Mode Use Characteristics of MIT Faculty, Staff and Student Commuters

Prepared for

MIT Transportation and Parking Committee

by

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Introduction

Purpose of This Study

This study is part of a larger effort to describe and model travel patterns with greater “behavioral realism” – that is, controlling for attitudinal and situational factors that affect travelers’ choices, such as constraints on chaining trips and timing of activities, and awareness of alternative routes. This research effort is described in a series of presentations, working papers and proposals (Ben-Akiva and Bowman, 1999; Ben-Akiva, Dong, Ramming and Walker, 1999; Ben-Akiva, Ramming and Walker, 1999; Ben-Akiva, Bowman, Ramming and Walker, 1998; Ben-Akiva, Bowman, Ramming and Walker, 1997; Ben-Akiva, Bowman and Gopinath, 1996). As part of this effort, this report provides a description of the modes by which employees and students come to MIT, and the frequency with which these modes are used. These members of the MIT community provide a convenient sample for developing more sophisticated models of travel behavior, particularly mode and route choice.

The specific purpose of this report is to describe the commuting patterns of members of the MIT community, paying particular attention to single-occupant auto use. The percentage of commuters who drive alone is of particular interest to the MIT Transportation and Parking Committee, because the committee’s responsibility includes oversight of the facilities where these commuters must park, and meeting the environmental and zoning regulations of the City of Cambridge, Commonwealth of Massachusetts and United States government.

This report considers two sources of travel information for MIT commuters: the 1990 Census Journey-to-Work Survey and the 1997 MIT Transportation Survey. Each survey is described in a following chapter. The final chapter makes statistical comparisons between these surveys, and provides some conclusions about possible sources of different modal splits.

This chapter continues by providing some statistics regarding the composition of the MIT community, a description the transportation facilities in proximity to MIT, and a brief overview of the travel data sources to be summarized and reviewed.

The MIT Community

The phrase “the MIT community” is often used to indicate that the Institute consists of more than professors and students. Research staff members conduct investigations in numerous fields and often supervise students. Support staff provide administrative and secretarial assistance to professors and departments. Administrators and senior officers oversee the day-to-day operations and long term planning activities of the Institute. MIT maintains its own medical and police staffs. Service staff members see that the physical infrastructure of the Institute functions smoothly.

In October 1997, a total of 18,057 people were affiliated with MIT. Of these, 8,177 were members of the faculty or staff. As Table 1-1 shows, 7,763 of these employees had offices on the main Cambridge campus. The remaining faculty or staff either had no office, or worked at the Haystack Observatory (including Millstone Hill Observatory) in Westford, Bates Linear Accelerator in Middleton, Lincoln Laboratory, Endicott House in Dedham, Woods Hole Oceanographic Institution or other off-campus locations.

Graduate students outnumber undergraduates by roughly 25 percent – 5,499 to 4,381.

The large majority of undergraduates – about two-thirds – live in MIT residence halls. Another ten percent live in fraternities, sororities and independent living groups (ILGs) in Cambridge – considered on-campus for the sake of this study. (For example, Zeta Psi is across Massachusetts Avenue from Random Hall.) Just over a fifth live in fraternities, sororities and ILGs (or FSILGs) in Boston and Brookline. The remaining four percent of undergraduates live in private apartments.

In contrast to undergraduates, about 70 percent of graduate students live off-campus. MIT offers on-campus residence halls for both single and married graduate students. Additionally, MIT owns some apartment buildings off-campus (such as 1010 Mass. Ave.) and offers these rooms to rent to graduate students, in some cases at subsidized rates. Graduate students affiliated with the joint Health Sciences and Technology program with Harvard may opt to live at Vanderbilt Hall, near the Harvard Medical School in Boston. Still other graduate students lease apartments from private landlords, or may own their own homes.

Table 1-1. Institute Affiliates at Cambridge Campus.

Classification	Number	
Faculty and Staff		**7,763**
Administrators	1,301	
Faculty	910	
Medical Staff	148	
Other Academic Staff	2,316	
Researchers	894	
Senior Officers	9	
Service Staff	754	
Support Staff	1,431	
Off-Campus Students		**5,114**
Graduate	3,957	
Undergraduate	1,157	
Total Commuters		**12,877**
On-Campus Students		**4,766**
Graduate	1,542	
Undergraduate	3,224	
Total		**17,643**

Sources: MIT Personnel Office (1997); Bernard (1997); Brennan (1997); Dorow (1997).

