CHICAGO METROPOLITAN AGENCY FOR PLANNING | **ON TO 2050** REPORT

Transit Ridership Growth Study

CMAP

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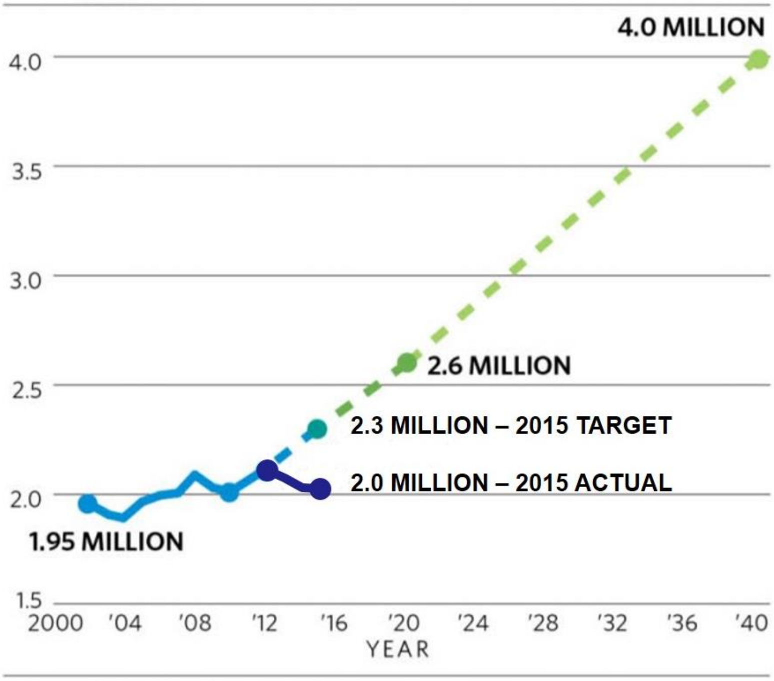
Introduction

GO TO 2040 includes goals to significantly increase public transit use. However, data from the past few years indicate that the region is not on track to reach its goals (Figure 1). This exploratory study evaluated what would need to occur to reach these ridership goals, including transit capital investments and policy changes related to parking, roadway pricing, and land use. The study's primary aim was to determine the relative productivity of various investments and policies that could increase transit ridership. The results will inform the recommended strategies and targets for ridership growth in the region in ON TO 2050.

Figure 1. GO TO 2040 targets for transit ridership versus actual ridership



Source: Federal Transit Administration National Transit Database.

Methods and overall results

GO TO 2040 frames its goal of approximately doubling transit system in terms of both ridership (unlinked trips or boardings) and transit mode share. Because mode share cannot be directly observed, ridership is much easier to track over time, and therefore is most often discussed as an indicator of plan implementation. However, mode share is a better measure of the success of implementing particular strategies; therefore the change in transit mode share[1] relative to

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[1] In this report "mode share" refers to weekday motorized mode share. Walking and biking trips were removed at the beginning of the modeling process, and weekday transit use was higher than weekend transit use. These two factors resulted in transit mode share values that over-represented transit as a percent of total regional trips. However, these values were chosen because they are consistent with measures and targets in the GO TO 2040 plan.

modeled current transit mode share (7.9 percent in 2015 for all weekday trips) was used as the primary evaluation metric. The actual GO TO 2040 transit mode share goal was 13.5 percent for weekday trips.

This study addressed the question of how current (2015) mode share would change based on specific interventions. Strategies and policy-sensitive factors were evaluated separately in "high" and "low" scenarios that reflect different levels of implementation or magnitudes of change. Each factor was analyzed using the regional travel demand model, as described in more detail under "Transit strategies evaluated" and "Other policy factors evaluated." The potential mode share gains from implementing each factor separately are shown in Figure 2.

Figure 2. Gain in mode share at low and high levels of strategy implementation, 2015

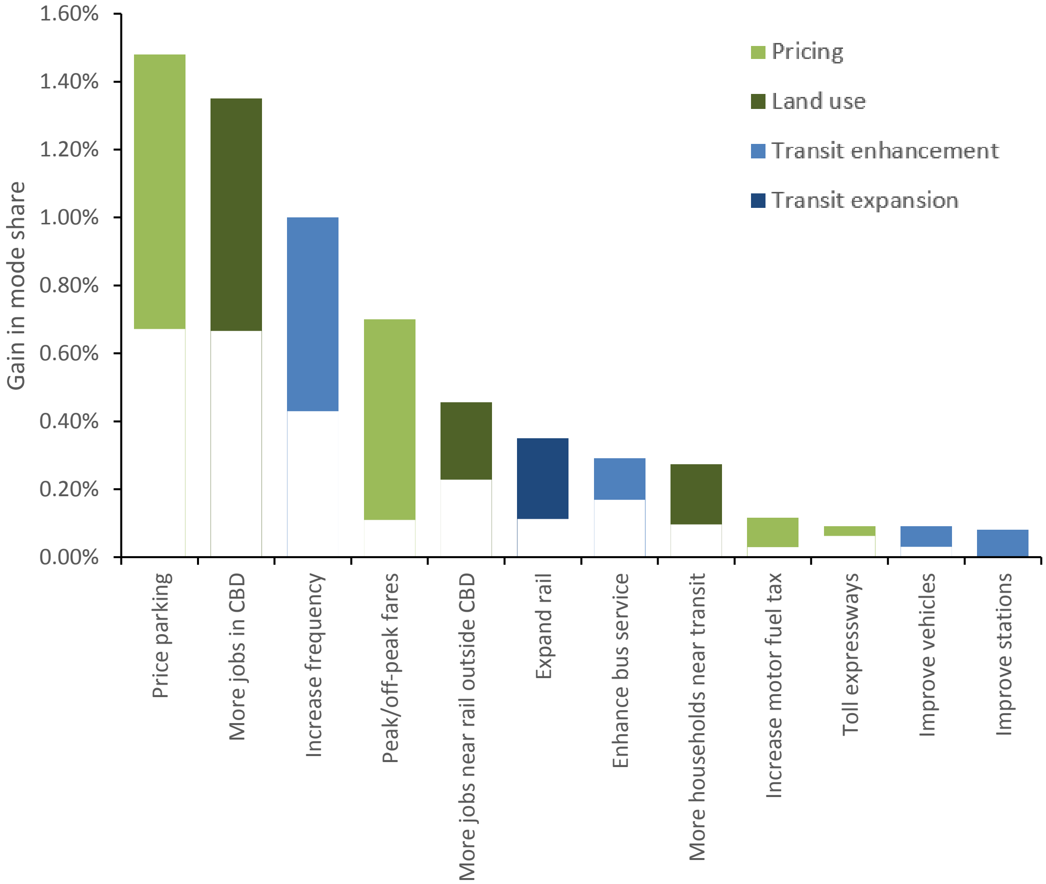
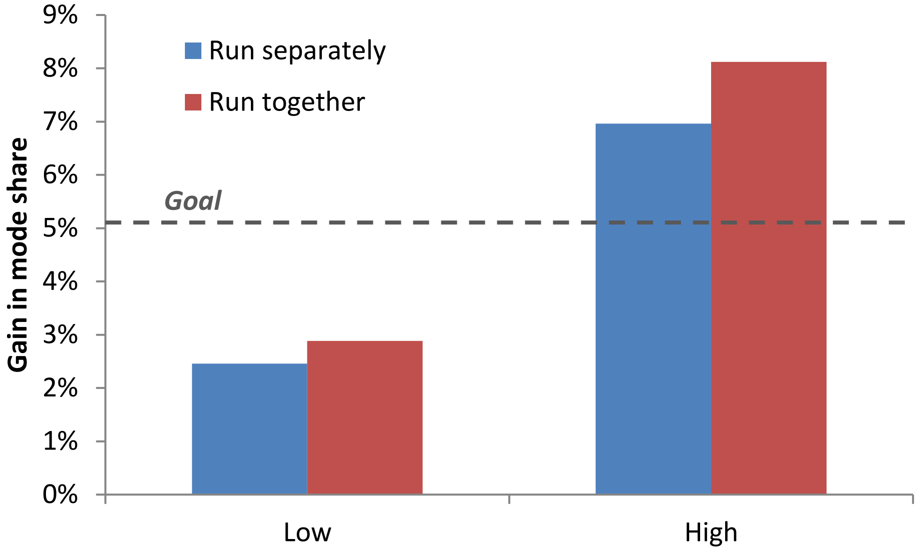


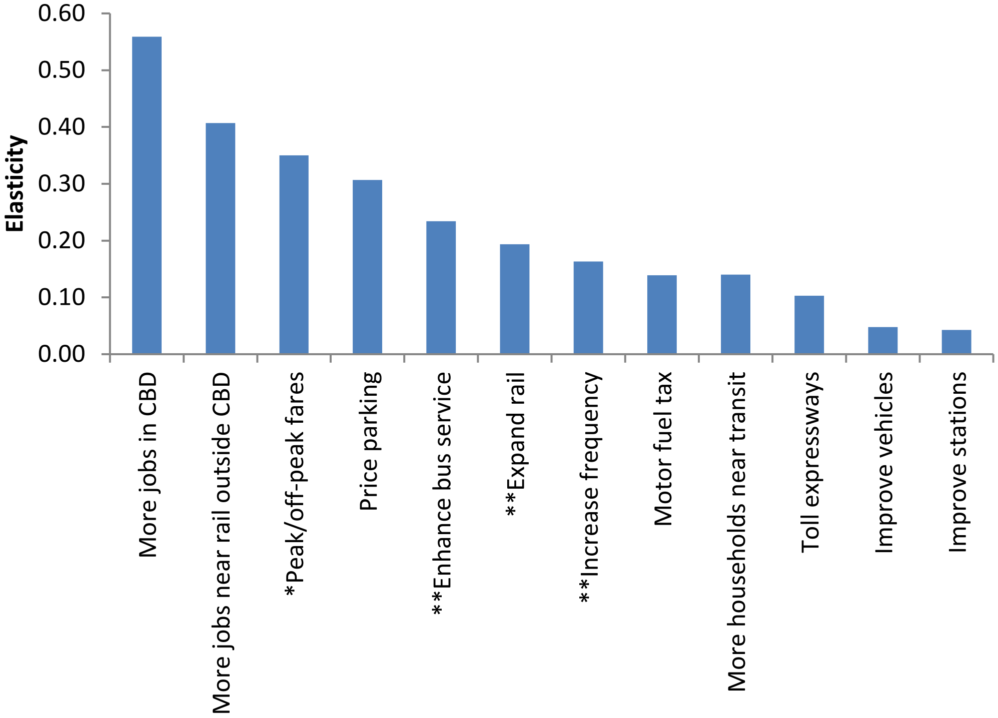
Figure 3. Total mode share gain from combined strategies and policies, 2015



When all strategies and policy factors were considered together, as shown in Figure 3, the results suggest that the combined alternatives that used the "low" ranges would achieve approximately half of the 2040 mode share goal, while the high alternative would exceed the goal substantially. Moreover, there were positive interactions between the strategies and policies: Modeling all strategies together yielded greater effects on transit mode share than simply adding their separate effects.

