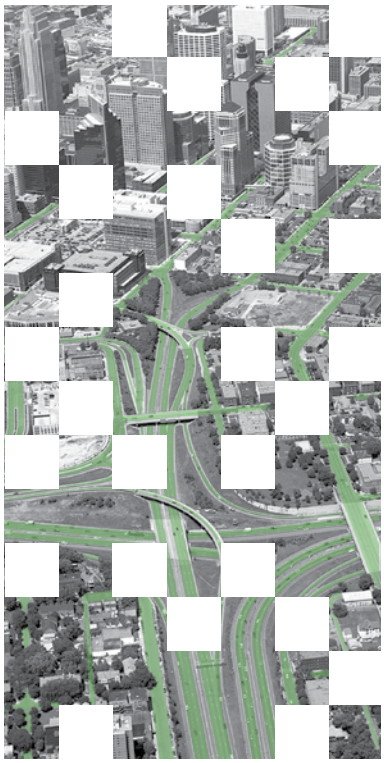

Measuring What Matters: Access to Destinations

Access to Destinations Study Research Summary No. 2

August 2010
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Center for Transportation Studies
University of Minnesota

Preface

The Access to Destinations Study is an interdisciplinary research and outreach effort coordinated by the University of Minnesota's Center for Transportation Studies, with support from sponsors including the Minnesota Department of Transportation, Hennepin County, the Metropolitan Council, and the McKnight Foundation. A full description of the study is available at www.cts.umn.edu/access-study/studyframework.

The research takes a new approach to understanding how people use the transportation system and how transportation and land use interact. Research activities were divided into three major research components:

I. Understanding Travel Dimensions and Reliability
This research focuses on improving our understanding of travel within urban transportation systems. Current travel measures are informative but are of limited use in helping us understand what is happening in specific locations and across a spectrum of different transportation modes.

II. Measuring Accessibility
This research uses detailed data on land use, travel behavior, and population demographics over the past 10 years, in combination with the research findings from Component I of the study, to develop methods for describing how our accessibility is changing.

III. Exploring Implications of Alternative Transportation and Land-Use Systems
The work undertaken in Components I and II will contribute to the development of an alternative approach to evaluating and planning our transportation system—one that takes into account all travel modes and land-use decisions.

Acknowledgments

This research summary incorporates findings from 11 research reports completed under the Access to Destinations study, available at www.cts.umn.edu/access-study/publications.

Research Team
- Gary A. Davis, Professor, Department of Civil Engineering, University of Minnesota Twin Cities
- Ahmed M. El-Geneidy, Assistant Professor, School of Urban Planning, McGill University
- John Hourdos, Director, Minnesota Traffic Observatory, University of Minnesota Twin Cities
- Michael Iacono, Research Fellow, Department of Civil Engineering, University of Minnesota Twin Cities
- Robert Johns, Director, John A. Volpe National Transportation Systems Center (former director, Center for Transportation Studies, University of Minnesota)
- Kevin Krizek, Associate Professor of Planning and Design, University of Colorado
- Eil Kwon, Director, Northland Advanced Transportation Research Laboratories, University of Minnesota Duluth
- Taek Kwon, Professor, Department of Electrical and Computer Engineering, University of Minnesota Duluth
- David M. Levinson, Associate Professor, Department of Civil Engineering, University of Minnesota Twin Cities
- Chen-Fu Liao, Educational Systems Manager, Minnesota Traffic Observatory, University of Minnesota Twin Cities
- Panos Michalopoulos, Professor, Department of Civil Engineering, University of Minnesota Twin Cities
- Ted Morris, Laboratory Manager, Minnesota Traffic Observatory, University of Minnesota Twin Cities

McKnight Advisory Panel
The McKnight Foundation has supported the outreach activities of the study and has provided oversight and guidance for the preparation of this document.
- Ann Canby, President, Surface Transportation Policy Project
- Caren Dewar, Executive Director, Urban Land Institute Minnesota
- Jim Erkel, Attorney and Program Director, Minnesota Center for Environmental Advocacy
- Brian Gage, Engineer Senior Administrative, Office of Capital Programs and Performance Measures, Minnesota Department of Transportation
- Curtis Johnson, Principal, Citistates Group
- Eric Muschler, Program Officer, McKnight Foundation
- Mark B. Nelson, Director, Office of Statewide Multimodal Planning, Minnesota Department of Transportation
- Lee Sheehy, Program Director, McKnight Foundation
- Dave Van Hattum, Policy and Advocacy Program Manager, Transit for Livable Communities
- Sam Zimbabwe, Technical Assistance Director, Reconnecting America

