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Transportation Investment and Economic Development in Minnesota Counties

Zhirong Jerry Zhao, Principal Investigator
Humphrey School of Public Affairs
University of Minnesota

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16. Abstract (Limit: 250 words)

This project examines the link between accumulated transportation capital stocks in Minnesota counties and their annual property tax revenues using longitudinal data in the 1995-2011 period. We separated the effects of two different transportation capital stocks, one associated with load roads and the other with trunk highways. In addition, we considered not only the internal effect of transportation investments within a county, but also the spillover effect due to transportation investments made in neighboring counties.

Estimations from panel-data regressions show that local-road capital stocks within a county have a positive effect on its property tax revenues, with an elasticity of 0.093, but much of the benefits may be the outcome of a zero-sum game due to inter-local competition of property tax bases. Trunk-highway capital stocks within a county also show a positive effect, with an elasticity of 0.013. The spillover effect of trunk-highway development is even higher: The average level of trunk-highway capital stocks in neighboring counties has a positive elasticity of 0.030 on a county's property tax revenues.

Applying the estimations to the county data in FY2010, we calculated the ROI (return of investment) of additional transportation investments on property tax bases. The average ROI on the growth of EMV (Estimated Market Values) within a county is about 1.254 for local roads, and about 0.871 for trunk highways. The regional impact would be reduced for local roads due to the inter-local competition, but significantly amplified for trunk highways due to spillover benefits.

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Transportation Investment and Economic Development in Minnesota Counties

Prepared by:

Jerry Zhao

Associate Professor
Humphrey School of Public Affairs
University of Minnesota

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Executive Summary

A widely discussed issue about transportation development in the United States is insufficient funding for road investments. Across the level of governments there is a lack of incentive to fund transportation, which may in part be explained by the fact that it is often unclear what benefits can be brought about by transportation development and how the benefits are distributed. To assist informed policy decision-making on US transportation development, we need to do a better job of examining the benefits of transportation, analyzing how the benefits are distributed, and communicating these findings to the public. Focusing on fiscal returns to local governments, this project examines the link between accumulated transportation capital stocks in Minnesota counties and their annual property tax revenues using longitudinal data in the 1995-2011 period.

In this project, the basic method is a conventional economic-development production function at the county-level augmented by transportation capital stocks. But we focus on local property tax revenues instead of typical economic output measures. Two separate stocks are used to distinguish the impacts of load roads and trunk highways. Not only do we consider transportation capital stocks for each county, but we also look at the average level of these stocks in their surrounding counties to account for potential benefit spillovers of transportation improvement. In the models, we also control for a set of county-level socioeconomic and demographic factors that tend to affect local property tax revenues. The econometric models are enhanced by spatial data analysis based on Geographic Information Systems (GIS). Before we estimate the statistical models, GIS mapping is used to visualize spatial patterns of transportation investments and property tax revenues across Minnesota counties. After getting model estimates, we apply model coefficients to project the change in property tax revenues across Minnesota counties and use maps to illustrate the corresponding growth of property tax bases, or Estimated Market Values (EMV). The use of spatial data analysis not only enables us to assess transportation benefits both within a county and across boundaries, but it also provides a convenient tool for public communication and public engagement.

Estimates from panel-data regressions show that local-road capital stocks within a county have a positive effect on its property tax revenues, with an elasticity of 0.093. Nevertheless, local-road capital stocks in neighboring counties have a negative effect, with an elasticity of -0.085. The results indicate that local-road investments generate substantive property-tax returns for a county, but much of the benefits may be the outcome of a zero-sum game due to inter-local competition of property tax bases. Like local-road capital stocks, trunk-highway capital stocks within a county also show a positive effect on property tax revenues; the elasticity is 0.013. What is more striking is the spillover effect of trunk highway development. We find that the average level of trunk-highway capital stocks in neighboring counties has an even larger effect on a county's property tax revenues, with an elasticity of 0.030. Adding the internal effect and spillover effect, trunk-highway investments in a county lead to substantive regional benefits, both within a county and across its boundaries. Applying the estimates of internal effects to the county data in FY2010, we calculated ROI (return of investment) of additional transportation investments. On average, an additional dollar of local-road investments within a county will lead to more property tax revenues within the county equivalent to $1.254 in the growth of EMV.

Likewise, an additional dollar of trunk-highway investments within a county will lead to property-tax benefits equivalent to $0.871 of EMV growth. If the external impacts are also considered, the total regional benefits of trunk-highway investments are almost quadrupled, with ROI reaching about 2.881.

The results have significant policy implications. As local-road capital stocks intensify the competition of economic activities (and hence property bases) across county boundaries, local governments concerned about their economic competitiveness, especially in comparison with their neighboring counties, shall consciously invest in their local roads. As trunk-highway capital stocks generate substantial local and regional benefits, counties may have more incentive to collaborate with neighboring counties in related projects, which may be jointly funded and planned at the state or regional level.

While the regression analysis may seem complicated and the results general, county engineers are encouraged to download and use the compiled data to assist local decision-making about transportation investments in several ways. The first application is for trend analysis and cross-jurisdictional comparisons. With the complete information of local-road capital stocks and trunk-highway capital stocks at the county level during 1995-2011, a county could develop a historical view about the trends of transportation development within the county, and then compare the stocks to those of other counties, which could be neighboring counties or others that are considered comparable or competing peers. The second application is to illustrate the link between historical transportation investment and the growth of tax bases. While this report focuses on the change in property tax revenues, the compiled data also include federal taxable income and gross sales. With the longitudinal data, a county could plot the change in its capital stocks over time alongside the change in its tax bases (property, income, or sales) and then examine the correlations during different periods of time. While such comparisons do not provide conclusive evidence about possible causal relationship among these variables, often they lead to meaningful observations for policy discussions, or practical hypothesis that can be further tested with future research employing more rigorous methods. Lastly, county engineers may use the elasticities found in this research to project the benefit of future transportation investment. The elasticity can be interpreted as a percentage-to-percentage change. With data about the current level of transportation capital stocks and property tax revenues, it would be convenient to calculate ROI (return of investment) for some additional amounts of transportation investment in each county. In this calculation, counties with lower accumulated capital stocks (relative to their property bases) would be shown to have larger ROIs, that is, much higher dollar-to-dollar benefits that could be generated through additional transportation funding.

The project may lay a solid foundation for several additional future research projects. We could further examine the link between transportation development and property tax changes under different circumstances. The impacts of transportation investment could differ depending on the type of counties, by the stages of roadway development, or by the categories of roadway projects. Additional research along this line could shed more light on the value of transportation improvement, with ample policy implications. We may extend the focus to other aspects of fiscal returns, such as the changes of income and sales tax bases. With a more complete knowledge of how transportation improvement affects different tax bases, we can then estimate how transportation-related tax benefits are distributed across levels of government. Along with an examination of transportation revenue contribution across localities, we can also study the potential spatial mismatch between resource allocation and benefit distribution associated with transportation.

Chapter 1: Introduction

A widely discussed issue about transportation development in the United States is insufficient funding for road investments. Across the level of governments there is a lack of incentive to fund transportation, which may in part be explained by the fact that it is often unclear what benefits can be brought about by transportation development and how the benefits are distributed. Without a strong evidence of benefits, the public will not support the use of additional revenues to fund transportation. Without knowing how the benefits are distributed, it is difficult to design proper fiscal arrangements to share the responsibilities across levels and units of governments. Hence an important discourse about transportation development is to do a better job of examining the benefits of transportation, analyzing how the benefits are distributed, and communicating these findings to the public. In this project, we aim to study fiscal returns of roadway development to local governments across Minnesota counties using longitudinal data in the 1995-2011 period.

There has been a body of literature on the impact of transportation investment on economic development. These studies typically measure economic development as demotic products, job creation, or salary growth, and then use a conventional production function of economic development augmented by public capital inputs, such as highway, rail, or other transportation investments. The findings, in general, confirm a positive elasticity between transportation investment and economic outputs, but the range of effects varies widely across studies. A unique contribution of this study is that we focus on fiscal returns of roadway development to local governments, in particular, the connection between long-term accumulated transportation capital stocks and property tax revenues of Minnesota counties. Fiscal returns as additional property tax revenues will provide local governments more incentives to fund transportation. Furthermore, spatial distribution of such returns can facilitate the joint efforts across localities to support projects that are expected to create significant regional benefits.