Transportation Near MIT

Roadways

A map of the MIT campus is shown on page 4. Memorial Drive is a four-lane parkway along the Charles River – divided for much of its frontage on the MIT Campus. Mass. Ave. is a four-lane major arterial running through the middle of campus. Vassar Street is a two-lane commuting route that divides the main campus from its northern fringes. Vassar Street connects to Main Street and Galileo Way. Main Street is a four-lane roadway through Kendall Square leading to the Longfellow Bridge. Galileo Way is a four-lane boulevard connecting to Binney Street and Land Blvd. (the continuation of Mem. Dr.).

Public Transportation

In addition to the roadway capacity in the vicinity of campus, public transportation is also readily available. MIT participates in the Charles River Transportation Management Association (CRTMA), which currently operates the Tech Shuttle between Kendall Square and the Hyatt Regency hotel. The Tech Shuttle operates weekdays from 7:15 a.m. to 7:10 p.m. The CRTMA shuttle debuted in May 1997, and was rerouted to its current Tech Shuttle configuration in February 1999, when Millennium Pharmaceuticals ended its participation in the TMA. MIT's Parking and Transportation Office also contracts with Standard Parking to operate SafeRide, a night time shuttle to FSILGs and graduate residences in Cambridge, Boston and Brookline. SafeRide begins service at 6 p.m. and runs until 3 a.m. Sunday through Wednesday, or 4 a.m. Thursday through Saturday. MIT also provides a shuttle to the Bates Linear Accelerator in Middleton at no charge to passengers. Similarly, MIT's Lincoln Laboratory in Lexington operates a shuttle to the main campus at no charge to passengers.

MIT is also an active participant in the shuttle services between the MIT campus and both Wellesley College and Woods Hole Oceanographic Institution. These shuttles charge no fare to passengers, and are used by both MIT employees and students.

The Massachusetts Bay Transportation Authority (MBTA) provides considerable service in the MIT area. Kendall Square is the location of a Red Line subway station. The Number 1 (Harvard-Dudley) and CT1 (Central Square-Boston Medical Center) buses serve Mass. Ave., including two major bus stops at 77 and 84 Mass. Ave. near the Stratton Student Center and Lobby 7, the entry to MIT's Infinite Corridor. The CT2 (Kendall-Ruggles) bus runs along Vassar Street, with stops at the Hyatt Regency (near some of the westernmost MIT dorms), Mass. Ave. and Kendall Square. Routes 64 (Oak Square), 68 (Harvard via Broadway), and 85 (Spring Hill) also have a terminus at Kendall Square. The Crosstown Transit routes CT1 and CT2 began service in September 1994. Route 68 began service, and Route 64 was rerouted to Broadway in September 1998.

Additionally, MIT community members can purchase tickets for the Medical Area and Scientific Community Organization, Inc. (MASCO) M2 shuttle at the Cashier's Office. The M2 shuttle operates between Harvard Square in Cambridge and Vanderbilt Hall in Boston's Longwood Medical Area, stopping at 77 or 84 Mass. Ave. in transit.

Sources of Transportation Data

The two sources of transportation data considered in this study are the Census Journey to Work and the 1997 MIT Transportation Survey. The Journey to Work data were collected in 1990 from a sample of individuals receiving a longer questionnaire during the regular decennial census. The proportions of faculty, staff and students commuting by various modes, as derived from the Journey to Work, are described in Chapter 2. In November 1997, the MIT Planning Office began a comprehensive study of transportation patterns, attitudes and various factors affecting transportation mode choice, to update their databases used for forecasting and reporting purposes. The results of this survey are described in Chapter 3.

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1990 Journey to Work

Description

The Journey to Work database is collected as part of the federal decennial census. The "long form" questionnaire, which is given to a subset of U.S. residents, includes questions about the usual mode of travel to work during the week before receiving the census form. Long form recipients are also asked to provide typical travel times for their commute journey. The long form questionnaire for Census 2000 is reprinted in Appendix B; the Journey to Work component – which is unchanged from the 1990 census – corresponds to questions 21 through 24.

