being defined as the set of houses within a given distance of an upgraded highway facility. A major advantage of the repeat sales model is that it requires no additional knowledge about housing characteristics, since these characteristics are essentially held constant by looking at the same unit over time [47]. One caveat is that the data set must be sufficiently screened prior to analysis to ensure that no major changes were made to a property during the period between successive transactions. This type of approach would be best suited for cases such as Jackson County, where smaller sample sizes, combined with limited structure and neighborhood variables, make analysis using conventional hedonic price methods more difficult.

Chapter 5

Conclusion

In this study we have examined the economic impact of highway improvements through the analysis of property values. Our method of hedonic regression analysis, as applied to three Minnesota counties in the study, yielded mixed results in terms of observable changes to locational premiums or discounts associated with being located near an improved highway link. For most of the study areas and property types analyzed here, no statistically significant change in property values was observed *as a result* of the construction or reconstruction projects under consideration. The exception seemed to be the ROC 52 project in Rochester, where small locational premiums were observed for properties near the completed highway (roughly 1 mile (1.6km) or less). It is worthwhile to reconsider some of the factors that led to these results.

One generic factor that appeared in all three case study locations was the issue of sample size. This was mostly a factor for the non-residential property types that were studied in Hennepin and Olmsted County, though it also affected the analysis of Jackson County to a lesser extent. The modeling approach applied in this study works best when large sample sizes are available, especially over a period of several years. This is necessary to break both time and space down into smaller, discrete units, such as the 1/4 mile distance bands used as spatial units, or individual years as units of time. Even with rather large counties, the collection of appropriately large samples for non-residential property types that can be linked to geographic information systems for further processing can be difficult. A second factor, which was most prominent for the Jackson County data, was the location of the project itself. The Highway 60 reconstruction project runs through the northwestern portion of Jackson County, completely avoiding the two largest towns in the county (Jackson and Lakefield). The result is that fewer of the observations of property sales in the county are in a location where they are likely to receive the "treatment effect" of being near the improved highway.

A third issue of importance in each case is how exactly to specify the effect of the improved highway in the empirical model. In the analysis of residential properties, we attempted to account for the possibility that a highway improvement might impart both positive and negative externalities on a nearby property. This was accomplished by measuring the distance to the roadway itself as a proxy for noise and other negative effects, and by measuring distance to the nearest access point as way to capture local accessibility effects. In the case of Olmsted County, we added the step of measuring network distance to the nearest highway access point, as opposed to the simpler measure of airline distance. The treatment of these measurement and specification issues has not been uniform in other empirical analyses of transportation improvements, and so there is no generally accepted method of dealing with these matters.

Lastly, it is important to recognize that, even at the scale of the projects that were included in this analysis, the resulting improvements to the transportation network are in most cases marginal. In each of the case study locations, the highway network is already largely developed. Most of the projects involved were reconstruction projects that added capacity to an existing facility. While these improvements may alleviate congestion in heavily-traveled locations, the resulting time savings to each individual is likely to be small enough that it does not greatly affect the relative accessibility in different locations, and hence property values. It is possible that the actual effects of the highway improvement were positive, but were too small to be picked up by the statistical methods applied. A useful test of this would be to try to identify locations for study where a new highway was built that greatly improved the accessibility of a particular location, perhaps at a sub-county level. An example for the Twin Cities region would be the recently-completed U.S. Highway 212.

As mentioned at the end of the preceding section, some other methods for evaluation exist that could be applied to the locations examined in this study. In cases where sales data are abundant, but building and structural attributes are not present, one could construct repeat sales indices for specific locations as a method of indirectly measuring location premiums associated with a highway improvement. Also, where available in sufficiently large numbers, records of raw land sales could be used, though this approach would likely be limited to residential properties. Both of these methods would provide a useful check for the type of analysis conducted in the present study.

We have tested the analysis of property value changes using formal statistical methods as a way to reveal the economic impacts of transportation improvements. Considering the results presented here, the limitations identified in existing data sets, and their implications for empirical analysis methods, we consider this approach at present a complement to existing, project-based methods of analysis. As we identified in our review of analytical approaches to the measurement of economic impacts, the issue of scale is often critical in deciding which method to adopt. For projects where impacts are mostly expected to be sub-regional in scale, the empirical methods employed here may be a useful way to measure the accessibility-related gains due to a highway improvement.

References

[1] Allen, B., C. Baumel, and D. Forkenbrock (1994). Expanding the set of efficiency gains of a highway investment: conceptual, methodological, and practical issues. *Transportation Journal 34*(1), 39–47.