We use two separate stocks to account for the impacts of load roads and state trunk highways. Besides transportation capital stocks for each county, we also look at the average level of these stocks in their surrounding counties to account for potential benefit spillovers of transportation improvement. In the models, we also control for a set of county-level socioeconomic and demographic factors that tend to affect local property tax revenues. The econometric models are enhanced by spatial data analysis based on Geographic Information Systems (GIS). Before we estimate the statistical models, GIS mapping is used to visualize spatial patterns of transportation investments and property tax revenues across Minnesota counties. After getting model estimates, we apply model coefficients to project the change in property tax revenues across Minnesota counties and use maps to illustrate the corresponding growth of property tax bases, or Estimated Market Values (EMV). The use of spatial data analysis not only enables us to assess transportation benefits both within a county and across boundaries, but it also provides a convenient tool for public communication and public engagement.

Our results show that local road capital stocks and trunk highway capital stocks both have significant positive effects on property tax revenues, but in different ways. Local road capital stocks within a county seem to have a larger internal effect for the county itself, but much of the benefits may come from inter-local competition of property tax bases. Trunk highway stocks have a smaller internal effect, but they also lead to substantial external benefits. The impacts of transportation capital stocks on property tax revenues can be translated into an equivalent increase in EMV. Applying estimated transportation impacts to actual data of Minnesota counties in FY2010, we also calculated ROI (return of investment) of additional transportation investments on EMV.

This project enhances the LRRB knowledge-building priority of “Funding, Communications, and Public Engagement.” End users include local policy makers, the state transportation department and the general public. Findings from the study have multiple implications. It will facilitate local policy makers in making informed decisions to fund transportation; it may enhance state-level decisions on the allocation of state transportation aid; and it can help engage the general public to better understand the importance of local road investments as well as proper ways to improve the current mechanism of local road funding.

The rest of the report is organized as follows. Section 2 provides a brief review of the literature on economic benefits of transportation development. Section 3 discusses typical research methods that are employed in this line of research, and the specific approaches used in this report. Section 4 explains data sources. Section 5 presents the findings, and Section 6 concludes.

Chapter 2: Literature Review

The conventional wisdom holds that increased urban infrastructure improves productivity. The 1994 World Development Report shows that a one percent increase in infrastructure stock across all countries correlates with a one percent increase in GDP (World Bank, 1994). However, empirical studies using different methods and data from different countries do not provide consistent evidence whether there is a significant relationship between public infrastructure capital and economic growth (Aschauer 1989; Holtz-Eakin, 1994; Cashin, 1995; Baltagi and Pinnoi, 1995). In a seminal paper, Aschauer (1989) finds that the stock of public infrastructure capital is a significant determinant of aggregate total factor productivity. After that, many empirical studies have been carried out to examine the relationships between infrastructure capital investment and economic development with increasingly sophisticated econometric techniques over time (Gramlich 1994).

A large part of the literature uses US data to estimate the impact of public capital stock on the output of different economic sectors, employing a production function model with a similar structure. Their output elasticity results vary widely, probably caused by differences between studies relative to spatial level of analysis, definition of capital stock, estimation techniques, or underlying models (Ozbay et al 2007). Holtz-Eakin (1994) applied a production function to state-level data consisting of output, labor, private capital, and state and local government capital. He found a significant impact of public sector capital on private output. Munnell (1990) estimated a model in which public capital affects output, employment growth, and private investment, controlling for level of technology, private capital stock and labor stock. The results confirmed that, at the state level, public capital has a significant positive impact on output.

Studies focused on transportation infrastructure in US often examine indirect effects beyond jurisdictional boundaries, which may happen due to a relocation of economic activity (Forkenbrock and Foster 1990), the spillover of benefits (Munnell 1992). Boarnet (1996) examined how highway investments redistribute economic activity, but dividing the economic impacts of transportation infrastructure into a direct effect (near a street or a highway) and indirect effect (more distant from the highway corridor). He concluded that the direct and indirect effects were equal in magnitude with opposing signs. Munnell (1992) found that transportation investment in one state not only promote economic development in the state but also have indirect benefits on neighboring states. Holtz-Eakin and Schwartz (1995) measured the indirect effect of highway capital investment on neighboring state, but the results rejected the hypothesis of positive output spillovers. Chandra and Thompson (2000) used US data for the period 1969-1993 and found that investments in interstate highways raised economic growth in counties the highways pass directly through, but the growth is at the expense of adjacent counties which suffer a decrease in economic growth. Berechman, Ozman, and Ozbay (2006) examined the elasticity of transportation investment on economic development with multiple levels of data from states, counties, and municipalities from 1990 and 2000, and found the effects to have both spatial spillovers and time lags.

Mixed results are found in related studies conducted in other countries. Berndt and Hansson (1992) measured the contribution of public infrastructure capital to private sector output and productivity in Sweden using annual data from 1960-1988. They found that increases in public infrastructure capital reduce private sector costs. Kavanagh (1997) estimated an aggregate production function for Ireland with the stock of public infrastructure as an added explanatory variable. She found a statistically insignificant elasticity between public capital and private sector output, and suggested several reasons to explain the insignificance, one possibility being the poor utilization of the public capital. Mamatzakis (1999) examined whether a long-run relationship between public capital stock and private sector productivity exists using data from Green between 1959 and 1993. The study found a strong output elasticity of public capital stock, emphasizing the importance of infrastructure for the productivity of the industrial sector. Kemmerling and Stephan (2002) estimated the contribution of infrastructure accumulation to private production using a panel of 87 German cities for the years 1980, 1986, and 1988, with a simultaneous-equation approach. They found that publication capitals significantly affect private production, and that the simultaneity between output and public capital is weak. Thus the causality direction is clear and the feedback effects are negligible. Bosca et al. (2002) analyzed the effects of infrastructure on the cost and productivity performance of the private productive sector of Spanish regions over the period 1980-1993 using a dual approach based on cost functions. The results indicated that the public sector has contributed significantly to enhance productivity and reduce costs in the private sector of almost every Spanish region. Recognizing the fact that most of the research attempting to link infrastructure to economic development has focused on developed nations, Ozment (2006) turned to developing countries of Africa, using data from the Central Intelligence Agency's World Factbook between 1981 and 1993. The change in kilometers of rail line, the kilometers of paved highways, and the number of airports with permanent runways were found to be highly significant and positively related to GDP per capita in those countries.

Another stream of literature examines the impact of infrastructure on long-term growth, which is typically defined as the annual change of per capita GDP. In a cross-country study of the growth impact of government spending, Easterly and Rebelo (1993) found that public expenditure on transport and communications significantly raises growth, but the effects of taxation are difficulty to isolate empirically. In contrast, Devarajan et al. (1996) found a negative relationship between the share of infrastructure expenditure in total expenditure and economic growth for a sample of 43 developing countries. They argued that this result may be due to the fact that excessive amounts of transportation and communication expenditures in those countries make such expenditures unproductive. In another cross-country study, Sanchez-Robles (1998) found that summary measures of physical infrastructure are positively and significantly related to growth in GDP per capita. In an unpublished manuscript, Easterly (2001) reported that a measure of telephone density contributes significantly to explain the growth performance of developing countries over the last two decades. In an Work Bank report, Loayza, Fajnzylber and Calderón (2003) examined the main stylized facts of growth in Latin America and the Caribbean countries compared to typical countries in the world over the 1960-2000 period, and found that that the same telecommunications indicator is robustly related to growth in a large panel data set including both industrial and developing countries.

The main focus of this project is the impact of transportation on the growth of local property tax revenues. The impact is important because local governments would have more incentive to fund transportation if they see sufficient paybacks as increased property tax revenues. No previous literature has been found to establish such a link. With a complete longitudinal data of annual property tax, transportation investments, and some other socioeconomic variables, the 87 Minnesota counties provide an ideal context to bridge this gap in the literature.

Chapter 3:Research Methods

In the first stream of studies that we reviewed in the previous section, the impact of public infrastructure on economic output is typically examined with a conventional economic-development production function model augmented by local transportation capital stock. It can be expressed as:

$$O_{i,t} = f(L_{i,t}, K_{i,t}, PK_{i,t}) \tag{1}$$

where O is the economic output, L is labor condition, K is private capital stock, and PK is public capital stock, with *i* and *t* denoting individual governmental unit (locality) and specific year, respectively. Public capital stock is calculated by adding previous year's capital stock ($PK_{i,t-1}$) adjusted by depreciation (δ) and new infrastructure investment ($I_{i,t}$):

$$PK_{i,t} = (1- \delta)PK_{i,t-1} + I_{i,t} \tag{2}$$

A methodology concern about the basic model is the possible spillover effect of infrastructure facilities, in that a locality's economic output may be affected not only by its own capital stock but also by the capital stock of neighboring localities. This concern could be addressed by including a spatially weighted measure of capital stock in neighboring local governments:

$$O_{i,t} = f(L_{i,t}, K_{i,t}, PK_{i,t}, wPK_{j,t}) \tag{3}$$

where $PK_{j,t}$ refers to public capital stock of other local governments, and *w* is the spatial weight matrix that may be determined by whether a local government *j* shares a common border with locality *i*, or by the inverse distance between locality *i* and *j*.