This chapter presents relevant Journey to Work data compiled by the City of Cambridge and briefly explains some of the factors that may affect commuters' mode choice habits.

Mode Shares

Appendix C presents some of the Journey to Work tabulations available from the City of Cambridge web site. Much of the MIT campus is located in census tract 3531. This tract is bounded on the south by the Charles River. The northern boundary jogs around many different blocks. From west to east, the northern boundary of tract 3531 consists of the following segments:

- the railroad between Vassar and Albany Streets, from the Charles River to Pacific St.,
- Pacific St., from the railroad to Sydney St.,
- Sydney St., from Pacific St. to Franklin St.,
- Franklin St., from Sydney St. to Brookline St.,
- Brookline St., from Franklin St. to Auburn St.,
- Auburn St., from Brookline St. to Pearl St.,
- Pearl St., from Auburn St. to Mass. Ave.,

- Mass. Ave., from Pearl St. to Norfolk St.,
- Norfolk St., from Mass. Ave. to Washington St.,
- Washington St., from Norfolk St. to Windsor St.,
- Windsor St., from Washington St. to Main St., and
- Main St., from Windsor St. to the Charles River at the Longfellow Bridge.

While this tract includes MIT, it also includes other establishments, such as the Metropolitan Fireproof Warehouse, the New England Confectionery Company, Budget car and truck rental, numerous storefronts in Central Square, Quest Diagnostics, and such popular restaurants among the MIT community as Mary Chung's, the Royal East, the Miracle of Science and Bertucci's.

Table 2-1 reproduces a tabulation by the City of Cambridge of the mode shares used by commuters coming to tract 3531. Table 2-1 presents the mode shares of three groups of commuters identified by their origins – Cambridge, the cities and towns that share a border with Cambridge, and all other communities. Not surprisingly, almost half of the commuters who live in Cambridge walk to tract 3531, while almost three-quarters of those living beyond abutting communities drive alone to the tract. Single-occupant-vehicle (SOV) rates for Cambridge residents are a little more than one-fifth, while almost two-fifths of commuters from abutting communities use SOVs. The combined SOV rate for all residents is 48.6 percent.

Table 2-1. Mode Shares of Commuters to Tract 3531 by Origin.

Mode	Cambridge	Abutting Communities	Elsewhere
Single-Occupancy Auto	21.3%	39.7%	72.5%
Multiple-Occupancy Auto	6.9%	11.5%	14.6%
Transit	11.7%	36.6%	11.2%
Bicycle	6.1%	4.0%	0.4%
Walk	49.8%	7.5%	1.2%
Other Means	4.1%	0.8%	0.1%

Notes: Abutting Communities are Arlington, Belmont, Boston, Brookline, Somerville and Watertown. Totals may not add to 100 percent because of rounding. Other means include motorcycle, inline skates and skateboard.

Source: Cambridge Community Planning Division (1999).

Transit has the greatest mode share among residents of abutting communities. This result is understandable considering that so many Cambridge residents choose to walk; the short in-vehicle times do not justify the wait for transit vehicles. For residents of abutting communities, the travel distances are such that transit offers a reasonable speed for an acceptable wait. Residents of more distant communities may be less likely to use transit because of the more sparse service away from the central cities of Boston and Cambridge. For such people, ridesharing may be a more attractive alternative, and therefore we observe a greater share of such residents opting to use multiple-occupancy private vehicles.

Strengths and Limitations of the Survey

The Journey to Work is a useful data set because it is collected at the same time – using the same geographical scheme – as the many other important socio-demographic variables that constitute the national census. The consistency of the Journey to Work questionnaire allows for comparisons to be made across different years (such as among 1970, 1980 and 1990).

One caveat that should be noted is that the Journey to Work database is a result of sampling. Only a subset of the population receives the “long form,” which includes the Journey to Work questions. The Census 2000 sampling plan, which is similar to that used in 1990, is for one person in six to receive the long form (Bureau of the Census, 1999b). One in six represents a national average – some areas are sampled more intensively, yet the Bureau of the Census has not provided information on the fraction of Cambridge residents receiving the long form.