Resource Staff
- Gina Baas, Assistant Director, Education and Outreach, Center for Transportation Studies, University of Minnesota
- Stephanie Malinoff, Manager, Outreach Services and Events, Center for Transportation Studies, University of Minnesota

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Writer: Curtis Johnson, Principal, Citistates Group
Editor: Pamela Snopl, Center for Transportation Studies
Graphic Designer: Cadie Wright Adhikary, Center for Transportation Studies
Photographers: Jonathan Chapman, Matt Miranda

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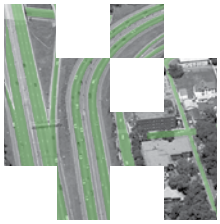


Executive Summary

In what is likely to be an enduring period of constrained public resources, lawmakers and government executives will seek the best information possible for making policy choices and deciding where to make public investments. In a landmark series of studies known as *Access to Destinations,* the Center for Transportation Studies (CTS) at the University of Minnesota has opened up new frontiers of information for better policy and investment decisions.

The actual ease of reaching destinations has been getting better all over the region, especially by auto—and land-use changes and increased development densities explain most of the improvement.

In this series CTS researchers analyzed, described, mapped, and charted how "accessibility" has changed over recent decades in the Minneapolis-St. Paul metropolitan region. They began by changing the question—from *how fast is traffic moving (mobility)* to *how easily are people reaching places they need or want to go (accessibility).* Asking the *accessibility* question stands in stark contrast to news accounts about traffic and the way most people talk about transportation. Every year the Texas Transportation Institute (TTI), working on the "mobility" question, publishes its ranking of which metro areas have the worst congestion, and which ones are getting worse faster.

The TTI report gets wide coverage, understandably so, because congestion can damage a schedule (making anyone's day less efficient), worsen air quality, and certainly be irritating. Congestion also has a "good side"—it signifies a successful region, with a growing number of people going places.

But in this research series, scholars were asking a different question, and they found a different answer: while until this last decade congestion had been steadily worsening, the actual ease of reaching destinations has been getting better—all over the region. And especially

by automobile. Accessibility has improved also via walking, biking, and public transit, but the striking findings are the improving access by automobile—*and discovering that land-use changes and increased development densities explain most of the improvement*.

Getting to useful answers to this new question required sorting through every available means of measuring ease of access. Researchers mapped modes of travel (auto, transit, walking, biking) in relation to the dominant destinations most people have. They analyzed the attributes of destinations that would affect which mode of travel people would ordinarily choose. They measured travel times by each mode to regular destinations with and without using a motorized vehicle. They probed more deeply into the interactions between changes in land use and the mode people chose for access to their destinations.

They also produced a new Web-based tool that policymakers and transportation managers can use to analyze the likely effects of new transportation investments on accessibility.

Given how little interaction there's been historically between the transportation and land-use planning sectors, this series forms a new foundation for what should be an extensive period of further investigation of how to improve access with public policy tools. It also marks the development of a new performance-measurement tool, in a time when performance management is of growing focus in transportation circles and is expected to be a key element of the next federal surface transportation bill.

Key Findings

In this study, the research team developed a new way to understand and analyze the relationship between transportation and land use. Among the notable findings:

- While congestion has been worsening, the ease of reaching destinations has been getting better almost everywhere in the region—especially by automobile. Accessibility has improved also via walking, biking, and public transit. The greatest increases in access occurred in the developing edges of the region.
- Although some new roads were added and others were improved, land-use changes and increased development densities explain most of the accessibility improvement.
- In 1995 only one traffic analysis zone (near the center of the metro region) could reach more than one million jobs within 20 minutes. By 2005, there were 20 zones with that claim. Well over half the population of the region can reach more than one million jobs within 30 minutes. And if 45 minutes is the standard, almost everyone can reach a million jobs.
- These accessibility increases occurred while the center of gravity for employment was shifting—slightly—toward the south and west of the region. Accessibility got better despite the absence of a matching shift on the part of workers. The labor force tended to shift more toward zones north and south of Minneapolis. Still, the researchers found the overall ratio of jobs to workers was improving (getting closer to 1:1) in most areas of the region.
- High accessibility to jobs has a positive effect on home values. High accessibility to workers has the opposite effect—indicating homebuyers will pay a premium to live near jobs and away from competing workers.
- The area has seen small but measurable decreases in walking travel time. Making it easier and safer to walk (e.g., expanded facilities/network such as the Midtown Greenway in Minneapolis) raises walking's desirability and lowers the time involved in a trip.

- A third of walking trips exceeded a mile, questioning the long-standing belief that a quarter of a mile was the limit of willingness to walk on a regular basis to any destination.
- New bike networks and facilities (such as the off-street trail along Hiawatha Avenue) also had a measurable effect.
- Multiple measures showed the impact of adding the region's first light-rail line. Overall, the region's accessibility is increasing, and proportionately more along the Hiawatha corridor and bus lines with high-frequency service.

Well over half the population of the region can reach more than one million jobs within 30 minutes.

Looking Back on Regional Development

Over the past two decades, the policy ground shifted for both transportation and land planning groups. Conference agendas began to feature workshops on "context sensitive" street design and strategies for mixed-use zoning. Planners were relearning how to allow multiple types of destinations to be closer together. Engineers were shifting to recognize opportunities for getting to these destinations without driving. Legislatures at all levels heard heightened pleas for investments in modern transit, broad sidewalks, dedicated bicycling lanes. In the Minneapolis–St. Paul region, the Metropolitan Council, whose current members reflect a conservative political philosophy, notably produced a *Guide for Transit-Oriented Development* in 2006. During this period, town centers began to spring up in suburbs, many of which had long been a seamless series of subdivisions interspersed by retail and commercial services.

As described in a 2001 report, *Market Choices and Fair Prices* (CTS 03-02), regions such as Minneapolis–St. Paul, unconstrained by mountains or oceans as natural boundaries, saw a constantly developing edge, energized both by population growth and people moving farther out in search of what they believed to be housing and property "value." The transportation system, though not always promptly, cooperated with new or upgraded roads. And of course, if a new road opened new territory, the whole corridor started filling up, along with the need for all the infrastructure of schools and shops and clinics—all the necessities that form the orbit around residential zones. As employers followed the path people made, employment became less centralized, moving to new areas even more rapidly than the labor force. Despite the best service that a good bus system could deploy, the region became utterly dependent on automobiles to get to most places. And though a rail and bus rapid transit system is on the drawing boards, with two rail lines and several BRTs already in service, the region's movement of people and goods continues to be mostly in private vehicles over roads.



Mapping Variations by Mode: The Matrix

The ultimate goal CTS researchers had is a matrix that both describes and potentially predicts how people access destinations by different modes (see below). The matrix itself is simple to use: Array in columns the most common destinations people have—employment, shopping, schools, parks. Then in the rows list the available modes of travel—auto, transit, bicycling, and walking. Using travel time as a filter, the matrix paints a more coherent picture of the capacity of different modes to facilitate the choices people make to get to their destinations.

As a starting point, this research series focused on employment as the destination and the automobile as the mode. Researchers then had to test the usefulness of competing ways to measure access. Without getting into technical details, let's just say there are three choices: Cumulative Opportunity, Gravity, and Place Rank. None is perfect. All have to be applied by mode (i.e., driving, transit, walking, biking) and point in time (e.g., the morning peak period, the afternoon peak, off-peak) for a particular type of opportunity (e.g., jobs, resident workers, shops, etc.).

Cumulative Opportunity calculates the number of opportunities that can be reached in a specific period of travel time (such as 30 minutes).