Because the high and low strategy alternatives were merely ranges chosen to reveal the magnitude of the effect on mode share, rather than minimum or maximum possible levels of implementation, it also was important to compare them to one another on a normalized basis. The main approach to normalization was to compare the elasticity of mode share with respect to changes in the strategy or policy (Figure 4). Elasticity was measured as the percent change in the dependent variable (transit mode share) divided by the percent change in the independent variable (parking fees, jobs in the city of Chicago's Central Business District, or CBD, etc.) A higher elasticity indicated that transit mode share would be relatively more responsive to changes in that variable.

Figure 4. System-wide elasticity of mode share with respect to strategy and policy implementation, low alternatives



*Average of peak and off-peak elasticities
**Elasticity with respect to service miles

Conclusions

Collaboration is needed to implement transit-supportive policies

Changing land use, pricing, and other policies increased mode share than anything else. Although transit pricing is within the transit agencies' control, some of the most effective policies, particularly for land use and auto pricing, are largely outside the control of the transit agencies and would require a collaborative strategy for implementation.

Central Business District employment growth has a very strong effect on transit use

Given that the existing transit network is largely a hub-and-spoke system oriented toward commutes to downtown Chicago, it is no surprise that even modest increases in CBD employment had a very large effect on ridership. High parking prices and auto congestion approaching downtown certainly would contribute to this effect, as well. Downtown Chicago is our region's strongest transit market. Increasing the number of jobs in the CBD had more than 10 times the effect on transit mode share than increasing the number of jobs by the same amount within a quarter-mile of stations in the region outside the CBD.

Jobs near transit have a stronger effect than households near transit

Transit systems work better when they serve more concentrated demand: The more people who are near transit, the more use it. Therefore, land use plays a large role in making the transit system more productive. Transit-oriented development that gives residents a realistic choice to take transit for commute and non-commute trips is important. CMAP's analysis found that concentrating households near rail was actually less effective than focusing the same number of households in both bus- and rail-served subzones. This finding underscores the importance of increasing household density in all transit-served areas, not just near rail.

However, the effects of more households near transit were greatly intensified when employment was also accessible to transit. Increasing the number of jobs within a quarter-mile of stations (outside the CBD) resulted in twice the transit mode share than making the same increase in households.

Variable fares have a significant effect

Varying fares for peak vs. non-peak periods could offer substantial benefits, encouraging greater transit ridership for the types of trips that are typically cheaper for transit agencies to provide (i.e., short, off-peak trips). New technology for transit fare cards, particularly the growing use of smart cards, could facilitate differentiated transit fares. This study found that variable fares produced by far the largest mode share gain of all policies under the transit agencies' control—suggesting the region can better tap off-peak demand. Implementing this strategy would increase fare revenue very slightly. Despite this, there are potential drawbacks to consider, including the possibility that making transit less cost-competitive during peak periods would shift peak riders to other modes. As with congestion pricing, peak pricing raises equity concerns that must be addressed.

Parking pricing yields large gains; congestion pricing yields smaller gains

Implementing congestion pricing is a key recommendation of GO TO 2040 because it provides travelers with additional choices and efficiently allocates roadway space. A toll on expressway travel that increases during peak periods would be expected to encourage drivers to travel outside the peaks, take an untolled route, or take a different mode, including transit.

Nevertheless, while congestion as well as overall driving would be lessened, modeling suggests that relatively few drivers in the peak periods would shift to transit. On the other hand, the revenue[2] from congestion pricing could be used to support transit capital or operating costs,

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[2] This study analyzed the effects of pricing all lanes on expressways, not just a separate managed lane. When only a subset of lanes is managed through pricing, the revenue generated is typically small, although it could provide a meaningful offset to the overall cost of building and operating the lane. The net revenue from pricing the full cross-section would be much larger and could provide significant funding for state-of-good-repair and multimodal transportation needs in the corridor, as well as help manage traffic.

among other transportation uses. Making transit improvements in combination with congestion pricing in the same corridor would likely show increased transit demand.

Pricing parking for trips that usually have free parking has a much more powerful effect on transit mode share. This strategy affects a much larger portion of the auto driver market than simply pricing expressways, because about 70 percent of regional vehicle miles traveled occur off the interstate system. Free or very inexpensive parking inhibits the success of transit service in two ways: It encourages more driving; and leads to an automobile-oriented urban form, with lower density and poor pedestrian connections.

Increasing service is an important part of meeting ridership goals

A critical part of building mode share is increasing service frequency. In recent years, service has been cut on some bus routes, and this has likely contributed to declines in bus ridership. However, simply doubling service frequency on all rail lines and bus routes -- even if it could be done, considering that significant capacity constraints limit frequency on some lines and routes -- would not be enough to meet the GO TO 2040 goals. Instead, increasing service would have to be part of an overall package of transit improvements and policy changes.

A key question is how to allocate increased service. While this study examines that issue, more analysis is needed. The responsiveness of ridership by line and route varies a great deal. One finding is that the ridership increase associated with new bus routes appears to be lower per service mile than the ridership gains associated with increasing frequency on existing routes. This difference would be even more pronounced if resources were concentrated to increase frequency only on higher-productivity existing routes. There is a clear tradeoff between increasing service coverage and increasing ridership.

Expansion and enhancement projects yield relatively small regional ridership gains

Projects to enhance or expand the bus and rail networks were tested separately. Implementing the large number of proposed rail extension and improvement projects in the region would lead to modest mode share gains. Projects aiming to speed up bus travel, by using techniques collectively referred to as bus rapid transit or arterial rapid transit, tend to be more effective at increasing mode share per service mile offered and likely less expensive than rail projects per rider gained. They also have a higher net mode shift, in that they tend to attract new riders rather than shifting them from other transit modes.

System-wide station and vehicle enhancements can reduce riders' perceived wait times and travel times by making the travel experience less onerous. However, at the levels of improvement investigated in this study, adding shelters and/or seating, and cleaning or overhauling stations and stops in the region without increasing the speed or frequency of service have a relatively minor effect on ridership. The same is true of vehicle improvements that increase comfort and productivity.

Sustaining ridership ultimately depends on transit capital investment

While the mode share gains from policy changes and increased service are the largest potential contributors to an ambitious goal to increase ridership, implementing transit projects does play an important role. A transit system with inadequate capacity that is not in a state of good repair cannot handle increased ridership. While capital investment itself has a relatively small effect on transit demand, investments that expand the system and bring it to a state of good repair are ultimately indispensable to accommodate current transit ridership and new demand stimulated by land use and pricing policies. Many studies have demonstrated this, both in the Chicago region and elsewhere.[3]

Strategies have synergies and co-benefits

When all strategies and policy factors are considered together, their effect is greater than the sum of each individually. There is value in pursuing many strategies at once. A potential rider may face several obstacles to riding and will not ride until all are addressed. Furthermore, several policy factors have a global effect on transit. To illustrate, whatever other transit improvements are made, increased household and job density near transit and policies that decrease the cost of transit relative to driving enlarge the market for transit, compounding the effects of other improvements. Lastly, it is not only transit users who see travel benefits from the strategies and policies considered here: Implementing all strategies together in the low scenario would reduce vehicle miles traveled (VMT) in congested conditions by about 6 percent.

Role of other factors beyond ridership

The potential for a strategy to increase ridership was far from the only consideration. This study also examined each strategy’s effect on the change in accessible jobs within a 75-minute transit trip, auto VMT, transit passenger miles traveled, and average transit work trip time. To measure congestion, the study measured excess VMT, or the mileage traveled by the volume of cars which caused a level of service of D or worse. Lastly, the study calculated a gain/loss ratio to estimate the extent to which implementing a strategy would shift riders from one mode to another. The gain/loss ratio was equal to the absolute value of the sum of increase in boardings (for modes on which ridership grows) divided by the decrease in boardings (for modes on which ridership declines). The higher the ratio, the more a strategy tended to grow the transit market.

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[3] For example: Regional Transportation Authority, “Investment in Public Transportation: The Economic Impacts of the RTA System on the Regional and State Economies,” 1995, https://archive.org/details/investmentinpubl00camb; Elizabeth Deakin, Arlee Reno, James Rubin, Sean Randolph, and Michael Cunningham, “BART State of Good Repair: Regional Impacts,” 2011, https://cmap.is/2w93mcg.

In general, the association between increased mode share and other performance measures was limited. Some strategies had relatively large effects on job accessibility but small effects on overall ridership (Table 1). Others had large effects on ridership while doing little improve other performance measures, such as average trip length.

Table 1. Change in performance measures for ‘low’ strategy implementation

Strategy	Average jobs within 75-minute transit trip	Vehicle miles traveled	Transit mode share gain	Gain/loss ratio**	Passenger miles traveled	Average transit work trip minutes	Excess vehicle miles traveled
Price parking	0.0%	-3,960,257	0.67%	---	+1,047,975	-0.54	-540,738
More jobs in CBD	1.0%	-1,694,669	0.67%	28.6	+1,566,421	-0.16	-532,987
Increase frequency	2.6%	+104,040	0.43%	---	+781,296	-0.50	-76,537
Peak/off-peak fares	0.0%	+50,965	0.11%	2.4	-296,645	-0.41	-6,104
More jobs near rail outside CBD	0.5%	-831,570	0.23%	23.9	+672,378	0.00	-194,425
Expand rail	2.2%	-210,127	0.11%	3.4	+863,567	-0.57	-52,089
Enhance bus service	1.7%	-15,824	0.17%	5.4	+323,781	-0.50	-36,879
More HH* near transit	0.6%	-493,598	0.02%	1.2	-919,900	-0.61	-270,395
Increase motor fuel tax	0.0%	-617,234	0.03%	---	+45,801	-0.02	-87,641
Toll expressways	0.0%	-1,269,079	0.06%	---	+635,423	+0.39	-861,666
Improve vehicles			0.06%				
Improve stations			0.00%				
All low scenarios	**8.5%**	**-8,937,353**	**2.6%**		**+4,720,097**	**-2.98**	**-2,659,462**
Base 2015	22.9%	175.8 m	7.94%	---	13.8 m	31.9	46.8 m
Total percent change	**+37%**	**–5%**	**---**	**---**	**+34%**	**-9%**	**-6%**

* Households ** Gain/loss ratio is not calculated when the strategy increases ridership for all service boards.

