EVALUATING COMMUTER BENEFITS REFORMS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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ABSTRACT

Employer benefits can play a key role in encouraging alternatives to drive-alone commuting. In 2016, the Massachusetts Institute of Technology (MIT) introduced a series of commuter benefits reforms for its ten thousand employees. Motivated by aging parking facilities and pressures for alternative land uses, as well as the Institute's climate goals, MIT sought to reduce parking demand by ten percent by leveraging financial incentives and techniques of behavioral science. The program provided each employee with a fully subsidized local transit pass built into their MIT ID card, paid for by MIT on a per-use basis to the transit agency. For drivers, annual parking permits were replaced with daily, pay-as-you-park pricing to eliminate sunk costs and encourage day-to-day mode choice. Other elements included a transit station parking subsidy and online dashboard with incentives. Program impacts were monitored using a joint approach of employee surveys and automatic data collection across travel modes.

The result was an eight percent reduction in parking demand in the first year at a net annual savings to MIT of $140 per employee (after accounting for reduced future parking infrastructure expenditures). Transit agency revenue increased as ridership among MIT employees rose ten percent, and the single-occupant vehicle mode share declined to 25%. The program helped MIT manage the closure of a 372-space garage without denying parking to any employees, and will help accommodate future parking supply reductions. The program serves as a case study of how employer benefits can effect a mode shift away from drive-alone commuting in a cost-effective manner.

Keywords: Travel demand management, commuter benefits, behavior change, parking, transit benefits

INTRODUCTION

In cities around the world, traffic congestion imposes a growing burden on economic productivity and quality of life. In American cities, increasing commuting times are costing drivers $305 billion annually in direct and indirect losses (*1*). While commuters have an inherent interest in reducing the disutility of their travel (in terms of travel cost, time and stress), employers may be similarly motivated to improve their workers' commutes. This motivation can stem in part from a desire to attract and retain workers, or an altruistic concern for commuter wellbeing. More commonly, though, employers also face various systemic pressures from the perspective of minimizing costs and adhering to government policies.

In particular, the provision of staff parking often imposes a steep cost for workplaces, in the form of construction and operations costs of parking facilities and the opportunity cost of such land occupying valuable real estate. Workplaces tend to develop a culture around commuting (*2*), with some having established decades-long practices of offering free parking as an employee benefit. Commuters that use public transit or other non-driving modes have long faced systemic inequities in the availability and amount of employer and government-provided transportation incentives.

This paper discusses a series of commuting benefit reforms at the Massachusetts Institute of Technology (MIT) that seek to reduce single-occupancy vehicle (SOV) travel among its ten thousand staff. The paper begins with background on travel demand management (TDM) strategies, motivating the application of behavioral science in transportation. The specific program reforms at MIT are then discussed, including changes to parking pricing and transit benefits. A systematic method of monitoring and evaluation is described, including the joint use of surveys and passive data collection across modes. Results are then presented from the lens of (a) individual impacts on travelers, including program awareness, attitudes and behavior, and (b) institutional impacts to MIT and the transit agency, including costs, benefits and infrastructure utilization. The paper concludes with a reflection on lessons learned from implementation for generalizing beyond MIT.

BACKGROUND

The origins of travel demand management (TDM) in the United States stem largely from federal government initiatives introduced in the 1970s and 1980s aimed at reducing air pollution (*3*), bolstered by 1990 amendments to the Clean Air Act that introduced mandatory employer trip reduction programs. The Congestion Mitigation and Air Quality (CMAQ) Program, introduced in 1991 by the Federal Highway Administration (FHWA), provides a majority of funding for regional TDM initiatives. Programs abound nationwide of varying efficacy, with a common thread that approaches appealing to personal benefits of travel time and reliability improvements are more effective than those focused on society-wide benefits of reduced congestion and pollution (*4*).

At the workplace level, initiatives may be motivated by regulatory requirements like a Trip Reduction Ordinance mandated by local or state laws. For example, the Washington State Commuter Trip Reduction Law requires employers to take steps to reduce the drive-alone mode share (*5*). Tax incentives also motivate employers to offer benefits, as they can deduct qualified transportation expenses from both taxable employee income and employer payroll tax. Commuters offered pre-tax transit benefits are found to be five times more likely to use transit as those not offered such benefits (*6*). Today, workplace TDM is often motivated by budget pressures (e.g., cost of providing parking) or competitiveness in attracting and retaining employees.

Colleges and universities are particularly well-suited to take measures to influence commuting patterns, given their centralized planning framework and control over transportation and land use policies on campus. Strategies often include ‘carrots’ like a parking cash-out and transit subsidies, alongside ‘sticks’ like increased parking pricing. A 2016 FHWA white paper profiled the TDM strategies of six universities, all of which achieved drive-alone mode shares of under fifty percent (MIT was one of these institutions, profiled before the launch of *AccessMIT*). It identified five key lessons learned. First, active parking management through pricing, incentives and full life cycle accounting is a key aspect of most successful programs. Second, leveraging centralized employer communication channels can expand the reach of TDM-related social marketing. Third, partnerships with local transit agencies can yield benefits of customized subsidy programs and/or service provision. Fourth, the integration of mobility options into a single package can ensure that benefits are not perceived to favor a particular mode or geography. Finally, regional, state, and local policies and partnerships provide important context upon which TDM programs should be designed (*7*).

Stanford University, for example, implemented a “Commute Club” incentive program, wherein employees are offered up to $300 in “Clean Air Cash” or carpool credits, rewards for adopting non-SOV commuting modes; it further offers fully-subsidized transit passes to eligible employees. These efforts helped it achieve a reduction in SOV mode share from 75% to 50% between 2003 and 2014. The University of Washington, which offers a universal transit pass program, has reduced its SOV mode share from 34% in 1990 to only 18% as of 2014. Its program requires few administrative resources as billing is processed through a centralized system and multiple transit providers are included on the same pass (*7*).