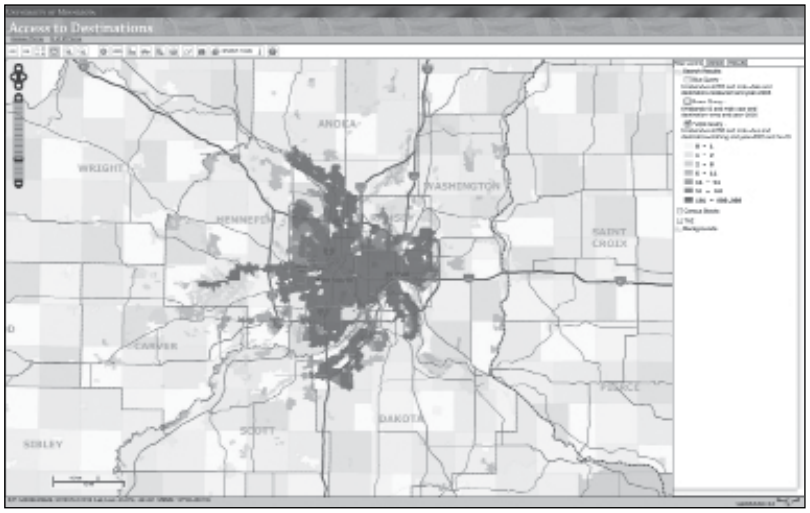
Gravity measures access in terms of the "cost" of getting there (travel time), and like Newton's law of gravity, finds nearby things exert stronger attraction than those far away.

Theoretically, *Place Rank* appears to be the most robust metric, despite its complexity; Place Rank basically accounts for the number of opportunities that an individual foregoes in a zone to reach an opportunity in another zone. For example, a high ranking would be awarded to a destination that attracts more workers from zones that have high numbers of jobs.

A Matrix of Metro Accessibility

People who make transportation and land-use decisions in the Minneapolis–St. Paul region have a new tool: an online "accessibility matrix" that captures variations in accessibility to different types of destinations for travelers who drive, bike, walk, or use transit.

For each origin area, a user can create a matrix with columns representing types of destinations and rows representing travel modes. Each cell tells how easy it is to reach the specified destination activity using a chosen mode. For example, a resident of Anoka could learn the accessibility of jobs in Eden Prairie by bus or by car.



The accessibility matrix is available on the study's Web site.

The Web interface—at www.cts.umn.edu/access-study—has a number of predefined maps and also allows users to create their own maps at the census block level. Users can select up to three filters, including year, mode, purpose, and destination type (such as retail, food, or time of day).

"It's a way of showing thousands of data points in a simple way," says David Levinson, one of the researchers.

As of the publication of this report, Mn/DOT had approved funding for Phase 4 of the Access to Destinations Study. Plans are to enhance the tool so that users can do scenario planning—estimating the impact on accessibility, for example, of a new lane, bus route, or private development—and make more-informed policy and investment choices.

Among the most interesting findings: a high accessibility ranking to jobs has a positive effect on home sales (in other words, a premium in the market for the ease of getting to work). But, just as important for planning, accessibility to workers has the opposite effect on real estate values, leading to the double-sided conclusion that homebuyers will pay a premium to live near jobs, *and* away from competing workers. The "competition" is both over jobs and over implied living space, not competing for space in close quarters.

Place Rank is not a perfect tool; the complexity of calculations requires a great deal of computational capacity and data on place-to-place flows. But it is also exceptional in that it can be put in play without depending on travel time data and, drawing on U.S. Census Bureau data and origin and destination data from regional sources, it can be comparably deployed in any region. In some of the studies, where each metric tracked a similar pattern, Cumulative Opportunity, with its more straightforward explanations, proved the most useful approach.

Arriving Without Driving

Even though the overwhelming majority of all long trips are still made using automobiles, this look ahead adopted by researchers supports getting good measures of changing accessibility to destinations by walking, bicycling, and transit. The objective was to assess how changes to the networks (the underlying infrastructure facilitating these modes) changed travel times, comparing 1995, 2000, and 2005.

Measures here necessarily rely on data about travel times, and those cannot be assessed without knowledge about the networks that support each mode. How fast do people typically walk, adjusted for the conditions under which they can walk? Dedicated bike lanes produce different average travel times than trips where bicyclists are competing with auto traffic for space. Getting to precise measures is complicated by incomplete historical mapping of infrastructure, such as when sidewalks were added, or when more extensive bike trails and dedicated lanes were built. And of course any assessment of travel times by transit is immensely complicated—by trips involving transfer, by the time required to get to a transit connection, and by the time to walk from the transit ride to the final destination.