In the second stream of empirical literature, the dependent variable is typically the annual difference in logged per capita GDP. In cross-country studies, the regressors may include several categories of common growth determinants (For a detailed review, see Loayza et al, 2005). The first factor is a country's initial GDP, because countries with a lower development level tend to have higher rates of growth due to "transitional convergence." Then there is a set of factors about "structural policies and institutions," including physical capital, human capital, financial development, trade openness, government burden, income inequality, governance, and infrastructure stocks. Another set of factors are related to "stabilization policies," such as inflation, real exchange rate, overvaluation, and financial crisis. Lastly, economic growth is also affected by external conditions, such as terms of trade shocks and capital flows.

At the subnational level, some of these factors, such as stabilization policies and external conditions, may be omitted due to the lack of variation within the same country. On the other hand, with interconnected markets and integrated regional infrastructure systems, there is a higher likelihood of benefit spillovers and thus the need to incorporate infrastructure stocks and some other conditional of neighboring localities.

Unlike previous studies, in this project the key dependent variable is annual property tax revenues in Minnesota counties. Thus we do not follow the standard production function, but instead replace labor and private capital stocks with county-level socioeconomic and demographic factors to assess the conditional effect of transportation stocks on the growth of property tax revenues. These control variables include population, age structure, population density, personal income, education attainment, and the level of urbanization, all of which are assumed to also affect local property tax revenues.

We use the abovementioned approach (Equation 2) to calculate two transportation capital stocks since 1995. One is about local road investments (including construction and maintenance) and the other about trunk highway investments (including construction and maintenance). In the calculation, we use a 2% annual depreciation rate that is suggested by the U.S. Bureau of Economic Analysis (2004). We also assume that, in 1995, the annual investments on either local roads or trunk highways were made at the 2% replacement level, so that each county would have the same amount of capital stocks, on either local roads or trunk highways, between 1994 and 1995. This assumption enables us to establish the baseline amounts for the two capital stocks in 1995, and then we move on to calculate capital stocks for all subsequent years, by subtracting 2% annual depreciation and adding newly incurred annual construction and maintenance costs.

As transportation development tends to have benefit spillovers, road investments made within one county (especially those on trunk highways that serve more regional purposes) may have positive economic impacts on neighboring counties. On the other hand, a county may enjoy an increased level of economic activities and tax base growth if substantive amounts of road investments are made on its neighboring counties, either because of a higher level of regional accessibility or due to indirect benefits as neighboring counties are improved economically. In this project, we take into consideration the benefit spillover of transportation by also examining how a county's property tax revenues are affected by transportation capital stocks of neighboring counties. Technically, we do it by including in our models the spatial-lag terms for the transportation capital stocks. The spatial lags are created with "rook" contiguity-based spatial weights, that is, counties are defined as neighboring ones if they share at least a common border. In this way, the spatial lag of a particular capital stock for a county is essentially the average level of said capital stock in all of its direct surrounding counties.

In our project, the econometric models are enhanced by spatial data analysis based on Geographic Information Systems (GIS). Before we estimate the statistical models, exploratory spatial-data analysis with GIS mapping is used to visualize spatial patterns of transportation investments and property tax revenues across Minnesota counties. After getting model estimates, we apply model coefficients to project the change in property tax revenues across Minnesota counties, and use maps to illustrate the corresponding growth of property tax bases (Estimated Market Values, EMV). More details of the analysis processes and the corresponding results will be presented in Section 5.

Chapter 4: Data Collection

In this project, transportation investment data come from two sources. One is the annual "Minnesota County Finances Report" compiled by Minnesota Office of the State Auditor since 1985. On the revenue side, this data include federal and state grants that are allocated for "Streets and Highways." On the expenditure size, this data include construction, maintenance, and administration outlays for "Streets and Highways." This data source provides the information about local road investments that are managed by counties. Another source is the "Trunk Highway Construction and Maintenance Costs" provided by Minnesota Department of Transportation (MnDOT). Available during the period 1995-2012, this data include annual trunk highway costs (construction and maintenance) that are allocated to each Minnesota counties based on highway segments. This data source provides the information about system-wide state trunk highway investments that are managed by MnDOT. From the MnDOT website, we also collected Minnesota Highway Construction Cost Index (MHCCI) during 1995-2011. Annual fiscal variables about transportation investments were first adjusted with MHCCI (with 2000 as the base year) before they were used to calculate the accumulated transportation capital stocks.

We measure economic development in a Minnesota county by the growth of its property tax. Four related variables have been included in our data collection. From Minnesota Office of the State Auditor, we got data about property tax capacity, property tax levy, and property tax revenues during 1985-2011. From Minnesota Department of Revenue, we got data about total Estimated Market Values (EMV) of each county during 2006-2011. Although it would be helpful to examine the link between transportation capital stocks and the change in EMV, in this report we decided not to use EMV as the dependent variable of regression models, because the data only cover a short period of time, and, what is even worse, a period of time with tremendous housing value changes due to the subprime mortgage crisis. Among the three property-tax variables from Minnesota Office of the State Auditor, we focused our analysis on property tax revenues that were actually collected each year. Before statistical modeling, property tax amounts were adjusted to Consumer Price Index (CPI)(with 2000 as the base year) collected from US Bureau of Labor Statistics to account for inflation.

Socioeconomic and demographic data that serve as control variables come from multiple sources. We collected data about population, population age groups, poverty, and education attainment from US Bureau of Census. Labor and employment data were gathered from Bureau of Labor Statistics. Some of these data could be directly downloaded, together with county-level GIS base-maps, from the National Historical Geographic Information System operated by Minnesota Population Center, University of Minnesota. Data about governmental size, measured as annual revenues or expenditures, are collected from Minnesota Office of State Auditor. Household and personal income data are gathered from Bureau of Economic Analysis. (Data for this research project, including variables that are collected or processed, are available for download through https://netfiles.umn.edu/xythoswfs/webview/_xy-16428505_1.)

Chapter 5: Analysis and Results

The focus of this study is the link between transportation capital stocks and property tax revenues in Minnesota counties. The analysis is conducted in three steps. In the first step, we calculated two transportation capital stocks and compared them with county property tax revenues using descriptive statistics (See Table 5.1) and GIS visualization (See Figure 5.1 & 2). In the second step, we used panel-data regressions to assess the link between transportation capital stocks on property tax revenue, holding constant socioeconomic and demographic features of Minnesota counties. Lastly, we applied model estimation results to illustrate the size of value-added impact due to transportation investments.

5.1 Descriptive statistics and GIS visualization

One transportation capital stock is related to local road investments incurred by the counties, and the other about trunk highway construction and maintenance administered by MnDOT within each county. Annual transportation expenditures were adjusted with Minnesota Highway Construction Cost Index (based year = 2000) before they were used to calculate the accumulated capital stocks. As Minnesota counties vary significantly with each other in terms of population and area, from policy perspective it is not quite meaningful to direct compare the amounts of capital stocks across counties. We normalized these amounts by county areas, because the accessibility of transportation is closely related to roadway density, especially in rural areas of the Greater Minnesota. Hence we got two county-level variables with annual variations, one is local road capital stock per square mile （LOCAL) and the other, trunk highway capital stock per square mile (TRUNK).

Table 5.1 shows that the two transportation stocks fluctuated over the 16-yeaer period but remained essentially at a similar level. The accumulated local road capital stock (LOCAL) stayed about $0.5 million per square mile, wile the accumulated trunk highway capital stock (TRUN) stayed about $0.17 million per square mile. The results indicate that annual construction and maintenance expenditures were incurred simply at the 2% depreciation and replacement level. In general, Minnesota counties did not receive additional investments to enlarge their transportation capital stocks either on local roads and trunk highways. Taking a closer look of annual fluctuations, we see that the two stocks reached their highest levels around 2006 and have been decreased since then, suggesting the decreased roadway expenditures in recent years at both state and local level due to budget shortfalls.

We used GIS techniques to generate the spatial lag of these two transportation stocks, denoted as LOCAL.W and TRUNK.W, respectively. These two variables reflect the average level of local road and trunk highway capital stocks per square mile in neighboring counties. As is expected, in Table 5.1, the two spatial-lag terms stayed at similar levels with the two transportation capital stocks, and they fluctuated in the same direction across years.