Study limitations

While the proximity of housing and employment has a strong effect on transit demand, the presence of transit infrastructure also makes nearby areas more attractive for development. In other words, transit capital investment helps stimulate its own demand over time. In using a base year of 2015, this study did not estimate how future land use would change in response to transit investment, although the effect is real and can be significant.[4] Mode share increases from transit enhancements and expansions can be expected to grow over time as those investments shape their markets, so the values reported in this study may underestimate the ultimate mode share.

CMAP's regional travel demand model was the main tool used in this study. The travel model is validated approximately every five years against observed data, most recently in 2017.[5] In general, the model produces reasonable results and is particularly well suited to comparing the order-of-magnitude effects of different strategies. However, the data used to calibrate the model were collected from a household travel survey administered in 2007-08 and may not fully capture today's demand patterns. For instance, transportation network companies such as Uber and Lyft were not providing the services they are today. CMAP is undertaking a new household travel survey in 2017-18.

The model uses procedures that simplify analysis, but in some cases may under- or over-estimate strategy effects. For example, the process of determining the transit travel time between origin and destination, which is needed to distribute trips and calculate mode share, averages travel times in a way that may underestimate bus rapid transit ridership. Furthermore, the conventional travel demand model does not constrain ridership by capacity, so crowding has no effect on the propensity to board a train or bus. The next-generation activity-based model under development at CMAP includes the effect of crowding.

Transit strategies evaluated

Expand rail network

Background

The extension of the Chicago Transit Authority (CTA) rail network has long been seen as the primary way to provide fast, high-frequency transit service to the highest density portion of the region, while extensions of Metra have been seen as the main way to increase direct transit connections to downtown Chicago for suburban markets. Of the many proposals to extend CTA rail and Metra commuter lines, in the past two decades the CTA Orange Line has been constructed, the Metra North Central Service began, and Metra lines have been extended to Manhattan and Elburn.

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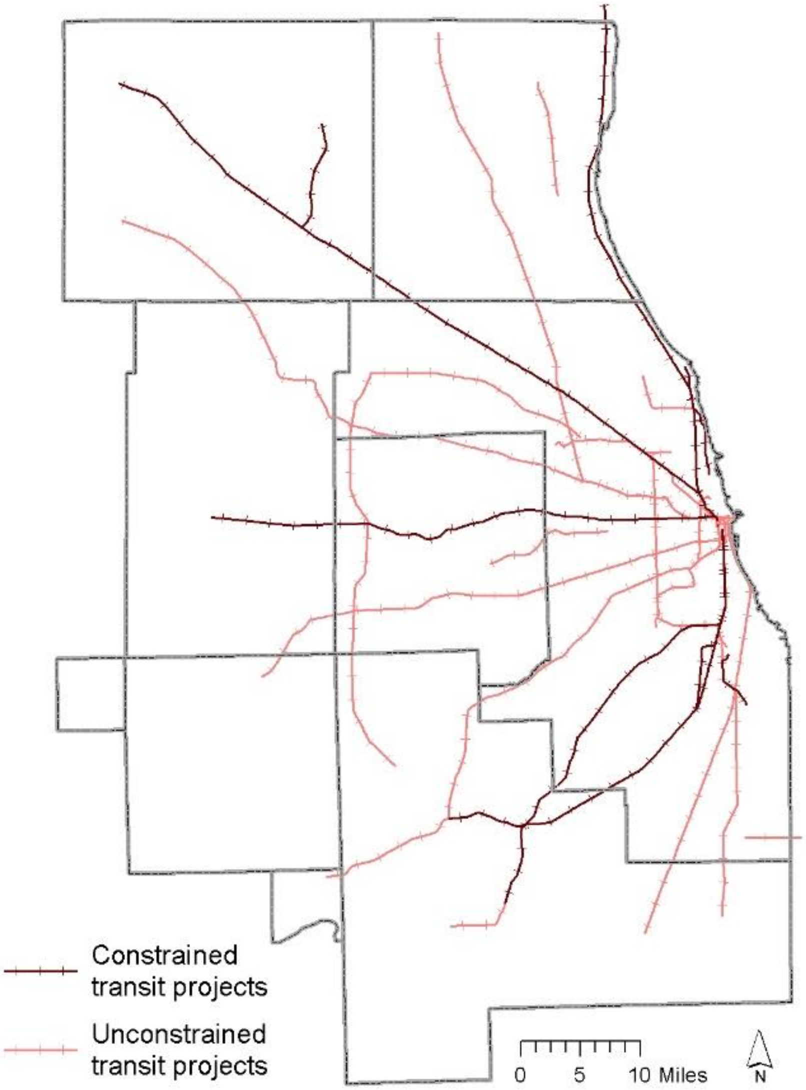
[4] The GO TO 2040 household and population forecasts account for the growth effects near major capital projects, as will the ON TO 2050 forecasts.

[5] Chicago Metropolitan Agency for Planning, "Trip-Based Travel Demand Model Validation Report," February 2017, https://cmap.is/2kZXiL8.

Figure 5. Constrained and unconstrained transit projects in GO TO 2040



Strategy description

As the low alternative, this study modeled the implementation of the two rail extensions and five line improvements recommended as fiscally constrained projects in GO TO 2040.[6] The CTA rail projects include the Red/Purple Line modernization, and the south extension of the Red Line to 130th Street. The Metra projects include several line improvements that would allow increases in runs per day, and the extension of the Union Pacific Northwest line to Johnsburg. The strategy does not analyze the effects of Phase 1 of the Union Station improvements. As the high alternative, this study models the implementation of both the fiscally constrained and unconstrained projects considered in GO TO 2040 (Figure 5).

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[6] Chicago Metropolitan Agency for Planning, "GO TO 2040 Update Appendix: Major Capital Projects," 2014, https://cmap.is/2v8iKRm.

Results

Constructing the constrained projects would modestly increase regional mode share by about 0.11 percentage points, while completing all unconstrained projects would increase mode share by 0.29 percentage points. The strategy is relatively expensive. Most of the projects include state of good repair elements that contribute significantly to their cost, so these additional costs were subtracted from the capital cost estimate. Expanding rail significantly increased the number of jobs accessible within a 75-minute transit trip, and almost all of the new trips were work trips.

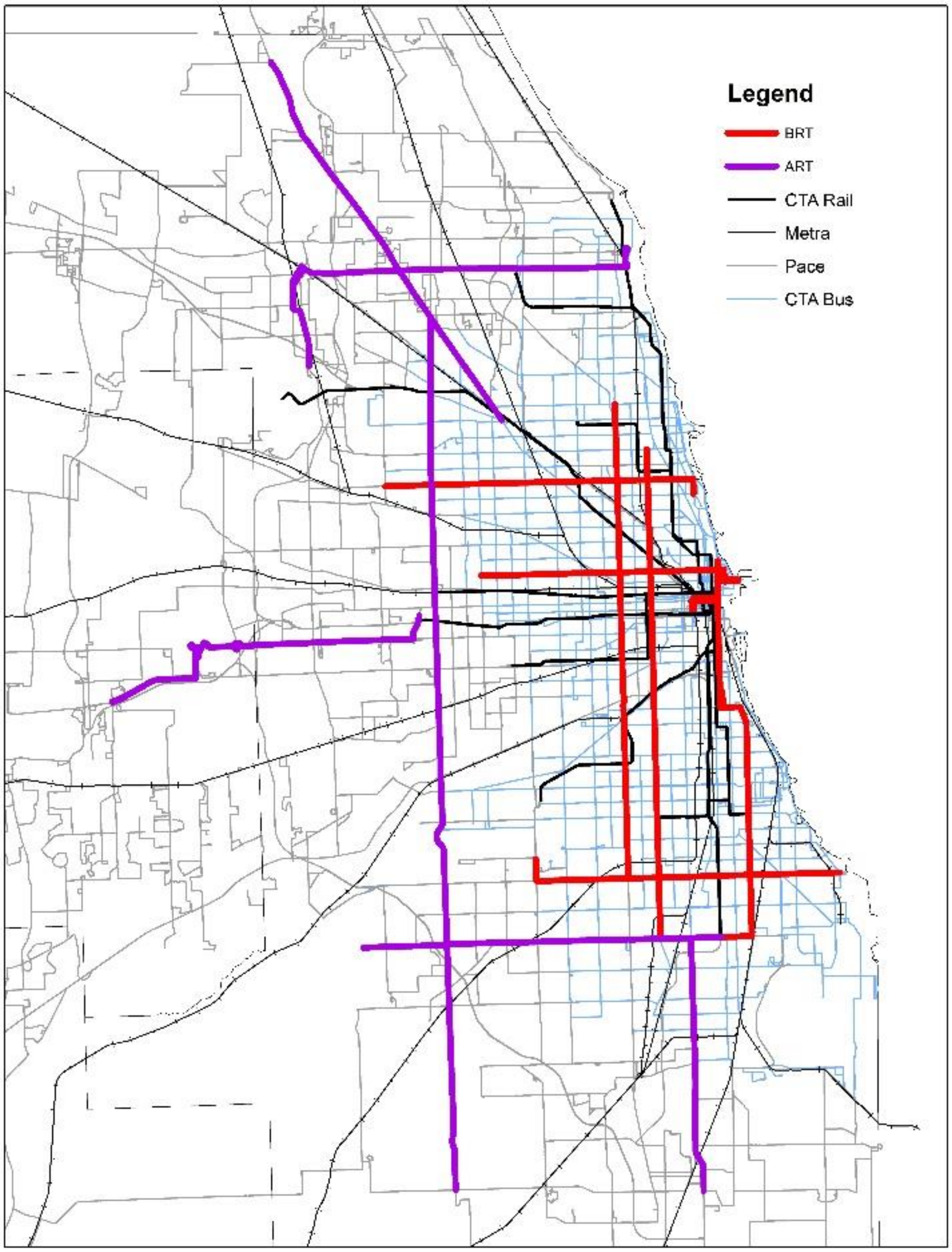
This strategy also slightly decreased commute trip time despite significantly longer trips, evidenced by the large increase in passenger-miles traveled. Expanding rail also had the second-worst gain/loss ratio of the strategies considered, with many riders attracted to rail from bus. This was mostly due to the CTA rail projects shifting riders from CTA bus. On the other hand, the inclusion of Metra projects had a relatively large effect on shifting travelers away from auto usage, although still not nearly as significant as the transit-supportive policies analyzed in this study.