Common to many of these initiatives is the leveraging of insights from behavioral science, a field that centers around the recognition of human irrationality and addresses the shortcomings associated with applying a rational utility-based framework to understand behavior (*8*). Research by Metcalfe and Dolan (*9*) has formally brought together the fields of behavioral science and transportation, helping explain how market failures in transportation can be addressed through an understanding of the transaction costs and informational barriers associated with travel decisions. For example, the role of habit has been found to be a stronger predictor of behavior than previously understood, with wide-ranging implications on TDM program design (*10*). Concepts of social norms, mental accounting and information salience also help explain why travelers do not simply optimize for travel time and cost as classical economics would suggest, and are applied in the research design below.

Context at MIT

Limited parking supply has been a major factor in constraining the growth of SOV commuting to MIT. A 1973 cap on non-residential parking by the U.S. Environmental Protection Agency and the City of Cambridge meant that the Institute could not provide parking spaces to more than 36% of its staff (*11*), and Cambridge’s own Parking and Transportation Demand Management Ordinance introduced in 1998 requires employers to take steps to reduce their SOV mode share. MIT owns approximately 3,900 parking spaces, and leases a small number of additional spaces. Recent construction of underground garages has cost the Institute over $100,000 per space in capital expenses, and current construction of underground spaces near the Kendall Square neighborhood is estimated to cost up to $200,000 per space.

Parking fees, which were $10 per year in 1990, have risen 11% annually since 2001 to reach $1,900 for the 2017-18 academic year. Despite the fee increases, the growing capital, operating and opportunity costs associated with land used for parking mean that MIT still subsidizes over a third of the cost of parking.

OVERVIEW OF *ACCESSMIT*

Building on research by (*11*) and a 2010 pilot project of enhanced transit benefits to MIT employees (*12*), MIT decided to overhaul its employee transportation benefits in 2016 with the launch of *AccessMIT*. It focuses on facilitating day-to-day flexibility by unlocking the sunk costs of driving while encouraging transit use. The program has five main components, discussed below.

1. Free Transit

The flagship element of the program was the introduction of zero-cost local transit passes to all benefits-eligible employees, making it the largest known employer in Massachusetts to offer such a benefit. MIT negotiated with the Massachusetts Bay Transportation Authority (MBTA) to pilot a new arrangement whereby MIT pays the MBTA for every trip made, at regular 'CharlieCard' fare, instead of purchasing 11,000 monthly passes. This pay-per-use arrangement ensured that MIT would not be liable for the cost of transit passes for the thousands of non-transit users at MIT. The 'CharlieChip' was embedded directly in each employee's ID card when all ID cards were voluntarily replaced throughout the summer and fall of 2016.

2. Daily Parking

Complementing the transit benefit enhancements, parking pricing was reformed to promote multimodality. Instead of annual permits, most staff parkers were switched to pay-per-day parking pricing at $10 per day. This removes the sunk cost of a permit, thereby encouraging commuters to consider alternative modes each day and saving them money on days in which they choose not to drive.

For those who had to continue to drive, the maximum annual parking charge was capped at $1,900, limiting the financial burden on remaining car commuters. Additionally, around a quarter of MIT's parking spaces are located in non-gated lots, where daily billing is not feasible, so an annual permit remains available to commuters assigned to these lots.

3. Commuter Rail

Among a series of secondary incentives part of *AccessMIT*, the subsidy for MBTA commuter rail monthly passes was increased from 50% to 60%.

4. Transit Station Parking Subsidy

As a means to encourage staff who do not live near MBTA service to take transit for part of their journey, MIT introduced a 50% subsidy of parking fees at MBTA rapid transit stations. This allows commuters to park at a subway or commuter rail station and take subsidized transit for the rest of their commute.

5. Online Commuter Dashboard

An online commuter dashboard called *AccessMyCommute*, hosted by vendor RideAmigos, was built to help employees track their commuting history. It automatically receives transit trip data from the ID-embedded transit pass, parking records from the parking lot entry/exit gates, and optionally walking and cycling commuters from a third-party app. The dashboard allows MIT to offer incentives for using low-carbon and active commuting modes, with points redeemable for lottery and deterministic prizes.

These five elements were introduced in addition to the suite of existing commuter benefits offered by MIT, including subsidized bike share and car share memberships and an emergency ride home service. A marketing firm was hired to prepare promotional materials about *AccessMIT*. The campaign, which appealed to the flexibility, affordability and sustainability of MIT's commuting options, involved a series of posters, digital displays and outreach materials distributed to parking coordinators in each department on campus (e.g. Figure 1). All benefits-eligible employees, including post-doctoral associates, were offered *AccessMIT* perks, while students—who seldom park on campus—were not included at this time.

FIGURE 1 Examples of promotional materials for *AccessMIT* disseminated across campus.

EVALUATION METHODS

As *AccessMIT* requires a financial commitment by the MIT administration, it was imperative to evaluate the extent to which the program is able to shift commuter travel behavior and reduce parking demand in a cost-effective manner. The study evaluates the program from the perspective of (a) the commuter, regarding changes in awareness, attitudes and travel behavior, and (b) the institutions, namely MIT and the transit agency, regarding financial impacts and infrastructure utilization.

In this study, program awareness, attitudes and participation are largely measured through MIT's biennial transportation surveys, issued by the MIT Institutional Research Office. These surveys collect responses from at least 50% of staff and students every other year, most recently in 2014 and 2016. To track behavior change, a multi-faceted framework of passive data collection is used. MBTA subway and bus ridership is monitored using the 'CharlieCard' chip integrated into staff ID cards, providing researchers with disaggregated usage data. Parking is monitored at MIT's gated facilities, wherein parkers tap their staff ID card to enter and exit the lot. Finally, participation in incentive programs is tracked through the *AccessMyCommute* dashboard and its back-end analytics.