We took similar procedures to measure the variation of property tax across counties and over time. The property tax revenues were first adjusted with customer price index (base year = 2000) to account for annual inflations, and then were normalized by county areas to get property tax revenues per square mile (PTR). Unlike transportation capital stocks, the average level of property tax revenues actually went up steadily during the study period, from about $0.33 million per square mile in 1995 to about $0.39 million per square mile in 2011. Property tax revenues went up even in the recent five years, despite the decease of housing prices due to the subprime mortgage crisis. A possible explanation is that local governments have been raising their tax efforts to keep up with the raising cost of public service delivery and the reduction of state government grants. The fact that local road investments have not caught up with local property tax revenues indicate that transportation investments have failed to compete with some other service areas during recent times of local fiscal stress.

Table 5.1: Property Tax Revenues and Transportation Capital Stocks (1995-2011)

Year	PTR	LOCAL	LOCAL.W	TRUNK	TRUNK.W
1995	$32,556	$548,025	$539,606	$122,376	$119,519
1996	$33,021	$548,990	$540,787	$127,878	$125,143
1997	$33,964	$549,360	$541,056	$132,604	$130,480
1998	$34,969	$547,540	$539,377	$138,027	$135,989
1999	$35,512	$547,056	$538,992	$143,212	$141,555
2000	$35,101	$547,603	$539,670	$148,255	$146,925
2001	$36,513	$548,112	$540,270	$153,565	$152,354
2002	$35,417	$549,105	$541,137	$160,681	$159,498
2003	$36,106	$550,065	$541,761	$169,031	$168,734
2004	$37,323	$550,141	$541,996	$176,489	$176,841
2005	$38,633	$549,528	$541,427	$183,935	$184,343
2006	$40,301	$549,370	$541,380	$190,625	$190,472
2007	$43,364	$549,226	$541,328	$196,697	$195,980
2008	$44,198	$546,905	$539,272	$201,933	$201,361
2009	$46,613	$545,248	$537,723	$207,348	$206,782
2010	$47,438	$543,807	$536,382	$212,224	$211,369
2011	$46,738	$542,011	$534,909	$215,823	$214,624
Averange	***$38,692***	***$547,769***	***$539,828***	***$169,452***	***$168,351***

PTR	Property tax revenues per square mile
LOCAL	Local road capital stock per square mile
LOCAL.W	Local roads capital stock per square mile in neigboring counties
TRUNK	Trunk highway capital stock per square mile
TRUNK.W	Trunk highway capital stock per square mile in neighboring counties