[2] Ambrose, B. W. (1990, Fall). An analysis of the factors affecting light industrial property valuation. *Journal of Real Estate Research 5*(3), 355–370.

[3] Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics 23*, 177–200.

[4] Babcock, M. W. and B. Bratsberg (1998). Measurement of economic impact of highway and bridge construction. *Journal of the Transportation Research Forum 37*(2), 52–66.

[5] Bailey, M. J., R. F. Muth, and H. O. Nourse (1963, December). A regression method for real estate price index construction. *Journal of the American Statistical Association 58*(304), 933–942.

[6] Berechman, J., D. Ozmen, and K. Ozbay (2006, November). Empirical analysis of transportation investment and economic development at state, county and municipality levels. *Transportation 33*(6), 537–551.

[7] Berechman, J. and R. E. Paaswell (2001, Sept./Dec. 2001). Accessibility improvements and local employment: an empirical analysis. *Journal of Transportation and Statistics 4*(2/3), 49–66.

[8] Bina, M. and K. Kockelman (2006, January). Location choice vis-á-vis transportation: the case of recent home buyers. In *Proceedings of the 85th Annual Meeting of the Transportation Research Board.*, Washington, D.C.

[9] Boarnet, M. (1997, March). Infrastructure services and the productivity of public capital: the case of streets and highways. *National Tax Journal 50*(1), 39–57.

[10] Boarnet, M. (1998). Spillovers and the locational effects of public infrastructure. *Journal of Regional Science 38*, 381–400.

[11] Carey, J. and J. Semmens (2003). Impact of highways on property values: case study of the superstition freeway corridor. *Transportation Research Record*, 128–135.

[12] Cervero, R. and M. Hansen (2002). Induced travel demand and induced road investment: a simultaneous equation analysis. *Journal of Transport Economics and Policy 36*(3), 469–490.

[13] Chen, H., A. Rufolo, and K. J. Dueker (1998). Measuring the impact of light rail systems on single-family home values: a hedonic approach with geographic information system application. *Transportation Research Record 1617*, 38–43.

[14] DeCorla-Souza, P. and H. Cohen (1998). Accounting for induced travel in evaluation of urban highway expansion. Online resource, U.S. Department of Transportation, Federal Highway Administration. http://www.fhwa.dot.gov/steam/doc.htm, Accessed on Nov. 2, 2007.

[15] DeCorla-Souza, P., H. Cohen, and K. Bhatt (1996). Using benefit-cost analysis to evaluate across modes and demand management strategies. In *Compendium of technical papers, 66th annual meeting of the Institute of Transportation Engineers*, Washington, D.C., pp. 439–445. Institute of Transportation Engineers: ITE.

[16] DeCorla-Souza, P., H. Cohen, D. Haling, and J. Hunt (1998). Using STEAM for benefit-cost analysis of transportation alternatives. *Transportation Research Record 1649*, 63–71.

[17] Delucchi, M. A. and S.-L. Hsu (1998, October). The external damage cost of noise emitted from motor vehicles. *Journal of Transportation and Statistics 1*(3), 1–24.

[18] Department of Transport and the Environment (2000). Guidance on the Methodologies for Multi-Modal Studies. Technical report, Department of Transport and the Environment. http://www.webtag.org.uk, Accessed on June 5, 2007.

[19] Duffy-Deno, K. T. and R. W. Eberts (1991). Public infrastructure and regional economic development: a simultaneous equations approach. *Journal of Urban Economics 30*, 329–343.

[20] Fishlow, A. (1965). *American Railroads and the Transformation of the Ante-bellum Economy*. Cambridge, MA: Harvard University Press.

[21] Fogel, R. (1964). *Railroads and American Economic Growth: Essays in Econometric History*. Baltimore, MD: Johns Hopkins Press.

[22] Forkenbrock, D. and N. Foster (1990). Economic benefits of a corridor highway investment. *Transportation Research 24*(4), 303–312.

[23] Garcia-Mila, T., T. J. McGuire, and R. H. Porter (1996, February). The effect of public capital in state-level production functions reconsidered. *Review of Economics and Statistics 78*(1), 177–180.

[24] Garrison, W. and D. Levinson (2006). *The Transportation Experience: Policy, Planning, and Deployment*. New York, NY: Oxford University Press.

[25] Goodwin, P. B., C. Hass-Klau, and S. Cairns (1998). Evidence on the effects of road capacity reduction on traffic levels. *Traffic Engineering and Control 39*(6), 348–354.

[26] Graham, D. (2007). Variable returns to agglomeration and the effect of road traffic congestion. *Journal of Urban Economics 62(1)*, 102–120.