In addition to employee behavior and attitudes, the success of the program is predicated on several criteria from the perspective of MIT and the MBTA. Increased transit subsidies by MIT require additional short-term financial outlays. Conversely, sustained reductions in parking demand reduce operations, maintenance and capital costs, and may free up land for alternative development, unlocking real estate previously allocated to parking. While difficult to measure, enhanced perceptions of MIT as an institution of higher education and employment can translate to other net gains for the Institute in the form of employee happiness and productivity, and ultimately attraction and retention of top talent. For the MBTA, the switch from monthly pass products towards pay-per-use billing is associated with revenue uncertainties, so the transit agency is concerned with how fare revenue has changed as a result of MIT's arrangement. This may inform future viability of such an arrangement both for MIT and other potential corporate partners.

RESULTS

As an early evaluation of *AccessMIT*, this paper centers on descriptive analysis of program impacts. Program results begin with the experience of individual commuters, including changes in travel behavior and commuting attitudes. This is followed by the institutional impacts, including the financial costs and benefits of the program and the utilization of parking infrastructure.

Commuter Behavior and Attitudes

Behavior Change: Mode Choice

The biennial MIT transportation survey was used to understand how employees responded to changes in commuting benefits. Of the 10,500 staff eligible to take the survey, a response rate of 54% (N=5,700) was achieved during the November 2016 survey period. As shown in Figure 2, general mode choice trends indicate a marked decrease in SOV mode share, the first appreciable drop since 2008. Drive-alone mode share declined from 41% in 2004 to only 24% in 2016, balanced by increases in public transit and active modes (walking and cycling). Despite the launch of a new carpool trip planning tool and the continuation of a 50% discount on carpool parking, rates of carpooling decreased slightly, consistent with long-term nationwide trends. For new hires since 2014, the drive-alone mode share (12%) is less than half that of all staff, while active modes and transit were both significantly higher. A summary of key results is shown in Table 1.

The 2016 survey introduced a new question asking respondents for their secondary mode (prompted as optional "during nice weather, flexible hours, etc.") alongside their primary mode. 62% of commuters selected a secondary mode of travel. The most common secondary modes were walk-accessed public transportation among drivers, and vice versa. Taxis and transportation network companies (e.g., Uber and Lyft), while essentially never listed a primary mode, were selected as the secondary mode for 500 staff. Among primary-mode drivers, 41% listed a secondary mode, and half of these drivers listed public transit.

As a "ground truth" measure, a week-long travel diary was included in the survey. It showed increased multimodality among commuters, especially drivers, with only 27% of parking permit holders driving to work for all five days of that week. When asked about changes to one's commuting pattern since the prior year, 15% of respondents reported changing their mode of travel. Figure 3 shows mode shifts among these commuters, indicating a significantly larger portion of SOV commuters switching to transit (17%) than vice versa (8%). We also observe that 12% of the changers were former pedestrians and cyclists who converted to transit use as their new primary mode, indicating an unintended consequence of the transit benefit.

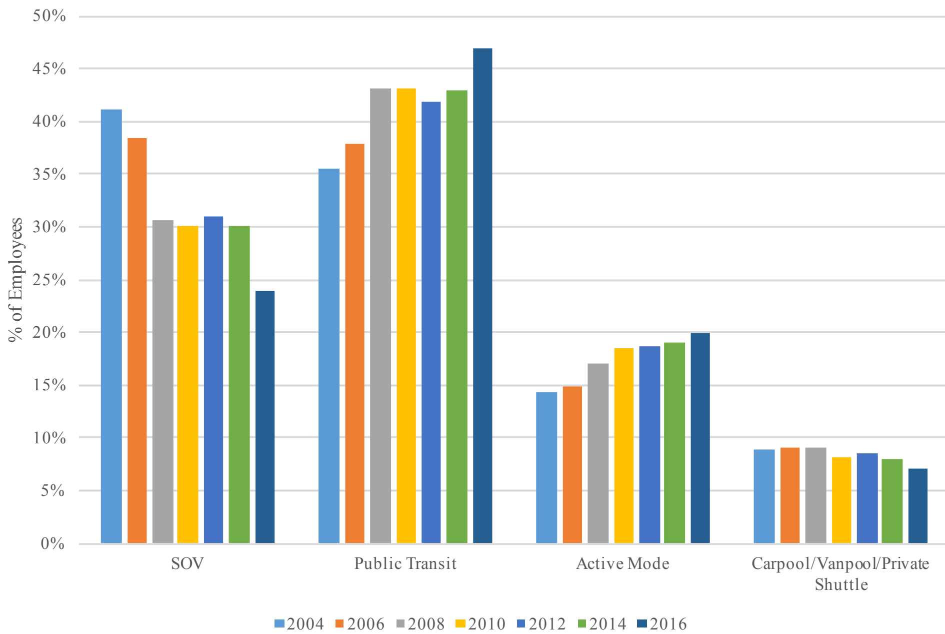

FIGURE 2 Reported primary mode choice, MIT employees (2004-2016 biennial Transportation Survey)