The research shows small though measurable decreases in travel time for walking, owing to improved or expanded facilities. New bike networks and facilities also had a measurable effect.

Walking

Given a broad consensus about speed—people seem to walk at an average of 3.4 miles per hour—the research shows over time small though measurable decreases in travel time, owing logically to improved or expanded facilities or what researchers called the "network." Researchers cited two Twin Cities zones that serve to illustrate the point by their improved travel times: the area just north of the Midtown Greenway in Minneapolis, and the area immediately southwest of downtown St. Paul. The study confirms something already intuitive: making it easier and safer to walk raises the desirability of walking and lowers the time involved in a trip, thus increasing the likelihood of walking as a selected mode of travel. What is not intuitive is the magnitude of these changes, which researchers can now measure.

Bicycling

Traveling on a bike is by its nature subject to a wide variety of conditions that affect average travel times.

So researchers took an empirical sampling approach. They used a sample of actual bicyclists outfitted with GPS devices on their helmets. Since it was only a sample and subjects could have been influenced by being part of a study, researchers exercise caution in drawing conclusions. The research was also limited by the incomplete historical mapping of bicycling trails and lane networks. Still it was possible to see how the differences in facilities created "impedances," or slow-downs, and affected the range of destinations that could be considered accessible by bicycle. What was encouraging was the confirmation that adding new networks has a measurable effect, citing the off-street trail along Hiawatha Avenue as a prime exhibit.

Multiple measures showed the impact of adding the region's first light-rail line.

Transit

Travel times on transit are considerably more complex to measure. Researchers experimented with ways to mitigate the likely error in measurement. But what still came through clearly was the expected impact of adding new capacity. Multiple measures showed the effects of adding the region's first light-rail line, along the Hiawatha Corridor. For example, travel times to and from the MSP airport showed decreases attributable to the introduction of this new capacity.

Driving—Getting More Precise on Travel Times

Automobile travel times have primarily focused on freeways. And even there, the measurement system is only slowly maturing. The Minnesota Department of Transportation has been measuring travel time data on freeways since the mid-1990s, when loop detectors began to be installed in the freeway system. By 2009 there were 4,500 loop detectors. While this now yields more data, comparative measurements over time are constrained by the missing data from the years of less-intensive measurement. Researchers used here what they called "multiple spatial and temporal imputation," a system of estimating error that succeeded in driving down the data deficit factor to less than 2 percent, resulting in significant improvements in the reliability of estimations.

But interest in travel times, in addition to probing nonmotorized modes, also deliberately went beyond the conventional focus on freeways. This turns out to be very difficult, which partially explains why the professional literature is so spare on this subject.

Arterials pose the biggest challenge. Speeds vary and are complicated by signals at intersections. In a corridor without red and green lights, researchers could easily produce a calculus of free-flow speeds, capacity of the road, and volume of traffic. But signalization alters the network travel time. After sorting through the available metrics (and also bowing to the fiscal constraints of the research itself), researchers chose the "matching license plate" method, which, like it sounds, tracks the movement of specific cars. It requires only two people in the field to monitor movement. Even with this method, researchers found an underestimation of the actual travel time on signalized roads using conventional models. Using a model named for the researchers who estimated it (Skabardonis and Dowling), the Access to Destinations researchers were able to mitigate the bias and get state-of-the-art estimates of travel times on the signalized arterial network.

Measuring by Mode and Purpose

Here again the study series found research territory with few previous footprints. In most planning analyses, trip purposes are represented only in highly aggregated terms. Very little has been known about how far people will actually travel to reach a variety of destinations and what differences there may be among those types of destinations. Getting these answers required plumbing new sources of data, such as parcel-level information for the seven-country metro region, and GIS datasets covering the 135,928 known business locations in the region. And deploying an unusually disaggregated "zonal" structure that stems from U.S. Census data, producing measures for nonmotorized travel that are remarkably aligned with actual bicycle and pedestrian travel behavior. Researchers concede that sample sizes are smaller but the data appear as scalable as computing power will permit.