Additionally, the Bureau of the Census uses an adjustment procedure to account for non-respondents. Their Frequently Asked Questions list (Bureau of the Census, 1999a) explains that the response rate for the long form in 1990 reduced the overall mail return response rates by less than a percent. However, no information about the response rate in Cambridge is readily available from the Bureau of the Census. Likewise, no margin of error is given in the Cambridge Community Planning Division tabulations. It is unclear whether this information, or the statistics necessary to calculate it, is available from more detailed Census tabulations.

We estimated the margin of error on the tract-wide 48.6 percent SOV rate assuming that 15 percent of 17,643 students and employees working at the Cambridge campus completed and returned the long form. With these assumptions, the margin of error would be about 2 percent. Margins of error for SOV rates for specific origins would of course be higher, since these rates would be based on fewer responses.

The Journey to Work data set has other limitations. With preparations for Census 2000 underway, data collected in 1990 are less likely to reflect current travel conditions. As part of these preparations, the MIT Planning Office has been approached by the Bureau of the Census to assist in achieving a greater response rate among students. Since students are underrepresented in the census, and students, with limited or no income, typically travel by modes such as walking, bicycling and transit, the Journey to Work may *overstate* the SOV share of commuters to the Institute.

Also, as noted above, tract 3531 does not uniquely correspond to the MIT campus; instead, the mode shares of commuters to MIT and other organizations are confounded. The Bureau of the Census uses geographical units that are smaller than the tract, such as the block and block group, so it is conceivable that a better representation of the MIT campus could be constructed with these finer areas. However, it is unclear whether a tabulation of Journey to Work mode shares could be developed. Is the necessary data available at these finer levels of detail, or would the Bureau of the Census suppress these total to protect the privacy of respondents? Would the cost of such a custom tabulation be feasible?

Finally, because the Journey to Work tabulation requires commuters to be associated with a single mode, sometimes arbitrary rules must be applied. First, the questionnaire requests that respondents provide the *usual* mode used during the previous week. A person who drives alone three of five days and bikes the other two is indistinguishable from one who drives alone every day, although the first makes fewer SOV trips per month. Also, the Journey to Work methodology does not appear to address weather seasons. Many MIT community members may use one mode during fair weather (such as bicycle, walk or transit) and switch to more auto-intensive modes during winter or rainy seasons.

Further, the census questionnaire instructs commuters who use more than one mode to complete their usual trip to report only the mode they used for the *longest distance*. The classification scheme has inherent benefits and limitations. For example, such a method would be useful for estimating say region-wide air quality impacts (since long SOV trips are identified as such), but not for say estimating the parking requirements at MIT or traffic signal timing plans for nearby intersections. That is, the mode used for the longest distance of a commute to MIT may not necessarily correspond to the mode of arrival on campus. As a counterexample, consider a commuter who drives alone from Ayer to Alewife, parks, and takes the Red Line to MIT. Such a person would report to the census that they drive alone, since the distance from Ayer to Alewife is greater than that from Alewife to Kendall. However, this person would not require a space at MIT parking lots nor contribute significantly to congestion on Cambridge arterials.

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1997 MIT Survey

Description

The last Institute-wide transportation survey was conducted during November and December 1997. These surveys are periodically conducted (the survey before last was distributed in 1994) by the MIT Planning Office to provide updates of community travel patterns, and to assess effectiveness of various financial incentives and transportation policies (such as the spring 1996 increase in parking rates, and the introduction of a T Pass subsidy program in fall 1996). The 1997 Transportation Survey also collected responses to a considerable number of attitudinal questions regarding knowledge of routes and willingness to gather information. The responses to these questions are being used for ongoing CTS research projects.

Three versions of the survey questionnaire were prepared – one for faculty and staff, one for off-campus students, and one for on-campus students – with some questions customized for each population. For example, the faculty and staff survey included questions about inter-city travel and access to Logan Airport. The student versions included greater mention of non-motorized modes, and a section about safety and the SafeRide shuttle.

The questionnaire for faculty and staff is presented in Appendix D. The questionnaire for students living off campus (including undergraduates living in Boston and Brookline Fraternities, Sororities and Independent Living Groups) is presented in Appendix E.