Enhance bus service to make it faster and more reliable

Background

Conventional bus service has been the backbone of the transit system in the Chicago region, in the past carrying more riders than any other transit mode. It is cost-efficient and flexible relative to rail, but it also has some disadvantages for riders, primarily that speeds tend to be slow because of frequent stopping and traffic congestion. Bus rapid transit (BRT) and arterial rapid transit (ART) are a package of improvements that aim to increase speed and make travel time more reliable through some combination of faster boarding, fewer stops, dedicated right of way, and traffic signal priority. A wide range of bus enhancements can qualify as BRT or ART. Numerous studies of enhancements to bus routes have been undertaken in the region, with several ongoing. A variety of enhancement strategies have been implemented on the Loop Link service in downtown Chicago and on the Jeffery Jump service in the southeast part of the city, and a service is in engineering along Milwaukee Avenue north of the Jefferson Park Transit Center.

Figure 6. BRT/ART routes considered in ridership growth study



Strategy description

This strategy examined the effects of implementing a subset of the BRT and ART routes planned by different agencies in the region as well as a more significant expansion. The low alternative included the first six "short-term" Pace ART projects -- Milwaukee, Dempster, Oak Brook, Harlem, 95th Street, and Halsted – and BRT service on the six highest-ridership CTA routes, including Western and Ashland BRT, 79th Street, Chicago Avenue, Belmont Avenue, Cottage Grove Avenue, and a route in Streeterville.

In the low alternative, BRT and ART routes were modeled as additional service; existing local routes were left in place. CTA speed was set as 16 mph in the peak, based on the expected speed for the center-running Ashland BRT alternative, and given five-minute headways (Table 2). Pace speed was set at 18 mph with 10-minute headways. For all routes, stops were roughly every half-mile (except some service in the Loop where stops are closer). In the high alternative, all existing bus routes were treated as BRT/ART routes.

BRT and ART were modeled as having buses unaffected by congestion and therefore able to maintain schedule adherence. The ridership effect of improved travel time reliability and station amenities were not modeled, as they could not be represented in the conventional trip-based model.

Table 2. Bus speeds and schedule adherence in CMAP travel demand model, 2015, peak

	Scheduled (mph)	As modeled with congestion (mph)
CTA Regular Bus	11	10
Pace Regular	17	15
CTA BRT	16	16
Pace ART	18	18

Results

Of the strategies that depend on capital improvements that are mostly under the control of the transit agencies, enhancing bus service had significant ridership benefit, increasing mode share by 0.17 percentage points in the low alternative. While probably not as strong an effect as rail investments, providing BRT or ART service also would encourage higher density development near the line, thus leading to higher transit usage in the future. In comparison to rail expansion, enhancing the bus system also tended to generate a higher fraction of new riders rather than riders attracted from another transit mode. This strategy also had the second-highest improvement in average commute time, again demonstrating the benefits of BRT/ART in increasing transit speeds. On the other hand, this strategy had limited effects on traffic congestion (likely because congestion tends to be very high in the dense corridors where the strategy would be implemented) and even smaller reductions in auto VMT (likely because the auto trips replaced are short.)

While Pace has planned an extensive network of ART lines as part of its Pace Pulse service, the first phase is centered where the market is strongest. The BRT/ART strategy is best suited to higher-density markets appropriate for high-frequency service where local service is typically slow.

Improve station and vehicle environments

Background

The biggest factor determining whether a traveler takes transit is the time spent on the trip—both in-vehicle time and time spent waiting to make connections. However, that choice is influenced by the *perception* of the time spent waiting, boarding, or riding, and research suggests that these perceptions depend on the amenities of the stations and vehicles.[7] In short, travelers are more likely to take transit if they can wait in a heated and sheltered station and get work done during the ride than if they must wait at an unsheltered bus stop and endure a cramped or otherwise uncomfortable ride. Thus, even if service frequency does not increase, more people can be attracted to transit by improving the attractiveness of the stations and vehicles.

Strategy description

This strategy was analyzed using a pre-production version of CMAP's activity-based model. Existing conditions at all stations and stops were classified with a 1 – 6 index representing existing levels of amenities. The stations' index values were then used to discount their perceived wait-time factors, with higher index values yielding smaller factors. When improvements were specified (such as heated shelters, real-time information, or better seating) the index value was increased in proportion to the achieved percentage of the maximum possible improvement. For example, a standard bus shelter (index of 2) that receives 50 percent of the total available improvements would see its index value increase 50 percent, from 2 to the maximum value of 6, for an improved value of 4 (making it as comfortable as waiting at a typical rail station). If Union Station (index of 5) received 50 percent of the available improvements, its index would become 5.5. This reflects the notion that, for the same level of investment, the more amenities a stop or station has to begin with, the harder it is to improve the comfort level of the riders waiting at it. Low and high levels of improvement were modeled, corresponding to approximately 15 percent and 50 percent of the possible improvements to each station or stop, respectively. More details on station classification are available in Sections 4.9-12 of the final report, on development of the transit modernization component of the activity-based model.[8]

Vehicle improvements (such as Wi-Fi service, level boarding, and more comfortable seating) were modeled in a similar way. Each possible vehicle improvement was used to discount either the perceived boarding time or the perceived in-vehicle time, depending on the particular

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[7] Hiroyuki Iseki, Michael Smart, Brian D. Taylor, Allison Yoh, "Thinking Outside the Bus," *Access*, 40: 9-15, 2012, http://www.accessmagazine.org/articles/spring-2012/thinking-outside-bus/. Also, the City of Chicago prepared a study of the ridership benefits of station improvements as part of its Central Area Plan: Stacey Falzarano, Richard Hazlett, and Thomas Adler, "Quantifying the Value of Transit Station and Access Improvements for Chicago's Rapid Transit System," Transportation Research Board Paper No. 01-2987, 2001, https://cmap.is/2icFz5p.

[8] Parsons Brinckerhoff and Resource Systems Group, "CMAP Transit Modernization Model Project: Final Report," 2013, https://cmap.is/2w9m2sb.

improvement. In the base model, Metra trains have a high perceived boarding time (a factor used in the activity-based model) because of their stairs and lack of standing room, but a low perceived in-vehicle time because of the comfortable seating. Conversely, CTA trains have a low perceived boarding time because of level-boarding and more standing room, but a moderate perceived in-vehicle time because of the somewhat limited seating. Again, low and high levels of improvement were modeled, corresponding to approximately 15 percent and 50 percent of the possible improvements to each vehicle, respectively.

Results

Overall, enhancing station and vehicle environments had a relatively small effect on ridership, in line with the small scale of the improvements. These enhancements also had different effects on different kinds of transit users, about which the activity-based model provides additional information. Station improvements had a larger effect on users who are older or lower income, presumably because those riders are more likely to take local buses; and, for reasons described above, the same set of improvements had a larger effect on perceived waiting time at bus stops than at rail stations. By contrast, vehicle improvements had a larger effect on ridership by higher income travelers because they are more likely to ride Metra, whose trains saw a bigger change in perceived boarding time than buses or CTA trains would have from the same set of improvements.

Implement differentiated transit fares

Background

This strategy would manage demand for transit services by charging different fares for different types of trips. Varying the fares by time of day (i.e., peak period vs. non-peak period) could offer substantial benefits by encouraging greater transit ridership for the types of trips that are cheaper for transit agencies to provide (i.e., short, off-peak trips). New technology for transit farecards, particularly the growing use of smart cards, could facilitate differentiated transit fares. Numerous academic studies have noted the benefits of variable or differentiated transit fares, yet relatively few transit agencies vary fares by time of day. In particular, there are only three known cases of combining a peak-hour fare increase with an off-peak fare decrease, and at least one demonstrates that peak pricing can achieve higher transit mode share as well as an increase in fare revenue.[9]

Strategy description

This study examined the effect of differentiating transit fares by time of day, with a low alternative of increasing fares 10 percent in peak periods and reducing them by 10 percent off-peak, and a high alternative of doing the same with 50 percent changes.

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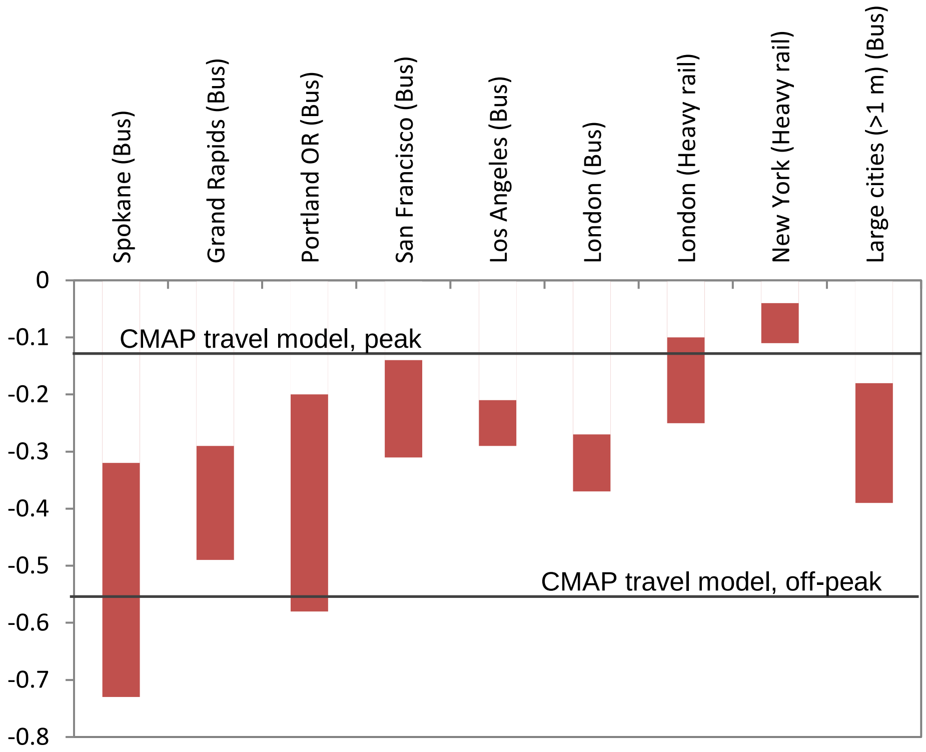
[9] Evan Gwee and Graham Currie, "Review of Time-Based Public Transport Fare Pricing," *Journeys* (2013).