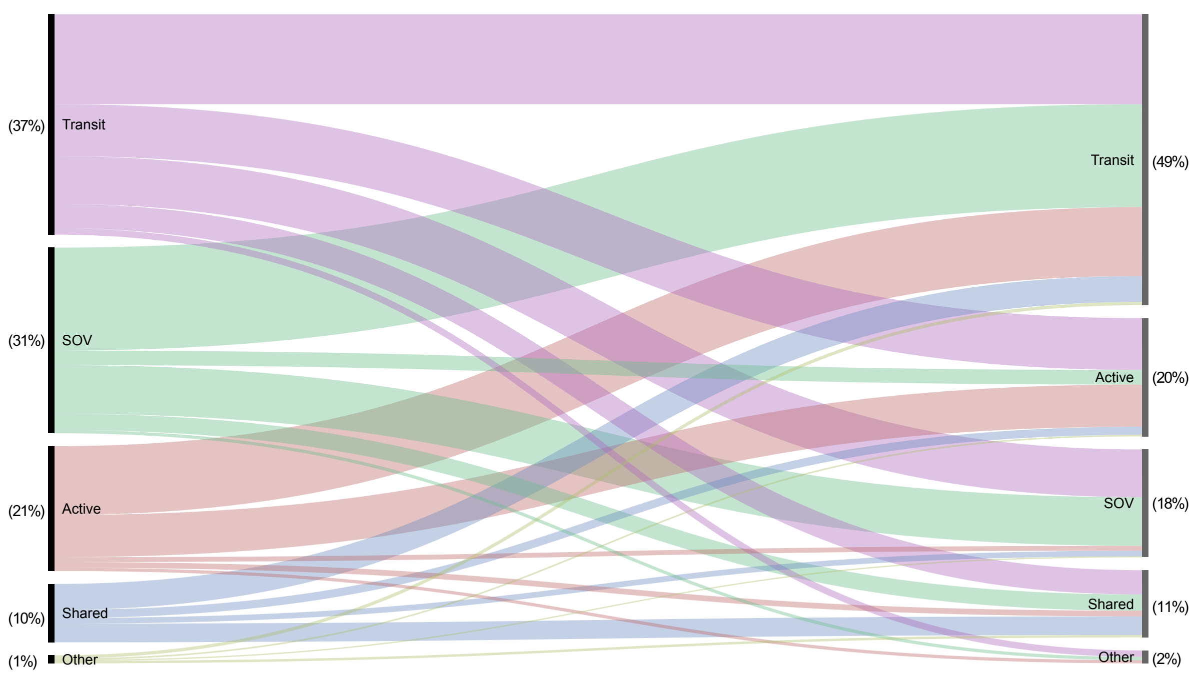

FIGURE 3 Stated mode shifts from 2015 (left) to 2016 (right) among survey respondents who reported *changing* their commuting modes. Continuity of the same mode implies a new secondary mode was chosen (not shown).

TABLE 1 Selected results before and after launch of *AccessMIT*

			Before *AccessMIT*	**After *AccessMIT* Launch**
Participation and Awareness		Survey Sample Size	6,386 (60%)	5,654 (54%)
		Staff who requested transit-enabled ID card	-	73%
		All Parking Permits	5,170	4,895
		% of Parking Permit Holders with Pay-Per-Day Permits	43%	77%
		Local transit passes	3,658	5,977
		Commuter rail passes	775	774
		Private Transit Subsidy Claimants	94	128
		MBTA Station Parking Subsidy Claimants	Not offered	470
		AccessMIT Program*	-	49% use 19% aware but do not use 19% unaware
		AccessMyCommute Dashboard*	-	12% use 37% aware but do not use 52% unaware
		Subsidized MBTA transit pass	51% use 46% aware but do not use 3% unaware	73% use 25% aware but do not use 2% unaware
Travel Behavior: Mode Choice	Reported Primary Mode Choice	Drive Alone	30%	24%
		Public Transit	43%	48%
		Walking/Cycling	19%	20%
		Shared Ride	8%	7%
	Reported Secondary Mode Choice Among Drivers*	Public Transit	-	20%
		Shared Ride	-	5%
		Active Mode	-	6%
		Work at Home	-	10%
		No Secondary Mode	-	57%
Travel Behavior: Parking Days		All Staff at MIT	1.25	1.14
		All Benefits-Eligible Staff at MIT	1.35	1.23
		Occasional/Frequent Parkers (20+ transactions per year)	2.63	2.65

*Question not asked in pre-*AccessMIT* survey

Respondents who answered ‘yes’ to having switched modes since the prior year were subsequently asked why they did so. As shown in Table 2, the most common reasons were a change in home location, followed by the new commuting benefits and ‘other’ reasons (of which the majority listed the free local transit pass). After aggregating the latter two reasons based on comments provided, almost half of those who shifted did so because of the benefits.

Parking Behavior

Changes in parking trends were monitored in three ways. First, the purchase of parking permits was compared to prior years. Second, the number of parking transactions—in/out activity at gated lots—was monitored on an aggregate and per-capita basis. Third, lot occupancy during peak weekday hours was monitored, discussed alongside institutional impacts.

The number of parking permits sold declined by 5% in the first year of *AccessMIT*, followed by another drop of 8% through the second year. The vast majority of drivers now hold pay-per-day parking permits (see Table 1), while the remaining minority are assigned to non-gated lots and continue to pay a fixed monthly rate.

As a measure of overall parking activity on campus, the total number of days parked among all employees is summed up and compared year-over-year. Overall parking transactions dropped 8% in the first year, leveling out into the second year. On a per-capita basis, parking frequency dropped 9% given the decrease in parking transactions combined with the modest growth in employee population. Those who used their transit pass frequently (at least one workday per week)

TABLE 2 Stated reasons for mode shift (2016 Transportation Survey)

Reason for mode shift	Percentage selected*
Moved place of residence	37%
New MIT commuter benefits	24%
Life event (e.g. family structure)	18%
Changed jobs/hours	7%
Availability of a vehicle (e.g. purchased a car)	7%
Other	26%

*Percentages add up beyond 100% due to multiple selection.

after the launch of *AccessMIT* exhibited a 31% decrease in parking transactions, while all others maintained similar parking frequency to before the program. Interestingly, the distribution of parking frequency exhibits an increasingly bimodal trend (see Figure 4). Many drivers park on campus either once every two to three weeks, or almost every weekday. Given that frequent parkers did not generally reduce their parking frequency after *AccessMIT* was introduced, this suggests that daily parking pricing did not necessarily encourage commuters to purchase a parking permit and park less often; instead, widespread reductions were seen among commuters who stopped purchasing a permit altogether.