How far people will walk is, in research terms, characterized in the negative: that is, by a "distance decay" model. This metric tracks the limits of willingness to travel certain distances. The analysis relies on a combination of data: the 2000 (every 10-year) Travel Behavior Inventory sponsored by the Metropolitan Council; the Council's origin-and-destination data; 3,000 on-board transit surveys; and field surveys of multi-use trail users.

Walking

Most walking trips involved distances of 1.86 miles or less. But up to a third of trips exceeded a mile, a finding with potentially breakthrough implications for the long-standing belief that a quarter of a mile was the limit of willingness to walk on a regular basis to any destination. If these are the new tolerances for walking distances, the implications for scaling activity-dense zones could be quite significant.

Up to a third of walking trips exceeded a mile, a finding with potentially breakthrough implications for assumptions about people's willingness to walk on a regular basis to any destination.

Bicycling

Here the longest trips bicyclists were willing to make were for recreation, personal entertainment, or fitness. But next longest were work trips. More than any other mode, the trip length tolerance varies significantly by trip purpose. Clearly, motivation to use a bicycle seems to be at its highest when the purpose of the trip is not an obligatory journey, but something for personal enrichment.

Transit

Here again the complications caused by time involved in getting to transit connections via car or walking or biking, and then the distortion of data generated by the pattern of transfers involved in arriving at intended destinations—all compound to limit conclusions from data. But, still, it is all about speed. Transit users seem to have a time budget. If it takes more time to get to a transit connection (or from it to a destination), the tendency is to use transit for shorter-haul trips. These thresholds, as expected, change when the form of service is express bus or rail.

Auto

No surprise to anyone—people's choice of the auto mode is limited primarily by their estimates of traffic delay. In the largest study of the series, researchers concentrated on the number of opportunities accessible by automobile from points of reference all over the region. Rather than rely only on the modeled travel times used by other studies, this effort took actual traffic data from both freeways and arterial roads, with travel times incorporating calculations of the delay caused by ramp metering. The land-use data for points of reference came from a combination of Metropolitan Council estimates of number of jobs, persons, and households, backed up by Census data.

The single most striking finding: accessibility

by automobile, from 1995–2005, increased almost everywhere in the region. The greatest increases in access occurred in the developing edges of the region, in part because there was little real growth at or near the center where access was already high. And while some new roads were built in this period and others were improved, nothing explains these gains except changes in land use and increased densification in multiple zones of the region.

In 1995 only one traffic analysis zone (near the center) in the entire region could reach more than one million jobs within 20 minutes. By 2005 there were 20 zones with that claim. Well over half the population of the region can reach over one million jobs within 30 minutes. And if 45 minutes is the standard, almost everyone can reach a million jobs. And these accessibility increases occurred while the center of gravity for employment was shifting—though slightly—toward the south and west of the region. It increased despite the absence of a matching shift on the part of workers. The labor force tended to shift more toward zones north and south of Minneapolis.

Research found the overall ratio of jobs to workers was improving (getting closer to 1:1) in most areas of the region. As one of the researchers, David Levinson, puts it, "Think of the region as a plate. It's a substantial plate overall, but the edges have become thicker and the southwestern arc of the plate the thickest."

Assessing the Role of Land Use

These studies break new ground in exploring how transportation behavior relates to changes in land use.

The access by automobile portion of the study, in addition to its access metrics, shows how cities (or entire metro areas) display the drive for efficiency of location. Firms seek productivity potential in locating near some combination of customers, suppliers, workers—even competitors. These tendencies are a kind of centripetal force, drawing activities in, together. But an equally powerful tendency pushes things outward—centrifugally. Firms and households both seek cheaper land and operating costs. While workers prefer proximity to work, they often also highly value a larger but affordable home with more land. As these forces compete, regions elude both maximum-possible as well as minimal densities—producing a largely market-driven scattering of destinations.

Since public policy influences market behavior in land uses, it becomes important to understand the dynamics of land-use decisions. This series also focused on "transitions" in the way land is used in the region. Easily recognized is vacant land becoming developed for some purpose. More complicated dynamics unfold when already developed land gets retooled for a new purpose or land gets cleared and reused in some different way. When transportation corridors are developed or significantly upgraded, this induces new clusters of land-use activity. But while these changes are observable enough, behind the curtain some mystery persists as to why land use in urban areas "organizes" the way it does. Researchers in this series made serious efforts to demystify this phenomenon, to model the complexity, to understand, explain, even forecast the changes.