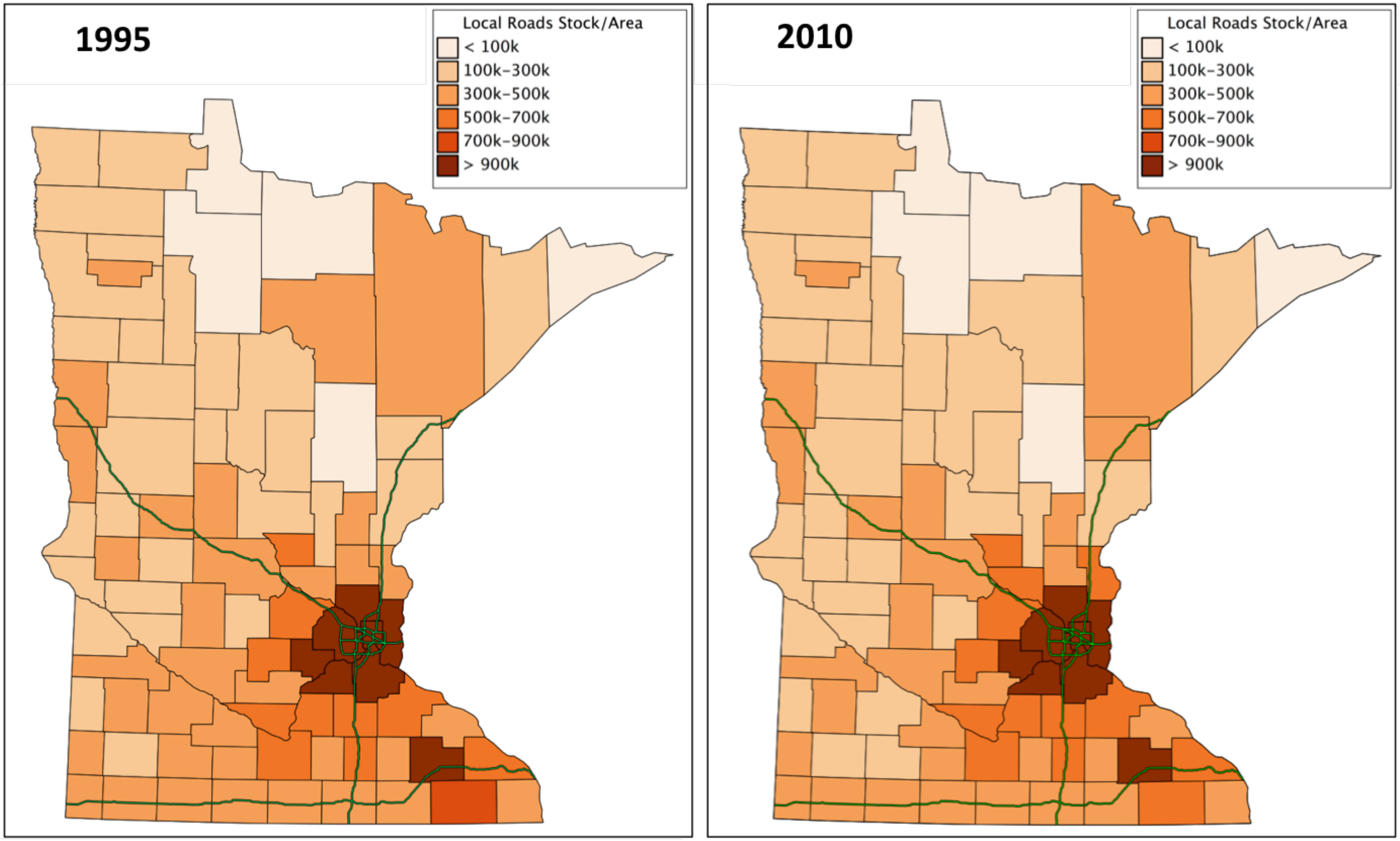

Figure 5.1: Local road Capital Stocks in Minnesota Counties, 1995 and 2010

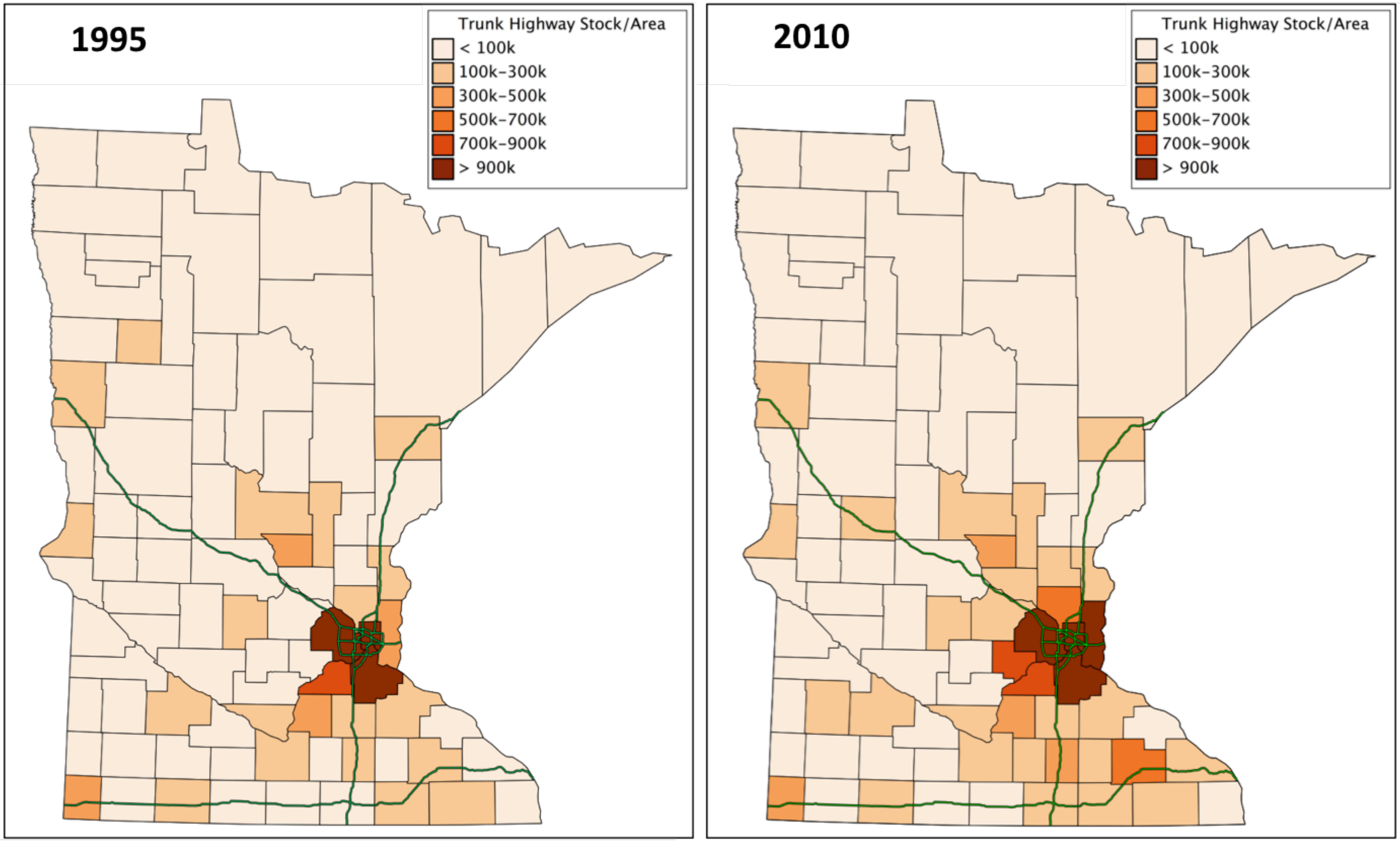

Figure 5.2: Trunk Highway Capital Stocks in Minnesota Counties, 1995 and 2010

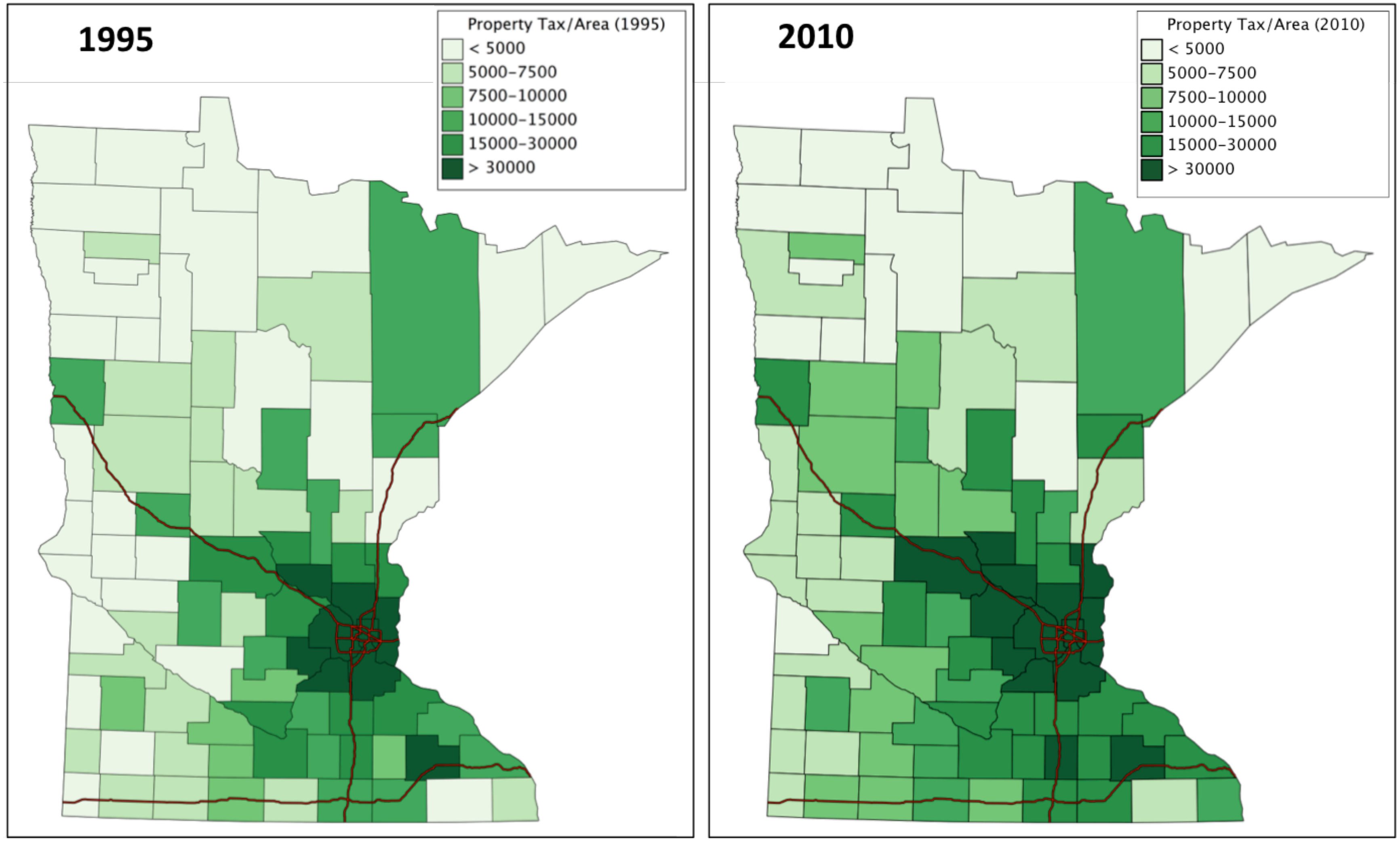

Figure 5.3: Property Tax Revenues in Minnesota Counties, 1995 and 2010

Figure 5.1 compares local road capital stocks (per square mile) across Minnesota counties in 1995 and 2010; Figure 5.2 provides similar comparison for trunk highway capital stocks (per square mile). In both panels of Figure 5.1, we see much higher level of load road stocks in the Twin Cities metropolitan statistical area (MSA) as well the Rochester MSA. No much difference can be discerned between the 1995 panel and the 2010 panel, suggesting that there has been no significant change of regional patterns in local road investments. In Figure 2, we see substantive increases of trunk highway capital stocks around the Twin Cities metro counties, the Rochester MSA, and the southeast part of the state in general. (Counties can use the calculated transportation capital stocks and these maps to make further comparisons across localities. Caution should be noted that whether some visible changes can be discerned by comparing maps is to some extent depending on the categorization in mapping.)

Some could also compare Figure 5.1 and Figure 2 directly since we used the same scales in both figures. The comparison clearly shows the fact that, within each county, the total amount of load road investments over time is much larger than that of trunk highways within the county. Figure 5.3 shows property tax revenue per square mile across Minnesota counties in 1995 and in 2010. Over the 17 years, we see substantive growth of property tax revenue in a large number of counties.

5.2 Panel-data regressions

In this step, we employed panel data regressions to study the impact of transportation capital stocks on property tax revenues using data of Minnesota counties during 1995-2011. The dependent variable is property tax revenue per square mile (PTR). The key independent variables include the two transportation capital stocks (LOCAL and TRUNK) and their spatial-lag terms (LOCAL.W and TRUNK.W). All these four variables are expected to have positive effects on PTR, and thus we developed the following hypotheses:

H_1 (Local road value-added): *Counties with higher local road capital stocks per square mile (LOCAL) tend to have higher property tax revenues per square mile (PTR).*

H_2 (Trunk highway value-added): *Counties with higher trunk highway capital stocks per square mile (TRUNK) tend to have higher property tax revenues per square mile (PTR).*

H_3 (Local road benefit spillover): *Counties with higher local road capital stocks per square mile in their neighboring counties (LOCAL.W) tend to have higher property tax revenues per square mile (PTR).*

H_4 (Trunk highway benefit spillover): *Counties with higher trunk highway capital stocks per square mile in their neighboring counties (TRUNK.W) tend to have higher property tax revenues per square mile (PTR).*

Following the transportation-impact literature (for instance, Berechman, Ozman, and Ozbay 2006), we conducted log-transformations for PTR and the four capital-stock variables. Thus the coefficients can be differently interpreted as elasticities indicating percentage-to-percentage changes.