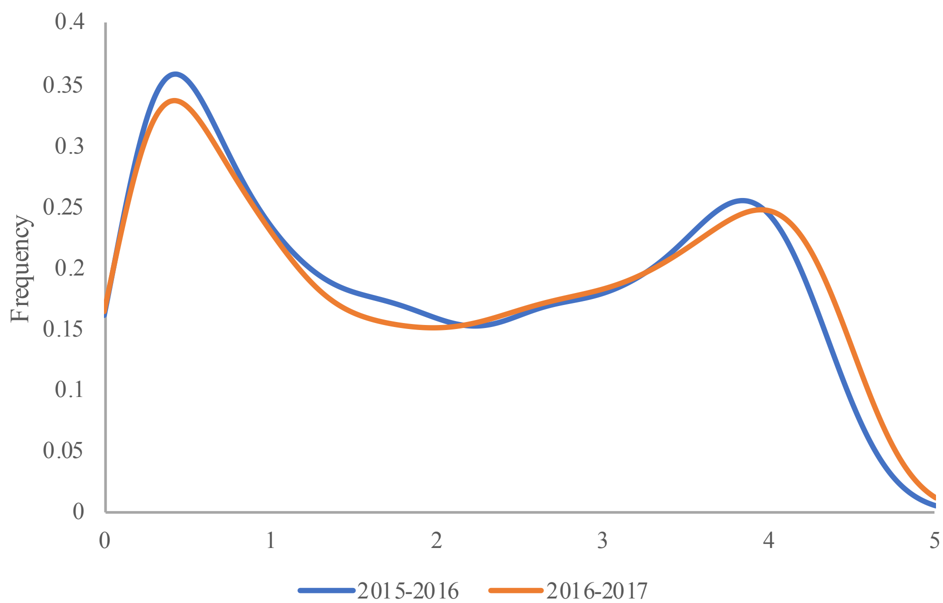

FIGURE 4 Frequency distribution of average weekly parking frequency, before and after *AccessMIT* launch.

The parkers who were switched from annual billing to daily pay-as-you-park pricing were charged $100 at the beginning of the year, then $10 per workday parked. This fee was capped at $1,760 in 2016-17, equal to the price of an annual permit. This means any parker who parked at least 166 out of 250 workdays would reach the cap, and no longer be billed for parking that year.

During the 2016-17 parking year, 543 employees with daily parking permits parked at least 166 workdays. Of the 3,800 daily parking permit holders, this suggests that only 14% would hit the cap.

In 2017-18, the daily rate was kept constant at $10 per day while the annual cap was raised from $1,760 to $1,900. This meant that a driver would now have to park 180 days to reach the cap. Extrapolating on the prior year's trends, this would reduce the proportion of parkers who reach the cap from 14% to only 9%, resulting in the daily pricing scheme working as a behavioral incentive to reduce parking for approximately two hundred more parkers, or 91% of all daily permit holders.

Attitudes Towards AccessMIT

The program was announced by the MIT Executive Vice President through an email sent to all employees. Unsurprisingly, the announcement of fully subsidized local transit was well-received by employees. Over the summer and fall of 2016, staff were asked to voluntarily swap their employee ID card for a new card with an embedded transit chip. By November, three quarters of staff had done so, with the remainder typically retaining their old card because they either had transit access through their commuter rail pass or believed they were ineligible (eligibility for post-doctoral associates was expanded after the initial launch).

The 2016 MIT Transportation survey included a set of additional questions asking about the extent to which *AccessMIT* benefits influenced commuting decisions. A majority (57%) of staff reported that the benefits influenced their commuting decisions. Of those who identified as drivers, either in 2016 or the year prior, 50% reported that the benefits influenced their commuting decisions.

To further delve into the aspects of the program that had an appreciable effect on behavior, respondents were asked to rate the five new elements of the program on a slider from 0 to 10 according to how much each influenced their travel patterns. The free transit pass was by far the most important new benefit, especially among staff who recently switched modes or are currently considering switching modes. The subsidy for parking at MBTA stations, as well as the increase in subsidy for commuter rail, were ranked as the next two most important elements, while daily parking pricing was seen as less influential. The online dashboard and incentives were consistently ranked least important.

Employees were asked how satisfied they are with MIT's transportation services overall. Comparing responses in 2012, 2014 and 2016, the proportion of staff reporting being "very satisfied" rose from 38% to 39% to 51%, respectively, indicating a stark increase after the introduction of *AccessMIT*. Only 1% of staff reported being very dissatisfied each year.

Employee Segmentation: Who Changed Behavior?

While the general trend among commuters has been a shift away from driving towards transit, significant heterogeneity exists in the commuting patterns of MIT employees. For example, while overall parking demand has dropped at MIT, the parking frequency among continuing drivers has not; this means that a substantial segment of the employee population was not receptive to the *AccessMIT* program, and/or face external constraints that preclude behavior shifts.

One dimension to consider is the attributes of the home neighborhood of each employee. While staff income was not available for this analysis, the median household income in an employee's neighborhood is a relevant proxy. Figure 5 plots median household income by census tract against four aspects of MIT commuter travel behavior. Figure 5(a) shows a positive relationship between area income and SOV mode share (R^2=0.21), while (b) shows no significant relationship between area income and the proportion of MIT commuters who changed their travel mode in the 2016 survey. Figures 5(c) and (d) indicate a positive association between area income and MIT parking frequency (R^2=0.21) and a negative association with transit frequency (R^2=0.24). Correlations between median household income and neighborhood transit proximity are to be acknowledged as a mediating factor in this analysis. The outlier in (d), with a moderate median household income but very high transit usage is in South Boston, where residents have access to Broadway and Andrew stations on the Red Line with rapid access to MIT campus.