Results

Analysis suggests that varying fares by time of day would result in a 0.11-0.70 percent increase in transit mode share, by far the largest potential gain of the policies that are under the transit agencies' control. As expected, work trips by transit decreased because they tend to occur in peak periods, which is likely the reason that the strategy resulted in an increase in overall auto VMT (although congestion still decreased.) The effect on work trips by transit was more than offset by new non-work trips. Overall, fare revenue also increased very slightly, by 3 percent. Like most of the other policy strategies, variable fare policy had no effect on the number of jobs accessible within 75 minutes because it did not change the level of service provided.

Figure 7. Comparison of modeled elasticity to literature values



Source: TCRP 2004 and Pham and Linsalata 1991.

Comparing these results with literature values, it appears that implied price elasticity from the travel model is roughly within the literature range (Figure 7). Based on the travel model, the implied price elasticity blended across all modes for the peak period is –0.13, while the off-peak elasticity is −0.56. According to the literature, typically off-peak transit ridership tends to have roughly one-and-a-half to two times the sensitivity to fare changes of peak period ridership with rail ridership demonstrating a much lower elasticity than bus ridership.[10] Note finally that

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[10] "Transit Pricing and Fares" *TCRP Report 95*, 2004, http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_95c12.pdf; Todd Litman, "Transit Price Elasticities and Cross-Elasticities," 2016, http://www.vtpi.org/tranelas.pdf; Larry Pham and Jim Linsalata, "Effects of Fare Changes on Bus Ridership," American Public Transit Association, 1991, www.apta.com.

Metra ridership, in this analysis, actually declined with the implementation of differentiated fares. This is likely because Metra service is more peak-oriented, CBD-oriented, and commute-oriented than the other service boards. By contrast, increasing peak-hour fares reduced peak-hour demand, and non-work trips were less likely to be long-distance trips headed to the CBD.

Increase transit service frequency

Background

Typically, an increase in transit service results in increased transit ridership. Regardless of how fast a transit service is, increasing its frequency reduces wait times and enables easier transfers, making it more attractive. Statistical models of the factors influencing usage of a transit service typically find that service frequency is the strongest predictor of ridership. Over the past few years, however, the overall trend has been toward reduced rather than increased transit service levels, at least on the bus system. There are several reasons a transit agency may reduce frequency on a route. Assets and staff providing service may be reallocated to routes with higher ridership, or funding issues may require service cuts as has been seen in the recent past. In addition, as infrastructure ages, it may not be able to handle desired service levels. Slow zones limit rail throughput and vehicle failures can limit the size of the fleet. Finally, in addition to increasing frequencies, technologies can be deployed that provide some of the benefits of reducing wait time and enabling easier transfers. Some examples are technologies that ensure schedule adherence, protect connections, and provide real time traveler information.

Strategy description

The frequency of all routes was adjusted upward for this strategy. The headway, or wait time between vehicles, was decreased by 25 percent in the low alternative and 50 percent in the high alternative. In other words, in the high alternative, twice as many hours of service would be provided, while in the low alternative, 33 percent more service hours would be offered.[11]

Like the other strategies considered, this is hypothetical. Significantly increasing service levels would not simply depend on being able to fund the operating subsidy, but also on investment in the capacity needed to provide these levels of service. This is the case both on the rail and bus system, although the issues are more complex and the level of investment higher for rail. Additional bus service means more buses, drivers and support staff, as well as additional bus garages. For example, all of CTA's bus garages are currently very close to, at, or over capacity. It is less straightforward for rail services because of their capacity constraints. For instance, the number of trains CTA can run per hour may be limited by the design of their signal systems, train yard capacity, etc., while the number of trains Metra can run often depends on agreements with the freight rail companies that own the track.

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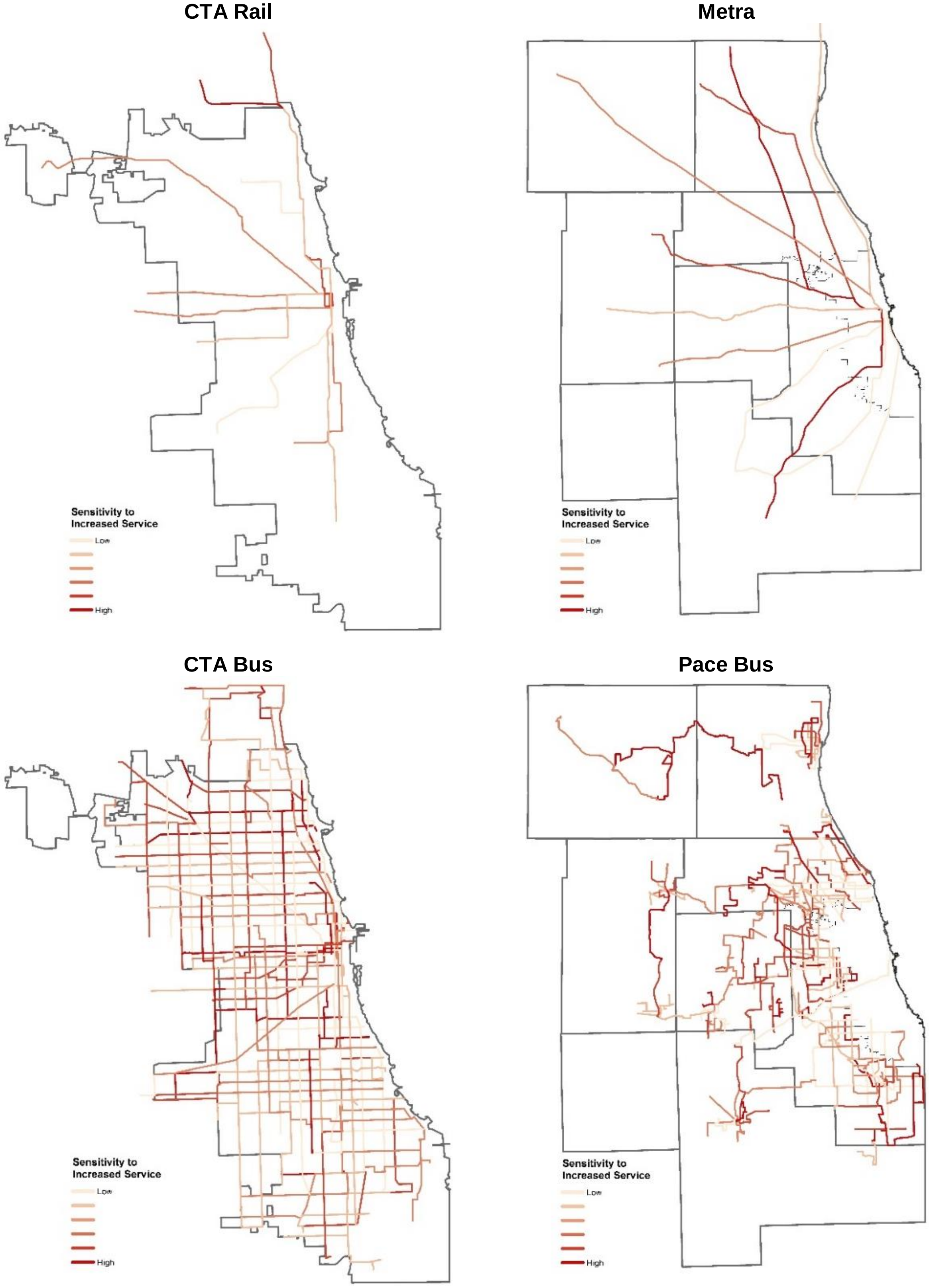
[11] Because headway and frequency are inversely related, a headway reduction of 25 percent translates into an increase in frequency (and an increase in total service hours) of 33 percent.

Results

The low and high alternatives resulted in a mode share gain of 0.43 and 1.00 percentage points, respectively. At the route and line levels, there was a great deal of variation in how ridership responded to increased service levels (Figure 8). Because sensitivity was measured by percent increase, very low ridership routes with limited service tended to increase more given their low base values. For bus service, few geographic patterns were evident in the responsiveness to service frequency increase. Note that Figure 8 compares ridership sensitivity by route for each mode; it does not compare sensitivity across modes.

On the rail system, this analysis suggested low demand for increasing service on the Metra Electric, Rock Island, and particularly the Heritage Corridor. By contrast, the SouthWest Service seemed to have significant additional demand in its corridor. The North Central Service also stood out as particularly sensitive to service increases, probably because of its currently limited service. The analysis also suggested that the Brown Line has relatively high demand for additional service, and—again, because of the low base service levels—the Yellow Line and the northern portion of the Purple Line stood out for having ridership sensitive to increased service.

Figure 8. Sensitivity of ridership to service increase by route and line

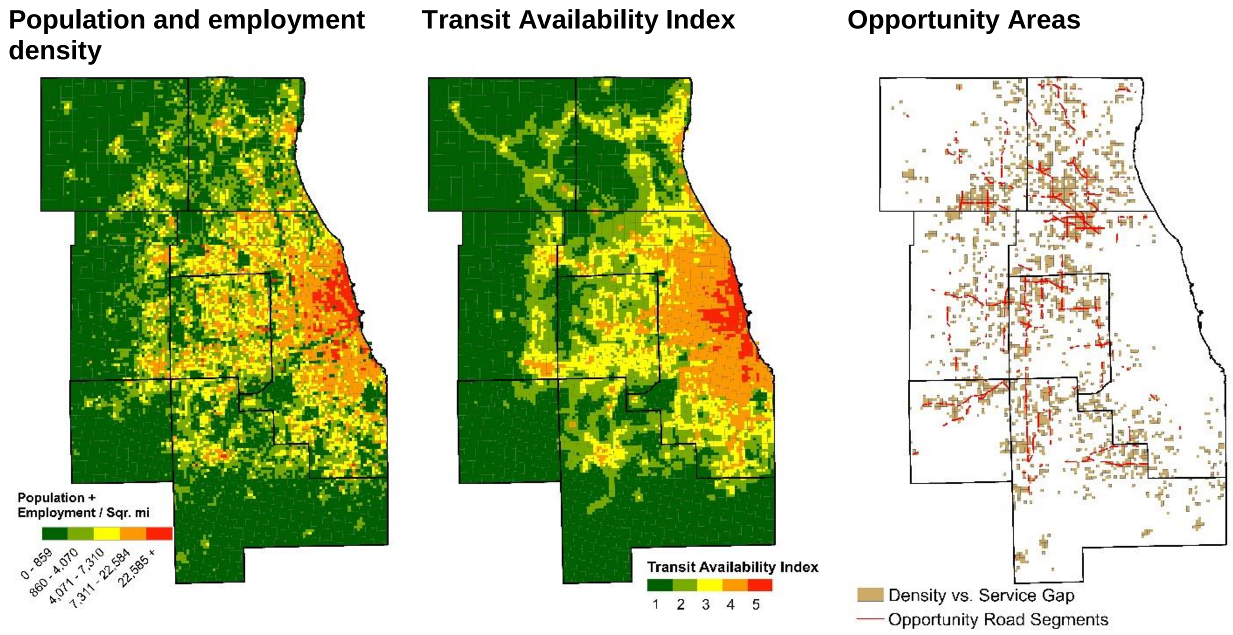


Address areas where transit availability is low

Background

In addition to ridership growth, GO TO 2040 also includes a goal to increase the availability of transit for households and jobs across the region. Transit availability is measured by the transit availability index, which is a 1 – 5 metric composed of indices for service frequency, proximity to stops and stations, the number of destinations that can be reached without a transfer, and the pedestrian environment. The GO TO 2040 target is for 78 percent of the population and 81 percent of jobs to have at least moderate transit availability (i.e. an index value of 3-5) by 2040. The strategy discussed here tested how mode share would respond to an effort to meet transit availability goals simply by providing more service. Note that improving transit access could also occur through land use change—that is, so that more households and jobs locate within areas already well-served by transit.