The models used treat land-use outcomes as a function of the interaction between transportation networks and urban land markets. When decisions get made about the location and intensity of new uses of urban land, some (even rough) measure of accessibility seems to be the thread that ties together the decision dynamics. Probing this at very intense levels of detail is tempting, but is also fraught with complexity that is difficult to manage in a research setting. So, the researchers in this study series actually sought to recast the process of modeling and forecasting land-use change in deliberately simpler terms. In fact, they pushed to compress the process into a few basic principles, after which they tested the data available from 1958 to 2005.

Again, there are competing models. One is the Markov Chain approach, which fundamentally

forecasts future land use as a function of current land use—rather like how weather forecasters work, proceeding on the principle that the change from today to tomorrow will be much like the change from yesterday to today.

An alternative approach builds on the Markov Chain by feeding in empirical determinants such as neighboring land uses, proximity to highways, and measures of regional accessibility, subjecting the mix to a regression model of analysis. Still another directly extends the Markov Chain regime to neighboring land uses.

All approaches relied on the parcel-level datasets now available from the Metropolitan Council. Researchers took these data and created new "cell-level" data that divides parcels into 75-meter-squared cells that are classified by the predominant land-use type in the cell, drawing from a taxonomy of 10 types. Researchers then used what is known as "backcasting" to base forecasts on historical land-use data. Two study areas were selected: the whole metro region as it stood in 1958 and also a small sample drawn from the corridor of a two-mile perimeter around the newly developed SH 610 freeway in the northwestern part of the region.

Despite pioneering research, getting to precise forecasting and effects of land-use changes remains elusive. No known models can yet fully reproduce patterns of land-use change over time. The simplest Markov Chain model tended to produce more dispersed and mixed patterns than actually occurred. The modified Markov Chain model reduced some error but still fell short of reliable predictive power. The regression model scored best, particularly in predicting commercial and industrial uses and spatial clustering, but also consistently overpredicted some land uses, chiefly residential.

So, in sum, no known measure of gauging land-use change is good enough yet for prime time. Predicting the exact location of future development is hard, probably harder than predicting future traffic. But this research makes real gains in mashing up complex data with simple, transparent models on which future analyses may be built.

Policy Implications

The Access to Destinations research has shown the power of asking a more relevant question. It has demonstrated that changes in individual and firm market choices, combined with land-use and transportation policies, enable people to reach more destinations in less time, even under conditions of worsening congestion. That is a headline for policymakers anywhere.

Questions

- Might the State of Minnesota forge a new framework through which transportation investments and changes are considered jointly with land-use planning?
- Should the Metropolitan Council petition the state to make all transportation investments subject to a new standard—one centered on whether and how much any new infrastructure or service might raise access to destinations?
- As a hedge against major energy, fiscal, and climate crises, should the state consider a strategy of investment in a more robust network of nonmotorized travel infrastructure—backed up by solid research about modes that maximize more access to destinations?
- How might government at all levels reset the incentives to improve "access?" Public policy and investments clearly drive the market for housing and provide capacity to transport people and goods. When roads, water, and sewer capacity are extended, development, often at low densities, follows. Investments that encourage non-auto modes and more intense use of land have the same potential for shaping the interaction of land use and travel behavior.
- Should public officials in charge of the transportation system incorporate access into their criteria for operational policies? For example, are residents who choose to live in cities penalized by ramp meters in favor of residents who choose to drive long distances to work and other destinations—an issue certainly ripe for debate? And should not all modes of transportation—from roads to every known type of transit—be subject to rigorous analysis of capacity to increase access to destinations?
- Does this initial series on "access" suggest that the State of Minnesota should build on this body of research and invest in further study, in part to establish the state as a leader in this field and, even more important, to leverage limited transportation dollars toward the greatest dividends? It seems clear that being closer to destinations increases system efficiency, decreases environmental impacts, and raises the quality of life experience for residents.

CTS
Center for Transportation Studies
University of Minnesota

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