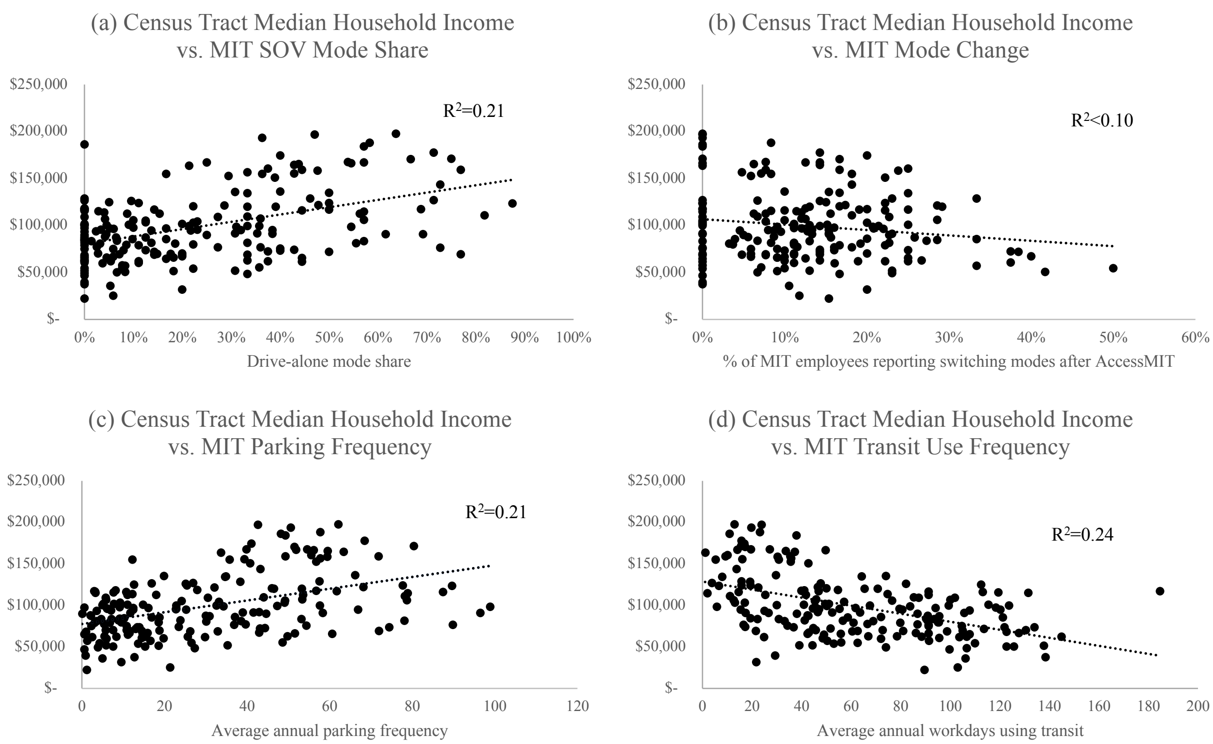

FIGURE 5 Relationships between median household income by census tract and attributes of MIT commuters living in these census tracts. Only census tracts with at least 15 MIT employees are included. (Source: 2016 American Community Survey)

In general, continuing parkers tend to be older, male, and live farthest away from campus. All groups except the new parkers increased their transit usage, with the largest increase coming from those who no longer hold parking permits. Across staff type, faculty tended to continue or begin parking in higher proportions than other groups, while non-faculty academic staff were more likely to give up their parking permit.

Institutional Impacts

Parking Lot Occupancy

Peak lot occupancy, usually reached between 11 a.m. and 1 p.m., fell approximately 2% at gated lots in the first year, and another 8% in the first eight months of the second year. Peak-of-the-peak demand, measured as the top five parking days each year, dropped by 2%. In non-gated lots, where manual counts were conducted, a 7% drop in demand was observed from 2015 to 2017.

Case Study: MIT's West Garage Closure

The reduction in average lot occupancy allowed MIT to decommission aging parking structures without undue impact on remaining parkers. MIT's 'West Garage', a 372-space elevated garage, was closed in September, 2017, as it reached the end of its structural lifespan. Its closure reduced parking supply on campus by close to 10%.

To manage the closure, the 585 staff parkers assigned to this garage were to be re-located to other lots across campus, including the large underground garage at the Stata Center. Due to concern that the Stata garage would be oversubscribed, facility managers introduced an 'Attendant Assist' program where cars would be valet parked in the aisles of the garage if the lot reached capacity. The program was carefully designed and marketed to minimize staff complaints and ensure a perception of safe and convenient parking. Furthermore, an informational campaign was launched to promote *AccessMIT* benefits to West Garage parkers and encourage them to try transit or carpooling. No parkers were denied a space on campus, but the space relocations led to some parkers having a slightly longer walk to their office.

After the closure, an impressive 17% of former West Garage parkers opted not to renew their parking permit after being reassigned a new parking location. The overall parking frequency among staff who used to park at West Garage dropped by approximately 16%, and even those that were frequent parkers (100+ days per year) exhibited a 4% decrease in average parking frequency. Figure 6 shows a breakdown of occupancy in five main parking areas, and indicates a net decline in parking demand after September 2017. Parking demand in Stata Garage never reached capacity, meaning that the Attendant Assist program was never used.

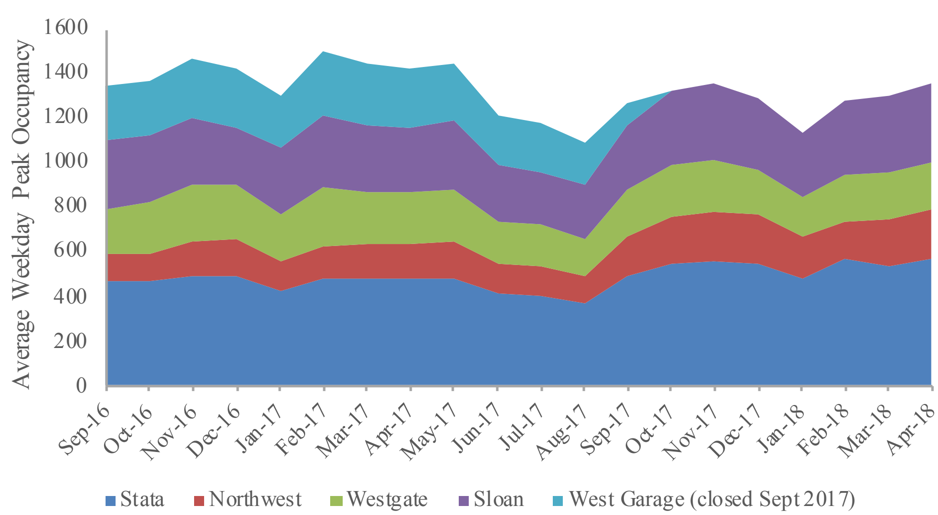

FIGURE 6 Comparison of occupancy in five main parking areas during 2016-17 and early 2017-18, showing the impacts of the West Garage closure in September 2017.