Table 5.2: Variable Explanations and Descriptive Statistics

	Mean	St.D.	Min	Median	Max	N
PTR	$38,692	$141,934	$789	$8,077	$1,298,074	1479
LOCAL	$547,769	$915,027	$59,685	$328,606	$7,328,625	1479
LOCAL.W	$539,828	$578,379	$98,491	$327,077	$2,926,385	1479
TRUNK	$169,452	$380,288	$0	$57,175	$3,765,881	1479
TRUNK.W	$168,351	$248,813	$304	$81,126	$1,626,026	1479
POP	57,968	139,028	3,530	21,676	1,169,151	1479
POPDEN	116.6	390.3	2.2	25.6	3147.4	1479
PCINCOME	$26,596	$4,686	$16,450	$26,042	$46,274	1479
BELOWHS	14.84%	4.92%	3.90%	14.40%	30.20%	1479
UNDER18	25.20%	2.54%	16.34%	25.12%	33.51%	1479
OVER65	15.18%	4.78%	4.48%	15.56%	27.79%	1479
URBAN	12.44%	27.62%	0.00%	0.00%	99.90%	1479

PTR	Property tax revenues per square mile
LOCAL	Local road capital stock per square mile
LOCAL.W	Local road capital stock per square mile in neigboring counties
TRUNK	Trunk highway capital stock per square mile
TRUNK.W	Trunk highway capital stock per square mile in neighboring counties
POP	Population
POPDEN	Population density per square mile
PCINCOME	Per capita personal income (in 2000 dollar)
BELOWHS	Percentage of population below high-school education
UNDER18	Percentage of population under age 18
OVER65	Percentage of populaton over age 65
URBAN	Percentage of population living in urbanized areas

We also control for variables that reflect socioeconomic and demographic features of Minnesota counties. We experimented different model specifications. Some control variables that are highly correlated with others were later removed to make the models more robust and parsimonious. The final models include the following control variables: population (POP), population density (POPDEN), per capita personal income (PCINCOME), percentage of population below high-school education (BELOWHS), percentage of population under age 18 (UNDER18), percentage of population over age 65 (OVER65), and percentage of population living in urbanization areas (URBAN). POP, POPDEN and URBAN are expected to have positive impacts because urbanized and more densely populated areas tend to have higher demands on properties and thus may drive up property tax values and property tax revenues. PCINCOME is expected to have a positive impact, while BELOWHS is expected to have a negative impact, because property tax values and property tax revenues shall be positively correlated with higher income and education level. According to public choice literature, variables about the age structure of population (UNDER18 and OVER65) tend to affect the level of local public services, but the directions of impact may go both ways. Table 5.2 provides explanations and descriptive statistics for the variables that are included in the final models, which are reported in Table 5.3 & 5.4.

The regressions involve a balance panel of 1479 observations (87 Minnesota counties over a 17-year period). We started by comparing different panel-data models to determine the best fit for this empirical setting. Table 5.3 shows the results of four different models. The "Internal" models focus on the two transportation capital stocks (LOCAL and TRUNK), while the "Combined" models also include the two spatial-lag terms (LOCAL.W and TRUNK.W) and thus take into account not only the internal effects of transportation investments in a county but also possible benefit spillovers due to transportation investments in neighboring counties. In pooling models, all of the 1479 observations from different years are pooled together to conduct OLS regressions. In fixed-effects models, we also controlled for county-specific dummy variables, thus to account for fixed effects due to time-invariant county-level variables that are not included as control variables. With regression diagnostics, we decided that the fixed-effects models are more appropriate than the pooling models. In addition, between the two fixed-effects models, the "Internal" one (column 3) yields more robust results than the "Combined" one, because including all four transportation stocks (LOCAL, TRUNK, LOCAL.W, and TRUNK.W) would lead to a high level of multicollinearity.

In Table 5.4, we focused on the fixed-effects approach to compare models with different combination of the four transportation stocks. M1 focuses on local road capital stocks, including the internal effect of LOCAL and the spillover effect of LOCAL.W. In contrast, M2 focuses on trunk highway capital stocks, TRUNK and TRUNK.W. M3 considers only the internal effects of LOCAL and TRUNK, while M4 includes all four variables of transportation capital stocks. As shown in the note below 5.4, M3 and M4 both suffer from high multicollinearity because of the very high correlation between LOCAL and TRUNK ($p = 0.815$), and that between LOCAL.W and TRUNK.W ($p = 0.926$). Accordingly, we chose to report as our key findings the results of M1 and M2, which have more robust and reliable coefficients.

M1 shows that local road capital stock within a county (LOCAL) has a positive and significant impact on the county's property tax revenues, with an elasticity of 0.093. That means 1% increase of local road capital stock leads to about 0.093% growth of property tax revenue. This result provides support for hypothesis H1. Interestingly, the average local road capital stock in neighboring counties (LOCAL.W) has a negative impact on a county's property tax revenue, with an elasticity of -0.085. A possible scenario of this result is due to regional competition of property tax bases as a county may lose some of its population or economic activity to neighboring counties with competitive advantages. Thus H3 is not supported: Instead of the expectation of benefit spillover, we find a strong evidence of inter-local competition. Adding the two coefficients together nearly cancels out each other, but still yields a positive combined effect (elasticity = 0.008). This finding suggesting that local road investments among nearby counties may be close to zero-sum games of property-tax competition, but the overall impact is still positive for the whole region.

Focusing on trunk highway capital stocks, M2 shows that trunk highway capital stock within a county (TRUNK) has a positive impact, with an elasticity of 0.013, and so does the average trunk highway capital stock in neighboring counties (TRUNK.W), with an elasticity of 0.030. The elasticity of benefit spillover is larger than that of the internal effect, indicating that economic benefits of trunk highway investments tend to be realized more regionally than in the county where the expenditures were made. In fact, adding the two coefficients show an even larger combined impact of trunk highway investments. Overall, 1% increase of trunk highway capital stock within a county together with the same amount of increase in its neighboring counties lead to about 0.043% growth of property tax revenue in the said county. The results provide strong supports to both hypotheses H2 and H4.

Table 5.3: Model Selection of Panel-Data Regressions

	Pooling (Internal)	**Pooling (Combined)**	**Fixed-Effects (Internal)**	**Fixed-Effects (Combined)**
(Intercept)	5.759 ***	6.780 ***		
LOCAL(log)	0.083 ***	0.105 ***	0.070 **	0.084 ***
LOCAL.W(log)	--	-0.177 ***	--	-0.213 ***
TRUNK(log)	0.005	0.008 *	0.010 **	0.015 ***
TRUNK.W(log)	--	0.079 ***	--	0.095 ***
POP(log)	-0.048 **	-0.069 ***	-0.037 *	-0.066 ***
POPDEN	0.853 ***	0.877 ***	0.866 ***	0.905 ***
PCINCOME	0.000 ***	0.000 ***	0.000 ***	0.000 ***
BELOWHS	-1.444 ***	-1.045 ***	-1.626 ***	-1.546 ***
UNDER18	-1.014 **	-0.783 *	-0.306	0.075
OVER65	0.760 ***	0.566 **	1.854 ***	2.061 ***
URBAN	0.229 ***	0.246 ***	0.241 ***	0.253 ***
Observations	*n=87; t=17*	*n=87; t=17*	*n=87; t=17*	*n=87; t=17*
Total sum of squares	*2214.100*	*2214.100*	*2190.500*	*2190.500*
Residual sum of squares	*83.215*	*80.003*	*77.806*	*73.571*
R-Squared	*0.962*	*0.964*	*0.964*	*0.966*
Adj. R-Squared	*0.956*	*0.956*	*0.948*	*0.948*

Table 5.4: Fixed-Effects Model Estimations

	M1 (LOCAL)		M2 (TRUNK)		M3 (Internal)		M4 (Combined)	
LOCAL(log)	0.093	***			0.070	**	0.084	***
LOCAL.W(log)	-0.085	***			--		-0.213	***
TRUNK(log)			0.013	***	0.010	**	0.015	***
TRUNK.W(log)			0.030	**	--		0.095	***
POP(log)	-0.047	**	-0.054	***	-0.037	*	-0.066	***
POPDEN	0.907	***	0.891	***	0.866	***	0.905	***
PCINCOME	0.000	***	0.000	***	0.000	***	0.000	***
BELOWHS	-1.812	***	-1.474	***	-1.626	***	-1.546	***
UNDER18	0.066		-0.481		-0.306		0.075	
OVER65	1.970	***	1.932	***	1.854	***	2.061	***
URBAN	0.218	***	0.284	***	0.241	***	0.253	***
Observations	*n=87; t=17*		*n=87; t=17*		*n=87; t=17*		*n=87; t=17*	
Total sum of squares	*2190.500*		*2190.500*		*2190.500*		*2190.500*	
Residual sum of squares	*77.123*		*77.774*		*77.806*		*73.571*	
R-Squared	*0.965*		*0.965*		*0.964*		*0.966*	
Adj. R-Squared	*0.948*		*0.948*		*0.948*		*0.948*	

Note: cor(LOCAL, TRUNK) = 0.815; cor(LOCAL.W, TRUNK.W)=0.926;
cor(LOCAL, LOCAL.W)=0.741; cor(TRUNK, TRUNK.W)=0.690

5.3 ROI of transportation capital stocks

In the third step, we provided an intuitive interpretation of model results by applying the estimates to assess the "return of investment" (ROI) in county property tax revenues and property tax base (in terms of Estimated Market Value, EMV) in response to 1% increase of transportation capital stocks.