Figure 9. Areas of high population and employment relative to transit availability



Strategy description

This strategy was designed to serve areas that have relatively high densities of households and jobs, yet a relatively low value for the transit availability index. The analysis was completed using "subzone" geography. Subzones are Public Land Survey System quarter-sections (0.5-mile by 0.5-mile squares) within the CMAP area, and quarter-quarter sections (0.25 by 0.25-mile squares) in the CBD. As a first step, the subzones in the region were ranked by their household and job densities (Figure 9) and then put into five categories so that the number of subzones in each density category was equal to the number of subzones in each category of the transit availability index. In other words, if there are 1,300 subzones with a transit availability index of

5, then there would be 1,300 subzones in the highest density category of 5. Second, the density rank was subtracted from the transit availability index, so that a subzone with a density category of 3 but a transit availability of 2 would have a difference of −1. Third, these differences were mapped (third panel in Figure 9) and arterial roads in these regions were identified as locations for additional routes.

Based on this simple ordinal analysis, a set of hypothetical bus routes was developed to serve those areas with relatively high population and employment for their level of transit availability (Figure 10). Routes were assumed to follow major highways. Both express buses and regular buses were added to the network, and identical service was provided in the peak and offpeak hours. Table 3 shows the service characteristics of the hypothetical routes in comparison to average headways and scheduled speeds across the Pace system.

Figure 10. Hypothetical bus network designed to improve transit availability index

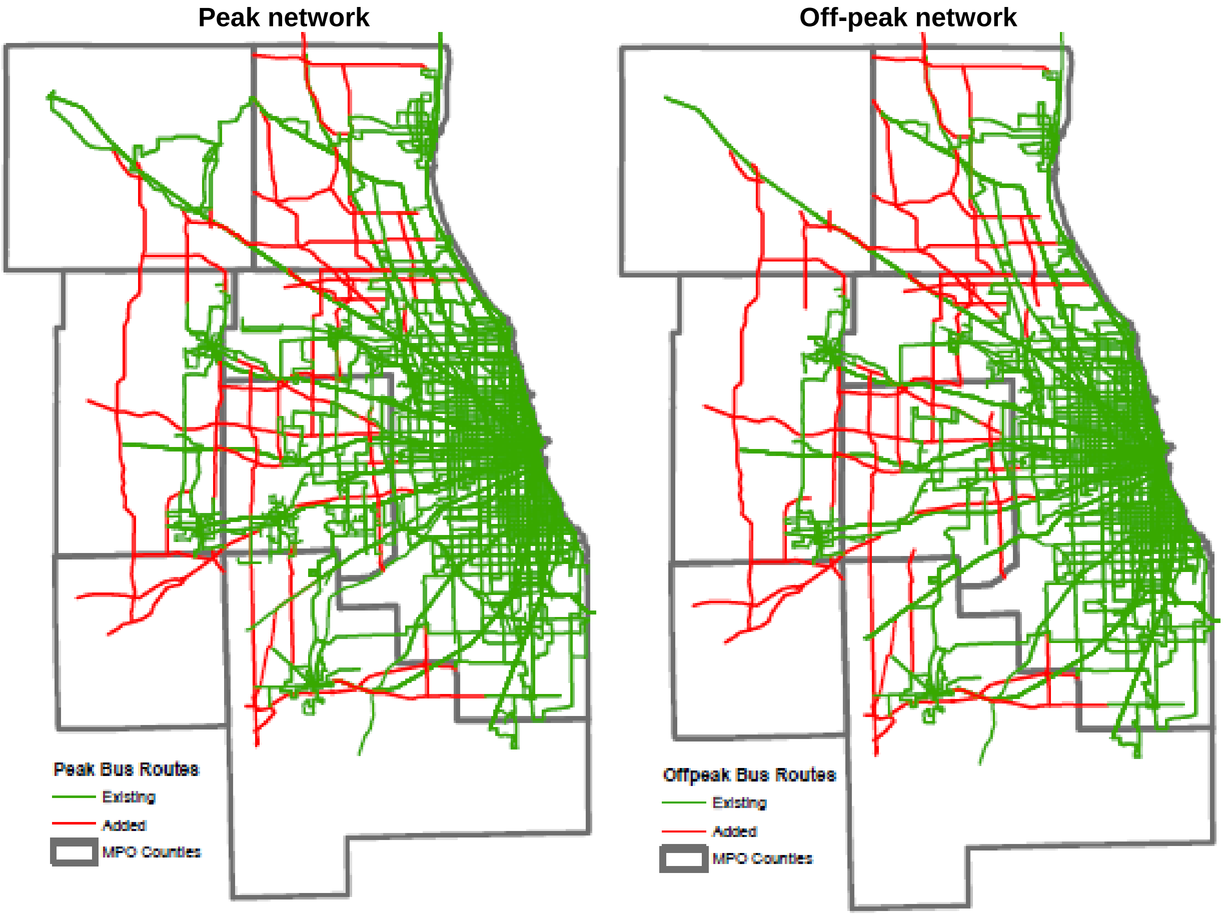


Table 3. Headway and speeds for hypothetical bus routes compared to observed

		Headway (minutes)			**Scheduled Speed (MPH)**		
		Observed Pace average	Low scenario	High scenario	Observed Pace average	Low scenario	High scenario
Peak	Regular	52	45	22.5	17	17	17
	Express	24	24	12	24	24	24
Offpeak	Regular	60	45	22.5	17	17	17
	Express	180	24	12	*24*	24	24

Results

The objective of this strategy was to improve transit availability for households and jobs. Doing so solely by increasing service coverage was relatively ineffective from the standpoint of ridership. The elasticity of mode share with respect to service miles on these new routes was low, and because new vehicles and labor would be required, cost-effectiveness is likely to be low as well. By comparison, the land use strategies discussed in this study increased the percentage of population and jobs with transit available without requiring new service. This is not to say, however, that there would be no costs to serving these new riders.

Note finally that other routes could be chosen besides the ones in this hypothetical analysis. Furthermore, many Pace routes currently take circuitous paths to serve particular trip generators. These nuances were not considered in this study, but they certainly affect route productivity.

Other policy factors evaluated

Implement more widespread pricing for parking

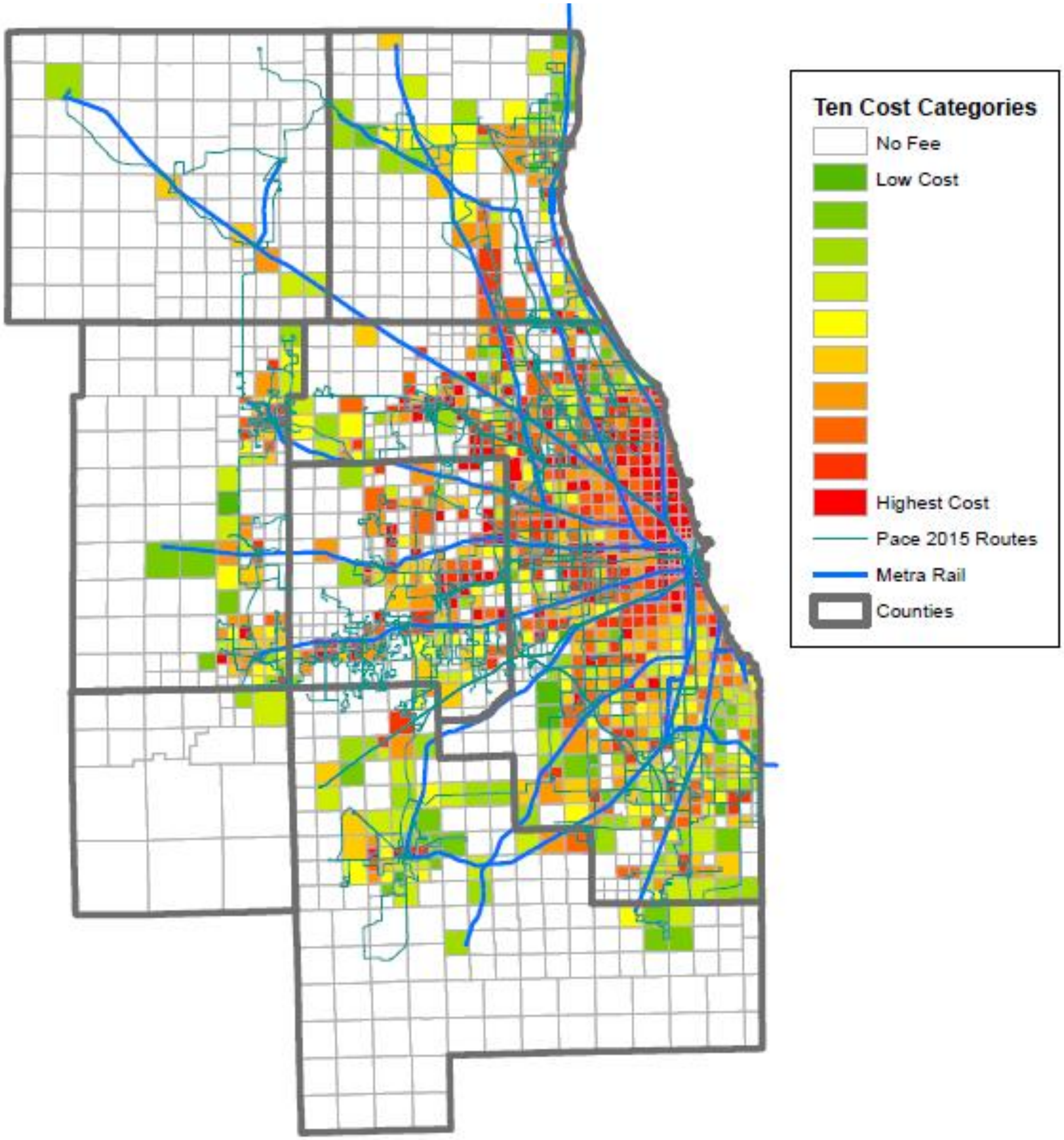
Background

Northeastern Illinois has more than 3 million off-street non-residential parking spaces and millions more on-street parking spaces. Much of this supply is available for use at no charge to drivers. Free parking encourages more driving, and having to provide sufficient parking spaces to meet demand for this free good typically leads to an automobile-oriented urban form, with lower density and poor pedestrian connections, both of which inhibit the success of transit service. While there are numerous ways to better manage parking—encouraging shared parking plans, reducing parking requirements for new developments, etc.—the market mechanism that works through pricing is arguably the most effective approach. Pricing parking also generates revenue that could be invested in transit service, among other transportation needs.