The averted parking crisis reflects the transience of parking demand, and the ability of a perceived 'shock' to the system to spark a shift in travel behavior. It also reflects the risk aversion of parking managers, concerned about over-capacity parking operations. It was hypothesized that the fear factor of parking uncertainty suppressed demand, but this behavioral lever may be weakened over time as commuters realized that capacity exists in various lots across campus. Conversely, parking re-assignments may have caused commuters to consider their travel habits more carefully, and explore the new benefits made available through *AccessMIT*. Given the literature on the role of habit in transportation and the potential for disruptions in habit to cause long-term changes in travel behavior (*13*) it may be that simply thinking about one's commute caused some staff to research and re-evaluate their choices.

Transit Usage

Several metrics can be used to measure the uptake in transit benefits. Local transit pass usage increased by 63%, as measured by the difference between the number of passes purchased prior to *AccessMIT* and the number of free passes actively used once *AccessMIT* was introduced. Pass usage increased throughout the 2016-17 academic year as more staff swapped their old ID card for a new one with a built-in pass and began using MBTA services. While the number of active passes increased by 10% throughout the year, the total monthly fare billed to MIT remained relatively consistent around $290,000 per month. This indicates that most of the heavy transit users were among the early adopters, and subsequent growth in pass usage is attributable to intermittent use.

Considering other new and increased subsidies, commuter rail pass purchases did not increase in the first year despite an increase in subsidy from 50% to 60%, indicating the enhanced subsidy did not have an initial behavioral effect. The second year, however, saw a 4% increase in commuter rail pass purchases. The new MBTA station parking subsidy was seen as an early success given its use by 5% of staff, although some of these claimants were already transit riders.

Similar to parking trends, individual transit pass usage displays an approximately bimodal distribution. Around 22% of active passes accrue an average monthly bill of under $10, while another 22% bill between $60 and $90 per month, reflecting the two clusters of intermittent users and regular transit commuters. The median monthly bill was $43 while the mean was $50, skewed upwards by a few users who billed over $200 per month.

Prior to *AccessMIT*, around 3,600 staff purchased a 50%-subsidized monthly local transit pass (at a cost of $42.25 to the employee). Once the fully-subsidized pass was introduced, the 3,600 top-billing users billed an average of only $74 per month. As one would expect with a prior 50% subsidy, the average pass purchaser did not use the monthly pass to its full value ($84.50), making it cost-effective for MIT to pay by rides taken once the universal pass was introduced.

Growth in MBTA ridership among MIT employees, while more difficult to calculate precisely due to untracked private CharlieCard usage, is estimated at around 10% since the launch of *AccessMIT*, based on a comparison of the 2014 and 2016 MIT Transportation Survey trip diaries.

Overall Costs

After the introduction of *AccessMIT*, employee parking revenues remained stable as increases in permit prices offset a reduction in parking campus-wide. As parking fees do not recoup the entire capital and operating costs of providing parking, the subsidy per space remains at around 34% or $987 per $1,900 permit. As parking demand declined 8%, which translates to around 340 fewer parking spaces required, and where each new underground space is estimated to cost approximately $10,400 per year (including capital and operating costs over a 40-year garage lifespan), the Institute benefits from annualized savings of around $3.5 million.

These savings are partially offset by the increased cost of providing transit subsidies. The total additional expense associated with enhanced transit benefits was approximately $2.1 million in the first year of *AccessMIT*, or $190 per employee. This comprises $2.8 million in pay-per-use pass expenses and $300,000 in additional commuter rail subsidies, less a $1 million reduction in monthly LinkPass and bus pass subsidies.

As a result of the transit cost increases being more than offset by reduced parking expenditures, the net savings to MIT are approximately $1.4 million annually or $140 per employee.

The MBTA now forgoes private fare revenue as all eligible staff have an employer-paid pass, but the net impact on MBTA revenue was growth of approximately 5% in the first year of *AccessMIT*. Annual fare revenue from MIT (both employees and employer contributions) grew from $6.5 million to $6.9 million in the first year. Despite early concerns that a pay-per-use employer agreement might lead to a reduction in transit agency fare revenue, this case study demonstrates that increased ridership more than offset the losses from under-utilized passes.

DISCUSSION

The introduction of enhanced commuting benefits for MIT's employees may be considered a success in its ability to effect a mode shift away from single-occupancy vehicles and to reduce parking demand by close to 10% in its first two years. While certain shortcomings may have tempered program results, the overall initiative serves as a promising exemplar on the application of behavioral science to achieve voluntary shifts in commuter travel behavior.

Aspects like the salience of daily parking charges, the 'power of free' with a 100%-subsidized transit pass, and the gamification and appeal to social norms introduced with the *AccessMyCommute* dashboard all drew on insights from this burgeoning field. However, the question remains as to whether the changes in behavior observed are a product of the behavioral science phenomena, or a more basic response to classical economic stimuli, namely costlier parking and cheaper alternatives. The randomized controlled experiment in (*14*) sought to disentangle these concepts through the targeted application of monetary and non-monetary interventions. As for the overall *AccessMIT* program, however, we are somewhat left to conjecture on what economic theory is most applicable. The stated result that commuters cared most about the free pass and least about the *AccessMyCommute* dashboard gives credence to the finding that basic pricing mechanisms outweigh the impact of any 'nudges', but the joint impacts of pricing and how such prices are communicated and internalized are closely intertwined.