Table 5.5 shows the results based on FY2010 data. Assuming that each county would increase its local road capital stock by 1%, we calculated the additional amount of investments across Minnesota counties, which range from $0.77 million to about $27.18 million. Then we calculated the growth of property tax revenues in Minnesota counties, assuming that each county would enjoy the growth of property tax revenues at the rate of the estimated elasticity (0.093, the internal effect of LOCAL). The additional property tax revenues range from about $1000 to about $0.5 million. After that, we divided the growth of property tax revenue in each county to the amount of additional local road investments there to get ROI on property tax revenues. It ranges from 0.001 to 0.018, with an average value of 0.004. Thus we can say that, on average, $1 additional local road investment in a county in FY2010 may lead to $0.004 of additional property tax revenue. This impact on property tax revenue may sound trivial, but the implicit affect on property tax bases is much larger. In FY2010, the effective property tax rates in Minnesota counties range from 0.0016 to 0.0059, with a mean value of 0.0033 (not shown in Table 5.5). To put it in another word, the actual change on a county's EMV would be about 300 times larger than the growth of property tax revenue. According to our calculation, the average ROI on EMV is 1.254. On average, an additional $1 of local road investment in a county in FY2010 would bring property tax benefits to the county equivalent to $1.254 in the growth of estimated property value. The distribution of local roads' ROI across Minnesota counties is illustrated by Figure 5.4. Counties that are shown to have higher ROI (for example, some Twin Cities metro counties) are those with higher property tax revenues relatively to their local road capital stocks in FY2010, because we assume a constant elasticity between local road capital stocks and property tax revenues. (Note that the distribution of ROI across counties may change if the elasticity varies across different counties, for instance, depending on their socioeconomic and infrastructure development stages. Such a variation shall be further examined in future studies.)

Table 5.5: ROI of Additional Transportation Investments across Counties (2010)

	Mean	St.D.	Min	Max	N
Additional local-road investments (million)	$3.557	$3.837	$0.774	$27.175	87
Growth of property tax revenue (million)	$0.022	$0.059	$0.001	$0.501	87
ROI on property tax revenue	0.004	0.003	0.001	0.018	87
ROI on property tax base (EMV)	1.254	0.789	0.273	4.513	87
Additional trunk-highway investments (million)	$1.276	$2.629	$0.056	$22.954	87
Growth of property tax revenue (million)	$0.003	$0.008	$0.000	$0.070	87
ROI on property tax revenue	0.003	0.002	0.000	0.010	87
ROI on property tax base (EMV)	0.871	0.744	0.127	5.040	87

Taking the same approach, we assessed ROI of trunk highway capital stocks to property tax revenues among Minnesota counties. Assuming that each county would increase its trunk highway capital stock by 1%, the additional investments would range from $0.06 million to $22.95 billion. The corresponding growth of property tax revenues would range from less than $1000 to about $0.07 million, with an elasticity of 0.013, the internal effect of TRUNK). The average ROI on property tax revenues is about 0.003, that is, $1 additional trunk highway investment in a county in FY2010 may lead to $0.003 of additional property tax revenue. The average ROI on EMV is about 0.871. It means that, on average, an additional $1 of trunk highway investment in a county in FY2010 would bring property tax benefits to the county equivalent to $0.871in the growth of estimated property value. Figure 5.5 shows that distribution of trunk highway's ROI across Minnesota counties. Counties around the Twin Cities metro are shown to have lower ROI than some rural counties to the west of the state. This is because the ratio of property tax revenues over trunk highway investments is lower in the Twin Cities due to the larger amounts of trunk highway expenditures there.

A simple comparison of Figure 5.4 and 5 may give an impression that local roads in general have higher ROI than trunk highways. Note that the two figures only show the internal impact of transportation investments. The overall regional impact for local road investments is substantively reduced (0.093 to 0.008 in terms of elasticity, or 1.254 to 0.110 in terms of ROI) due to inter-local competition of property tax bases, while the overall regional impact for trunk highway investments could be nearly quadrupled (0.013 to 0.043 in terms of elasticity, or 0.871 to 2.881 in terms of ROI).