Strategy description

This strategy modeled the effect of applying a parking charge for trips taken to non-residential destinations in the region. Parking charges were applied to all trips to destination zones where all-day transit service is available (Figure 11). To approximately simulate market forces, the charge was assumed to increase as employment density increased, reflecting increased demand for parking. This was accomplished by identifying deciles of employment density in the zones outside the CBD and assigning higher fees as the density decile increased. (The travel demand model already has parking prices assigned to the CBD, and these were left unchanged.) While there is some judgment in determining potential fees, this strategy examined two pricing structures. First, prices outside the CBD were allowed to range either from 25 cents per trip in the lowest density zones to $2.50 in the highest density zones; and second, from 50 cents to $5.00. In addition, the parking cost during the midday was half the cost during the peak. This simple approach could be modified in future studies by instead estimating the prices needed to recover the cost of the land and structures used for parking.

Figure 11. Zones where parking charges were applied



Results

Pricing parking had large effects on transit mode share. The lower range of prices produced a mode share gain of 0.67 percentage points and the higher a gain of 1.48 percentage points. The size of the effect likely was due to the fact that the parking fee applied to any trip ending in a place other than home; by contrast, other fees depend on the length of the trip (motor fuel tax) or the type of facility used (congestion pricing). Furthermore, in the low alternative, the parking charge in the highest density zones was comparable to on-street parking meter rates in Chicago outside of the CBD as well as to the full fare on local transit. The analytical framework used in this study required that the charge be perceived by the traveler as an additional cost for each trip, but actual implementation would likely be on an hourly basis.

Both the low and high alternatives reduced average transit trip time, with the higher range having twice as large a reduction, due to changes in the mix of transit trip numbers and lengths. Because short auto trips become relatively more expensive than long auto trips, and it is generally easier to substitute transit for short auto trips, shorter auto trips were likely being shifted onto transit. Like most of the other policy strategies, parking pricing had no effect on the number of jobs accessible within 75 minutes because it did not change the transit level of service provided.

Implement congestion pricing on the expressway system

Background

CMAP advocates for the implementation of congestion pricing because it provides drivers with additional choices and allocates roadway space more efficiently. A variable toll on expressway travel that increases during peak periods would be expected to encourage drivers to travel outside the peaks, take an untolled route, or instead take a different mode, including transit. GO TO 2040 includes a goal of tolling and implementing congestion pricing on existing limited-access highway capacity over the longer term.

Strategy description

Previous CMAP study of congestion pricing[12] determined that a toll of approximately 5 to 30 cents per mile during the morning peak would be needed to keep traffic flowing freely in an express toll lane. These values served as the basis for the low scenario tolls. Tolls were applied to the entire Interstate system in this analysis, by mile rather than at toll plazas, and the tolls varied in relation to the traffic volume on the segment. For all times of day, when volumes on the segment were less than or equal to capacity, the toll applied was zero. As volumes exceeded capacity, tolls were applied as a continuous value in relation to how far capacity was exceeded. As shown in Table 5, most of the tolls were in the 5 to 30 cent range. Only a few odd segments received the very high values shown, but they were presented for completeness. For the high toll scenario, the tolls in cents per mile were doubled.

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[12] "Congestion Pricing: an Analysis of the GO TO 2040 Major Capital Projects," Chicago Metropolitan Agency for Planning, 2012, https://cmap.is/13meiRC.

Table 3. Schedule of tolls applied in low and high scenarios

	Cents per Mile			**Cents per Mile**	
Volume/ Capacity	Low Scenario	High Scenario	**Volume/ Capacity**	Low Scenario	High Scenario
≤ 1	0	0	**1.6**	73	146
1.1	15	30	**1.7**	82	164
1.2	28	57	**1.8**	91	182
1.3	41	81	**1.9**	99	199
1.4	52	104	**2**	107	215
1.5	63	126			

Note: Intermediate toll values are not shown but were applied as volume to volume/capacity ratios between the values shown.

Results

In general, congestion pricing on the expressway system would not shift many travelers to the transit system, likely because the expressways serve longer distance trips. However, congestion pricing on the expressway system would benefit Metra the most because its service competes most with expressways. Congestion pricing did increase arterial congestion, which would affect bus service. These effects could potentially be ameliorated with appropriate arterial improvements. Given that congestion pricing also would generate a significant amount of revenue, arterial and transit improvements could be funded to offset effects in congestion-priced corridors.

Increase motor fuel tax

Background

GO TO 2040 recommends increasing the motor fuel tax (MFT) by 8 cents per gallon, then indexing it to inflation in future years and eventually replacing it with an alternative such as a VMT tax. This is primarily aimed at raising needed revenues for the transportation system through a user fee, but because it also changes the cost of driving relative to transit, it could make transit more attractive as well. In 2016 the Metropolitan Planning Council proposed increasing the MFT by 30 cents per gallon in order for the state of Illinois to significantly reduce the backlog of infrastructure investment needs.

Strategy description

This strategy was evaluated with an MFT increase of 8 cents per gallon (low scenario) and 30 cents per gallon (high scenario). The values were converted to costs per mile using current fleet fuel efficiency information and added to the auto operating costs used in the travel demand model.

Results

Increasing the MFT, even fairly dramatically, would not substantially increase transit mode share. The low MFT increase translated into an increase in per-mile operating cost of 1.3-2.2 percent, depending on traffic speed, while the high increase translated into a 5.1-8.6 percent increase in operating cost. When combined with the other factors that influence mode choice, such as the value of travel time, these relatively minor changes in out-of-pocket cost for auto travel would add up to a small effect on transit mode share.

Note that, over short time periods, gas prices can fluctuate more than the 8-30 cents per gallon evaluated here. The MFT increases evaluated here are small relative to variability caused by market factors. These market-driven changes in gas prices affect transit ridership, and short-term ridership forecasting by the service boards takes that into account. However, this study is examined the responsiveness of transit ridership to increasing MFT as a matter of policy, not to forecast the general effect of increasing gas prices.

More transit-supportive land use

Background

Transit systems work better when they serve more concentrated demand. While park-and-ride systems and last-mile connections can help aggregate riders, the number of people and jobs within the station catchment area largely defines ridership potential. Thus, the main transit-supportive land use change is increasing residential or employment density near transit stations or stops, as implemented practically through zoning changes or financial incentives. In particular, given that the rail transit system is strongly oriented toward the Chicago Loop, having relatively more employment located there would tend to increase demand on the transit system.

Strategy description

Transit-supportive land use has three potential components: an increase in households near transit, an increase in employment in the central business district (CBD, defined as the area bounded by Chicago Avenue, Halsted Street, Roosevelt Road, and Lake Michigan), and an increase in employment near transit outside of the CBD. Accordingly, 2015 households and employment were hypothetically shifted in three separate scenarios, as follows:

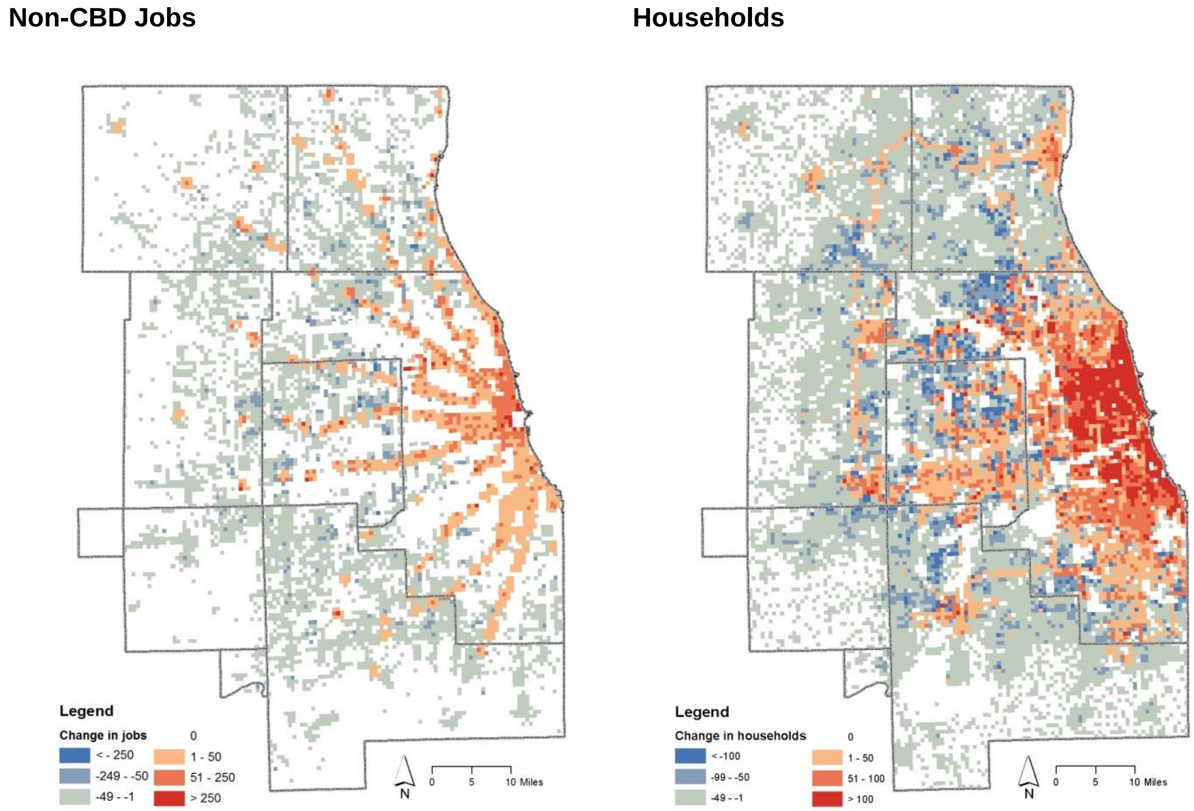
1. The number of jobs in the CBD was increased by 15 percent (low) – approximately 10 years of growth at current rates, as estimated from Illinois Department of Employment security data -- and 30 percent (high) by shifting an equal number of jobs from each subzone not served by any transit. These scenarios represented 1.6 and 3.1 percent of regional jobs, respectively, or 74,000 and 148,000 jobs.
2. The number of jobs outside the CBD but within a quarter-mile of rail transit was increased by the same absolute number of jobs as the first scenario, and distributed in

proportion to the existing number of jobs in non-CBD, transit-served subzones. This increased the density of jobs near rail transit by 6 and 12 percent respectively, again by shifting an equal number of jobs from subzones not served by transit.