[27] Gramlich, E. (1994, September). Infrastructure investment: a review essay. *Journal of Economic Literature 32*, 1176–1196.

[28] Haider, M. and E. Miller (2000). Effects of transportation infrastructure and locational elements on residential real estate values: application of spatial autoregressive techniques. *Transportation Research Record 1722*, 1–8.

[29] Halvorsen, R. and R. Palmquist (1980). The interpretation of dummy variables in semilogarithmic equations. *American Economic Review 70*, 474–475.

[30] Handy, S., K. Kockelman, S. Kubly, S. Srinivasan, J. Jarrett, M. Oden, and H. Mahmassani (2001). Economic effects of highway relief routes on small and medium-size communities. project report 1843-2. Technical report, Texas DOT. Center for Transportation Research, The University of Texas, Austin, TX.

[31] Hansen, M. and Y. Huang (1997, May). Road supply and traffic in Californina urban areas. *Transportation Research, Part A 31A*(3), 205–218.

[32] Harris, B. (2001). Accessibility: concepts and applications. *Journal of Transportation and Statistics 4*(2-3), 15–30.

[33] Haughwout, A. F. (1998). Aggregate production functions, interregional equilibrium, and the measurement of infrastructure productivity. *Journal of Urban Economics 44*, 216–227.

[34] Heiner, J. and K. Kockelman (2005). The costs of right of way acquisition: methods and models for estimation. *Journal of Transportation Engineering 131(3)*, 193–204.

[35] Hills, P. J. (1996, February). What is induced traffic? *Transportation 23*(1), 5–16.

[36] Holtz-Eakin, D. (1994). Public sector capital and the productivity puzzle. *Review of Economics and Statistics 76*, 12–21.

[37] Hughes, W. T. and C. Sirmans (1992, November). Traffic externalities and single-family house prices. *Journal of Regional Science 32*(4), 487–500.

[38] Kim, C. W., T. T. Phipps, and L. Anselin (2003). Measuring the benefits of air quality improvement: a spatial hedonic approach. *Journal of Environmental Economics and Management 45*, 24–39.

[39] Kowalski, J. G. and C. C. Paraskevopoulos (1990). The impact of location on urban industrial land prices. *Journal of Urban Economics 27*, 16–24.

[40] Lee, D. B., L. A. Klein, and G. Camus (1999). Induced traffic and induced demand. *Transportation Research Record 1659*, 68–75.

[41] Levinson, D. and W. Chen (2005). Paving new ground. In D. M. Levinson and K. J. Krizek (Eds.), *Access to Destinations*, Chapter 13, pp. 243–266. Amsterdam, The Netherlands: Elsevier.

[42] Levinson, D. and S. Kanchi (2002). Road capacity and the allocation of time. *Journal of Transportation and Statistics 5*(1), 25–46.

[43] Levinson, D. and R. Karamalaputi (2003). Induced supply: a model of highway network expansion at the microscopic level. *Journal of Transport Economics and Policy 37*(3), 297–318.

[44] Levinson, D. and K. Krizek (Eds.) (2005). *Access to destinations*, Amsterdam, The Netherlands. Elsevier.

[45] Luskin, D. and A. Chandrasekaran (2005). Employer valuations of employee commuting time: case study of office tenants in North Dallas, Texas. *Transportation Research Record 1902*, 10–17.

[46] Luskin, D. and E. Mallard (2005). "Potential gains from more efficient spending on Texas highways". In *Proceedings of the 84th Annual Meeting of the Transportation Research Board, January, Washington D.C.*

[47] Malpezzi, S. (2003). Hedonic pricing models: a selective and applied review. In T. O'Sullivan and K. Gibb (Eds.), *Housing economics and public policy: essays in honour of Duncan Maclennan*, pp. 67–89. Oxford, UK: Blackwell Science.

[48] Martínez, F. (1995). Access: the transport-land use economic link. *Transportation Research 29*, 457–470.

[49] Martínez, F. (2000). Towards a land-use and transport interaction framework. In D. Hensher and K. Button (Eds.), *Handbook of transport modelling*, pp. 145–164. Amsterdam, The Netherlands: Elsevier.

[50] McMillen, D. P. and J. F. McDonald (2004). Reaction of house prices to a new rapid transit line: Chicago's midway line, 1983-1999. *Real Estate Economics 32*(3), 463–486.

[51] McTrans (2007). MicroBENCOST. http://mctrans.ce.ufl.edu/store/description.asp?itemID=166. Accessed June 6, 2007.

[52] Mills, E. S. (1993, Spring-Summer). The misuse of regional economic models. *Cato Journal 13*(1), 29–39.