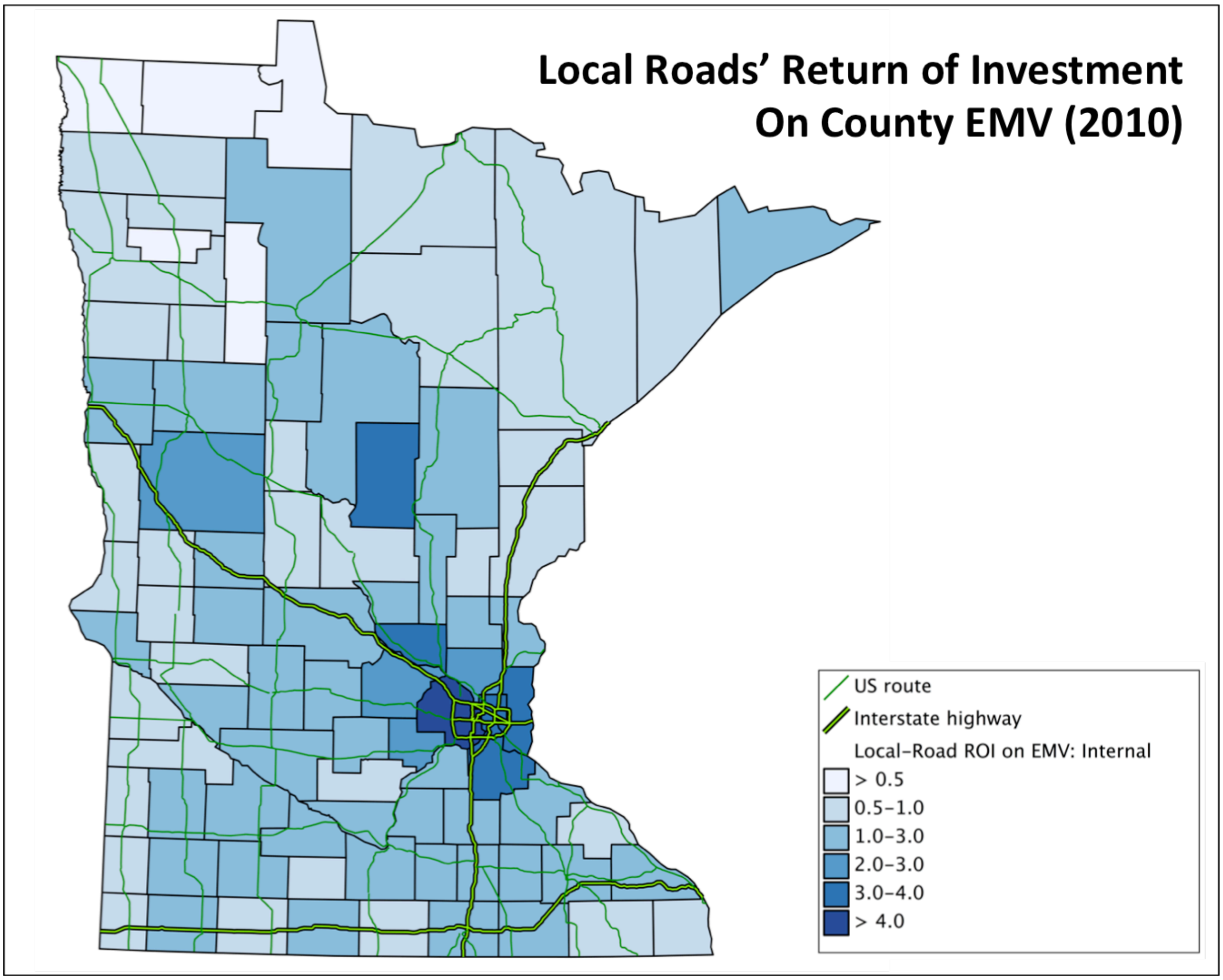

Figure 5.4: The Return of Local road Investments on County EMV, 2010

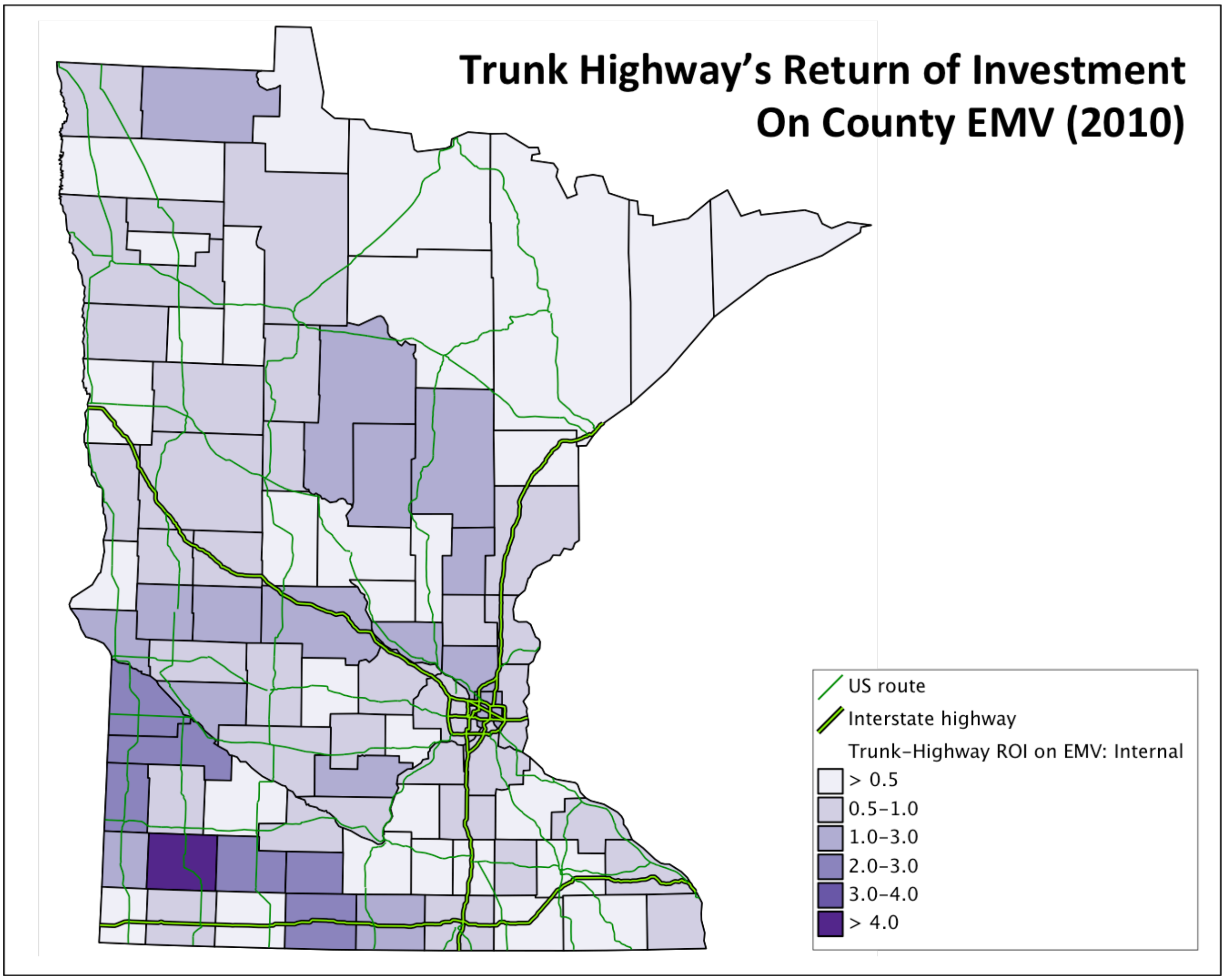

Figure 5.5: The Return of Trunk highway Investments on County EMV, 2010

Chapter 6: Conclusions

To assist informed policy decision-making on US transportation development, we need more and better evidence about the economic benefits of transportation investment. Focusing on fiscal returns to local governments, this project examines the link between accumulated transportation capital stocks in Minnesota counties and their annual property tax revenues with longitudinal data in the 1995-2011 period. The analysis has two unique features. First, we separated the effects of two different transportation capital stocks, one associated with load roads and the other with trunk highways. Second, we considered not only the internal effect of transportation investments within a county, but also the spillover effect due to transportation investments made in neighboring counties.

Estimates from panel-data regressions show that local road capital stocks within a county have a positive effect on its property tax revenues, with an elasticity of 0.093. Nevertheless, local road capital stocks in neighboring counties have a negative effect, with an elasticity of -0.085. The results indicate that local road investments generate substantive property-tax returns for a county, but much of the benefits may be the outcome of a zero-sum game due to inter-local competition of property tax bases. Like local road capital stocks, trunk highway capital stocks within a county also show a positive effect on property tax revenues; the elasticity is 0.013. What is more striking is the spillover effect of trunk highway development. We find that the average level of trunk highway capital stocks in neighboring counties has an even larger effect on a county's property tax revenues, with an elasticity of 0.030. Adding the internal effect and spillover effect, trunk highway investments in a county lead to substantive regional benefits, both within a county and across its boundaries. Applying the estimates of internal effects to the county data in FY2010, we calculated ROI (return of investment) of additional transportation investments. On average, an additional dollar of local road investments within a county will lead to more property tax revenues within the county equivalent to $1.254 in the growth of EMV. Likewise, an additional dollar of trunk highway investments within a county will lead to property-tax benefits equivalent to $0.871 of EMV growth. If the external impacts are also considered, the total regional benefits of trunk highway investments are even higher, almost quadrupled.

The results have significant policy implications. As local road capital stocks intensify the competition of economic activities (and hence property bases) across county boundaries, local governments concerned about their economic competitiveness, especially in comparison with their neighboring counties, will consciously invest in their local roads. As trunk highway capital stocks generate substantial local and regional benefits, counties may have more incentive to collaborate with their neighboring ones in related projects, which may be jointly funded and planned at the state or regional level.

While the regression analysis may seem complicated and the results general, county engineers are encouraged to download and use the compiled data (available through https://netfiles.umn.edu/xythoswfs/webview/_xy-16428505_1) to assist local decision-making about transportation investments in several ways. The first application is for trend analysis and cross-jurisdictional comparisons. With the complete information of local road capital stocks and trunk highway capital stocks at the county level during 1995-2011, a county could develop a historical view about the trends of transportation development within the county, and then compare the stocks to those of other counties, which could be neighboring counties or others that are considered comparable or competing peers. The second application is to illustrate the link between historical transportation investment and the growth of tax bases. While this report focuses on the change in property tax revenues, the compiled data also include federal taxable income and gross sales. With the longitudinal data, a county could plot the change in its capital stocks over time alongside the change in its tax bases (property, income, or sales) and then examine the correlations during different periods of time. While such comparisons do not provide conclusive evidence about possible causal relationship among these variables, often they lead to meaningful observations for policy discussions, or practical hypothesis that can be further tested with future research employing more rigorous methods. Lastly, county engineers may use the estimates found in this research to project the benefit of future transportation investment. The elasticity can be interpreted as a percentage-to-percentage change. With data about the current level of transportation capital stocks and property tax revenues, it would be convenient to calculate ROI (return of investment) for some additional amounts of transportation investment in each county. In this calculation, counties with lower accumulated capital stocks (relative to their property bases) would be shown to have larger ROIs, that is, much higher dollar-to-dollar benefits that could be generated through additional transportation funding.

The project may lay a solid foundation for several additional future research projects. First, we could further examine the link between transportation development and property tax changes under different circumstances. Results of this research are the average impact across all Minnesota counties during a 17-year period. Nevertheless, the actual elasticity may differ depending on the type of counties, by the stages of roadway development, or by the categories of roadway projects. Additional research along this line could shed more light on the value of transportation improvement, with ample policy implications. Second, we may extend the focus to other aspects of fiscal returns, such as the changes of income and sales tax bases. With a more complete knowledge of how transportation improvement affects different tax bases, we can estimate how transportation-related tax benefits are distributed across levels of government. Along with an examination of transportation revenue contribution across localities, we can also study the potential spatial mismatch between resource allocation and benefit distribution associated with transportation.

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