Cost Salience

One of the most surprising findings was that the switch from annual parking pricing to daily charging did *not* result in a decrease in average parking frequency among parking permit holders as expected. Researchers hypothesized that drivers would generally continue to purchase permits (whose price was $100 per year), and simply park less (given a $10/day fee). However, on average, the decreases in parking came mostly from those who ceased to purchase a permit, with a small further decrease from permit holders who did not previously park every day.

The impact of daily parking pricing is clearly predicated on its leveraging of cost salience, or the degree to which the expense is perceived by commuters. This is determined by both (a) the manner in which the cost is presented, and (b) the temporal lag between the parking event and the perceived transaction. On point (a), most employees have their parking charges deducted directly from their paycheck. There is a line item for parking charges, which includes the $100 annual fee apportioned throughout the year alongside the $10 per day parking fee (if the parker has not yet reached the annual cap). However, because employees were paid on a monthly or bi-monthly basis (or for some hourly employees, weekly), the annual portion of the parking charges are prorated to match the pay cycle, and a delay exists between when the daily charges are incurred and the fee shows up on the paycheck. As a result, a typical parking charge is not a round number and does not easily line up with an employee's memory of how much they parked in the prior weeks.

To point (b), this also reflects a temporal lag between the time an employee parks and the time they see the charge reflected on their paycheck. Given the literature on cost salience emphasizing the importance of a quick behavioral feedback loop (*15*), shortening the time gap between parking transactions and paycheck deductions may improve the cost salience.

Various ideas have been presented to the Parking & Transportation Committee to remedy this lack of cost salience. A new mobile parking management app could offer immediate push notifications to drivers upon entering or exiting the lot, indicating the charges incurred (and the savings available next time they do not park). Additionally, a line item breakdown on the paycheck could identify exactly how the parking charge was calculated, and how much MIT subsidizes the charge. Further, the *AccessMyCommute* dashboard could have a ledger built in to show how parking charges are accrued, and emphasize the opportunity for savings through the daily parking scheme.

Communicating Program Objectives

An important lesson from the launch of *AccessMIT* is that a shared, collective vision for the program should be articulated and adopted by a wide breadth of institutional stakeholders. On external communications, one challenge was to achieve a balanced tone of encouraging alternative modes without alienating existing drivers. For some, the daily parking pricing was perceived as punitive, with survey responses indicating a fear that the daily permits would cost more than the annual passes. Parkers sometimes tried to negotiate for (or demand) an annual permit, despite the fact that a daily permit can *only* save the parker money (due to prices being capped at the annual rate).

In a recent technology upgrade, the employee parking permit online portal was streamlined and the annual opt-in period was replaced with automatic renewal of parking permits for continuing parkers. While this was motivated by a desire to minimize confusion and hassle around parking, it may also stem the decline of permit acquisitions as the role of defaults is well-known to greatly affect individual behavior (*16*).

Program Equity

Key to measuring the success of any policy on employee benefits is understanding its impacts on equity across socioeconomic strata. For example, decades ago when MIT provided free parking, this was implicitly a subsidy for wealthy motorists, while employees without access to a vehicle were forced to pay for transit. Recent increases in the cost of parking, along with taxable income deductions for transit expenses, have reduced this inequity. With the introduction of a zero-cost transit pass, a great stride has been taken towards having an equitable transportation policy for all MIT staff commuters.

Concerns have been raised, however, surrounding the daily parking pricing scheme and the extent to which it disproportionately penalizes lower-income workers. Higher-paid employees tend to have a large degree of flexibility in their schedules, and can choose not to commute to MIT during certain days or hours when parking fees are charged. Conversely, a typical support staff that works a rigid 9 am - 5 pm schedule does not have the same time flexibility. The result is that these lower-income workers may be more likely to accrue higher parking fees. To address this concern, MIT is considering tiering parking fees by employee income.

CONCLUSION

While a number of growing pains accompanied the rollout of *AccessMIT*, the overall story is that of a successful reduction in parking demand within the first two years of implementation. With parking permit sales, overall parking transactions and per capita driving rates on the decline, this project demonstrated the efficacy of a holistic reform of employer commuting benefits in achieving a reduction in parking demand with associated decreases in carbon footprint, while also resulting in net annual savings of over $1 million for the Institute. This mode shift is especially striking considering the program started with a very low drive-alone mode share of 30%, meaning that the 'low-hanging fruit', or easily-converted commuters, had long since switched from driving.

Next steps for the program include enhancing the equity of benefits among employees for whom public transit is not a viable commuting option. New carpool incentive programs are being explored to help drivers dynamically share their rides and receive discounted parking for doing so. It is also expected that the annual cap on daily parking rates will gradually be raised and ultimately eliminated such that all drivers will have a marginal cost savings associated with each day they do not park on campus.

In generalizing study findings, MIT's model of parking pricing reforms can be leveraged by employers regardless of available transit alternatives, especially if complemented by a campaign encouraging and facilitating carpooling. For example, daily parking pricing can encourage flexible or casual carpool arrangements, replacing the rigidity of annual carpool group registrations. The institutional politics involved in introducing commuter benefit reforms pose a universal challenge, and it should be noted that the program launched at MIT was discussed for over a decade prior to implementation. Crystallizing the argument that short-term expenses will be more than offset by long-term savings (both internal and societal), as evidenced in this paper, is key to assuaging concerns about immediate fiscal impacts. Finally, the lessons learned around increasing cost salience for parking and reducing it for alternative modes are widely applicable regardless of program specifics.

This case study seeks to provide a proof-of-concept for other workplaces considering ways to reduce their parking demand and SOV mode share, as well as for transit agencies looking at potential strategies to enhance their corporate pass programs without jeopardizing farebox revenue. The paper aimed to show how MIT's program, introduced in collaboration with the MBTA, can be an exemplar for both.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Rosenfield, A., Attanucci, J., Zhao, J.; data collection, analysis and interpretation: Rosenfield, A., Attanucci, J., Zhao, J.; draft manuscript preparation: Rosenfield, A. All authors reviewed the results and approved the final version of the manuscript.

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