3. The number of households within a quarter-mile of any transit was increased by 10 percent or 20 percent, again keeping total regional household count constant by shifting an equal number of households from each subzone not served by any transit. In this method, the households that shifted took on the attributes of the households in the subzones into which they were shifted, including their trip rates. This approach simplified the analysis, but it should be noted that households in transit-served subzones tend to be smaller and have fewer cars, among other characteristics, and so this approach may have somewhat overestimated the effect on ridership.

All subzones intersecting a quarter-mile buffer of a rail station were considered to be served by rail transit – which in practice means that parts of the intersecting subzones will be beyond a quarter-mile away from the station. Any subzone within which a bus stop was located was considered to be served by bus transit.

Figure 12. Subzones where households and job totals were changed (low alternative for both)



Results

Increasing the number of jobs in the CBD had by far the largest effect on mode share of any of the factors considered, a 0.67 percentage point mode share gain in the low version and 1.35 percentage points in the high version. Furthermore, increasing the number of jobs in the CBD had three times the effect on mode share than increasing the number of jobs by the same amount within a quarter-mile of stations outside the CBD. In terms of the relative effectiveness of increasing household or job density around transit, increasing the number of jobs within a quarter-mile of stations (outside the CBD) resulted in twice the increase in transit mode share than the same increase in households. In general, furthermore, mode share also had a mildly non-linear response to density: as density increased, mode share increased disproportionately more.

Note that the household scenarios were defined differently than the employment scenarios in that households could be moved to any transit-served subzone, while employment was moved only to rail subzones. This was because a preliminary analysis with an equal amount of household relocation restricted to rail subzones showed that mode share gain would be *higher* with the more dispersed household relocation pattern shown in Figure 12, where density was also increased in bus-only areas. The reason seemed to be that many jobs are located in these bus-only areas; increasing household density along the bus lines serving these employment areas would encourage people to take the bus to work rather than drive. This finding underscores the importance of increasing household density in all transit-served areas, not just near rail.

It is worth comparing these results to recent experience. While employment has been growing strongly in the CBD, the proportion of households locating within transit-served areas has not, at least at the regional level—although some areas, such as the Brown Line corridor in Chicago, have seen dramatic population increases in recent years. Thus, trends have been mixed. Lastly, capacity constraints on the transit system have not been fully quantified, but the ridership gains estimated with CBD employment growth are probably limited in practice by capacity.[13]

Strategies not evaluated

Moving toward a state of good repair

Improving the condition of transit assets and advancing toward a state of good repair (SOGR) is the first concern of transit agencies in the region. The state of repair of certain elements of the transit system also have a particular effect on ridership. Track condition may limit speed through the presence of slow zones, which could make the service less attractive to riders. Deteriorated stations and stops would tend to increase the perceived cost of waiting for a train or bus, again having a negative effect on ridership. Mechanical reliability, which is a function of the condition of various system elements (such as vehicles, signals, etc.), also affects travel time reliability, with frequent breakdowns making the service less attractive.

The concern with SOGR is not so much that improvements could play a major role in stimulating new ridership, but that if SOGR investment falls, ridership would decline. As such, sustaining existing ridership and growing new ridership ultimately depends on having a functioning system, even though SOGR improvements alone are not expected to cause significant ridership increases.

Reducing user cost of transit

Reducing fares across the board

Most basically, reducing fares would naturally increase ridership. In fact, a test evaluation suggested that making all transit trips free to the rider would result in a 3.08 percentage point mode share gain, with lesser fare reductions resulting in mode share gains that are some fraction of that maximum. However, any fare revenue would either need to be made up through another source, or agencies would have to offer reduced service or forgo capital

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[13] The conventional CMAP travel demand model does not constrain ridership by capacity, so crowding has no effect on the propensity to board a train or bus. The next-generation activity-based model that is under development at CMAP, and nearing production use, does include the effect of crowding.

maintenance. Because of the new riders attracted to the system, demand for service and various capital needs would also increase, yet fares would offset those costs to a lesser degree. Unless fare reductions were combined with revenue transferred from, e.g., parking fees or congestion pricing, they would not be a sustainable way to increase ridership.

Universal transfers or discounted interagency transfers

Discounting transfers between services has the effect of increasing convenience, flexibility and simplicity, and arguably it is the hallmark of a truly integrated regional transit system. When New York introduced free transfer between subway and bus, combined ridership rose 16 percent in two years.[14] CTA and Pace already provide transfer discounts within their service, and the Metra link-up pass functions to some degree as a discounted transfer between Metra and CTA or Pace. Integrating fixed fares with Metra's zone system presents some challenges that could potentially be easier to solve with the Ventra payment platform. However, like reduced fares across the board, discounted or universal transfers do run the risk of cutting into revenue while also increasing demand. More study is needed on how to design a financially sustainable transfer policy prior to assessing the ridership benefits.

Increase participation in transit benefit program

Under federal law, transit users may exclude from federal income taxes up to $255/month in commuting costs through employer-sponsored programs. The effect of this benefit is to reduce the cost of using transit by an amount that depends on the commuter's marginal tax rate and the type of ticket purchased. For instance, a rider in the 15 percent tax bracket purchasing a CTA monthly pass for $100 would see the effective cost of the pass reduced to $85. Studies have shown that, when transit benefits are offered by employers, employees are more likely to take transit. Participation in these programs by employers is estimated to be 22 percent in the region.[15] Small businesses are particularly slow to participate in the program. It would be valuable for more employers to participate, as the user cost reduction is born by the federal government rather than locally, but the mode share gain likely would not be very high.

Note also that the federal transit benefit program could itself be changed in ways that benefit transit more. For instance, regional policy-makers could consider whether rides taken on rideshare services, such as Via and UberPool, should be eligible for the pre-tax benefit, as they are now. Similarly, pre-tax benefits are also offered for parking and also capped at $255 per month, although this works against the parking pricing strategy discussed in this report.

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[14] Bruce Schaller, "Lessons From MetroCard Fare Initiatives," *New York Transportation Journal*, Fall/Winter 1998, http://www.schallerconsult.com/pub/metrocrd.htm.

[15] "Commuter Benefit Impact Survey," Transit Center, 2010, https://cmap.is/2wXSxr6.

Other strategies

Providing additional parking at transit stations

Park-and-ride lots are a major part of accessing the transit system. A Metra survey found 62,546 vehicles at Metra park-and-ride lots in 2014, with lots at 77 of the 206 stations more than 85 percent occupied. CTA and Pace also have networks of park-and-ride lots. However, the travel demand model does not constrain transit ridership by parking lot capacity, so the value of expanding (or reducing) commuter lots cannot be evaluated directly. Nor can the model readily compare the ridership benefits of encouraging walkable development in the station area versus having an auto-oriented station area with larger commuter lots, an important question.

Marketing

The transit agencies often use marketing to inform riders of new or changed services, and the RTA as well as the service boards conduct more general advertising campaigns aimed at attracting new riders or retaining those who are already riders. Studies have shown that attitudes are becoming more favorable toward transit, especially among younger adults. Marketing can play a role in promoting and reinforcing positive images of transit.[16] But in the travel demand model, people are already assumed to have perfect information about the transit service available to them, how much it will cost, and how long it will take to arrive at a destination. Thus, the effects of marketing were not estimated in this study.

Infill stations

Infill stations can be an attractive way to serve new markets by taking advantage of new population and employment growth along existing transit lines, and some can enable transit to serve more destinations by allowing easier transfers. On the other hand, by adding dwell time along the line, they reduce service speed, making the service less appealing to riders. Many areas of potential rail infill stations already have access to transit via bus or park-and-ride, resulting in a high risk of shifting riders from existing transit rather than growing transit mode share. The net result of these main factors determines the effect on mode share. However, additional research is needed to identify potential locations for infill stations.

Next steps

The strategies presented in this report help set a direction for transit investment in CMAP's future work, including ON TO 2050. This work illustrates that a variety of factors influence transit ridership. Achieving the region's targets for growing transit ridership will require changes in many areas including land use, policy, transportation finance, and transit

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[16] Transit Cooperative Research Program, "Report 50: A Handbook of Proven Marketing Strategies for Public Transit," *Transportation Research Board*, 1999.

infrastructure. Strategies laid out in this report offer guidance on the level of impact that can be expected from implementation. Moving forward, CMAP will continue to work toward making transit the preferred travel option for as many of the region's residents as possible.

233 South Wacker Drive, Suite 800
Chicago, Illinois 60606
312-454-0400
ONTO2050@cmap.illinois.gov

www.cmap.illinois.gov

The Chicago Metropolitan Agency for Planning (CMAP) is our region's comprehensive planning organization. The agency and its partners are developing ON TO 2050, a new comprehensive regional plan to help the seven counties and 284 communities of northeastern Illinois implement strategies that address transportation, housing, economic development, open space, the environment, and other quality-of-life issues.
See www.cmap.illinois.gov for more information.

ON TO 2050 reports will define further research needs as the plan is being developed prior to adoption in October 2018.

FY18-0027 | August 2017