[53] Mohring, H. (1993). Maximizing, measuring, and not double counting transportation-improvement benefits: a primer on closed- and open-economy cost-benefit analysis. *Transportation research. Part B: methodological 27*(6), 413–424.

[54] Mohring, H. and M. Harwitz (1962). *Highway Benefits: An Analytical Framework*. Published for the Transportation Center at Northwestern University by Northwestern University Press.

[55] Mokhtarian, P. L., F. Samaniego, R. Shumway, and N. Willits (2002). Revisiting the notion of induced traffic through a matched-pairs study. *Transportation 29*(2), 193–220.

[56] Munnell, A. H. (1990, January/February). Why has productivity growth declined? Productivity and public investment. *New England Economic Review*, 3–22.

[57] Nadiri, M. and T. Mamuneas (1996). "Highway capital and productivity growth". In *Economic Returns from Transportation Investment*. Landsdowne, VA: Eno Transportation Foundation, Inc.

[58] Noland, R. (2007). Transport planning and environmental assessment: implications of induced travel effects. *International Journal of Sustainable Transportation 1(1)*, 1–28.

[59] Ozbay, K., D. Ozmen, and J. Berechman (2006, May). Modeling and analysis of the link between accessibility and employment growth. *Journal of Transportation Engineering 132*(5), 385–393.

[60] Parthasarathi, P., D. M. Levinson, and R. Karamalaputi (2003). Induced demand: a microscopic perspective. *Urban Studies 40*(7), 1335–1351.

[61] Peiser, R. B. (1987). The determinants of nonresidential urban land values. *Journal of Urban Economics 22*, 340–360.

[62] Ryan, S. (1999). Property values and transportation facilities: finding the transportation land-use connection. *Journal of Planning Literature 13*(4), 412–427.

[63] Shirley, C. and C. Winston (2004). Firm inventory behavior and the returns from highway infrastructure investments. *Journal of Urban Economics 55*, 398–415.

[64] Sivitanidou, R. and P. Sivitanides (1995). Industrial rent differentials: the case of greater Los Angeles. *Environment and Planning A 27*, 1133–1146.

[65] Srinivasan, S. and K. Kockelman (2002). The impacts of bypasses on small-and medium-sized communities: an econometric analysis. *The Journal of Transportation and Statistics 5(2)*, 57–69.

[66] Srour, I., K. Kockelman, and T. Dunn (2002). Accessibility indices: a connection to residential land prices and location choices. *Transportation Research Record 1805*, 25–34.

[67] Stephanedes, Y. J. (1990). Distributional effects of state highway investment on local and regional development. *Transportation Research Record 1274*, 156–164.

[68] Stephanedes, Y. J. and D. M. Eagle (1986). Highway expenditures and non-metropolitan employment. *Journal of Advanced Transportation 20*(1), 43–61.

[69] Stephanedes, Y. J. and D. M. Eagle (1987). Highway impacts on regional employment. *Journal of Advanced Transportation 21*(1), 67–79.

[70] Ten Siethoff, B. and K. Kockelman (2002). Property values and highway expansion: timing, size, location, and use effects. *Transportation Research Record 1812*, 191–200.

[71] Treyz, G. I., D. Rickman, and G. Shao (1992). The REMI economic-demographic forecasting and simulation model. *International Regional Science Review 14*, 221–253.

[72] van Wee, B., M. Hagoort, and J. A. Annema (2001). Accessibility measures with competition. *Journal of Transport Geography 9*, 199–208.

[73] Vilain, P., L. N. Liu, and D. Aimen (1999). Estimate of commodity inflows to a substate region: an input-output based approach. *Transportation Research Record 1653*, 17–26.

[74] Wang, F. T. and P. M. Zorn (1997). Estimating house price growth with repeat sales data: what's the aim of the game? *Journal of Housing Economics 6*, 93–118.

[75] Weisbrod, G. E. and M. Grovak (1998). Comparing approaches for valuing economic development benefits of transportation projects. *Transportation Research Record 1649*, 86–94.

[76] Weisbrod, G. E. and F. Treyz (1998, October). Productivity and accessibility: bridging project-specific and macroeconomic analyses of transportation investment. *Journal of Transportation and Statistics 1*(3), 65–79.

[77] Weiss, M. and R. Figura (2003). Provisional typology of highway economic development projects. *Transportation Research Record 1839*, 115–119.

[78] Williams, M. and J. Mullen (1998, October). Highway capacity spillover and interstate manufacturing activity. *International Journal of Transport Economics 25*(3), 287–295.