On campus students (including those living in ILGs in Cambridge) are assumed to use non-motorized modes or public transportation to get to campus, because they are ineligible to receive student commuter parking stickers. That is, students living on campus may receive parking stickers to store their car overnight in resident lots, but they would not drive their car from say the west end of campus (where many dormitories and fraternity houses are located) to the east end of campus, because they would be unable to park at an MIT lot on the east side of campus.

The primary means of survey distribution and data collection was a web-based form. While internet survey instruments may be subject to various response biases for the general U.S. population, a web-based survey was deemed appropriate for an institution with such a high rate of technological adoption. Students and professors regularly exchange messages and problem sets over email, and even custodial or physical plant staff have internet access. A web-based survey also eliminated transcription errors, as respondents would provide electronic data entry. Paper surveys were made available to those who requested one. Returned paper surveys were entered into the web forms by Planning Office staff.

Coding and Processing

The Center for Transportation Studies received the raw electronic data files from the Planning Office. Whenever possible, the raw responses have been preserved through the cleaning and editing process. Employees and off-campus students were asked to describe their primary or most common mode and route from home to MIT by listing the sequence in which they used various modes. Respondents were classified by mode of arrival based on the sequence of mode use reported.

However, some respondents appeared to misunderstand the information being requested. Rather than providing the sequence they used a mode in a multi-modal trip, some people appeared to be providing the *ranking* or *frequency* with which they used each mode for single-mode trips. For example, a person who drives alone 60 percent of the time, bicycles 25 percent, and takes the bus the remaining 15 percent may have marked a 1 by drive alone, 2 by bicycle and 3 by bus, when for this situation, only a 1 by drive alone was requested. Records were manually reviewed to detect such cases. In some instances, a combination of modes would seem an illogical sequence, such as bike / subway / drive alone. In these cases, only the first mode reported was retained.

Respondents were also asked to provide their total journey time and that time broken down by time spent walking, waiting and in vehicles. Records claiming to involve transit segments, but indicating no waiting time were identified and corrected. Further, auto users were asked to provide a text description of their route. Such a description would easily identify whether a person traveled all the way to MIT in a private vehicle, or whether they stopped at a park and ride lot.

Unweighted Mode Use

Responses were received from 1,381 members of the faculty and staff, and from 574 students living off campus. Mode shares based on unweighted responses of employees and students are shown in Table 3-1. Among employees, driving alone is the most popular mode, followed closely by walking to transit. When auto access and walk access to transit are combined, more employee respondents used transit than drove alone to MIT. Students prefer walking to transit and bicycling. When these mode shares are combined in proportion to the numbers of employees and off-campus students at MIT, the result is that almost a third of this population walks to transit, about a quarter drives alone, and about a sixth bikes. The margin of error for the SOV rate is 3 percent (2 percent for the rate among employees and off-campus students combined). A 95 percent confidence level is used throughout this report.

Table 3-1. Unweighted Mode Shares.

Mode	Employee Share	Off-Campus Student Share	Combined Share
Single-Occupancy Auto	37.5%	8.0%	25.8%
Multiple-Occupancy Auto	12.6%	6.1%	10.0%
Transit – Walk Access	31.2%	33.6%	32.2%
Transit – Auto Access	8.6%	5.4%	7.3%
Bicycle	6.2%	32.4%	16.6%
Motorcycle	0.2%	0.5%	0.3%
Walk	3.5%	12.9%	7.3%
Other Means	0.1%	1.1%	0.5%

Notes: Totals may not add to 100 percent because of rounding. Other means include inline skates and skateboard. Sample sizes are 1,381 employees and 574 off-campus students. Combined share calculated based on 7,763 employees working at the main Cambridge campus and 5,114 commuting students.

Source: 1997 MIT Transportation Survey.

Since survey respondents reported their home ZIP codes, they could be grouped by origin using the same classification system the City of Cambridge used to summarize the Journey to Work data. This cross-tabulation is shown in Table 3-2. Of faculty, staff and students living in Cambridge, but not on campus, over a third bicycle to MIT, another roughly 30 percent walk to transit, and about a sixth walk. Only about 12 percent of Cambridge residents drive alone to MIT, and another 4 percent share a ride. Note that auto access to transit is used by a very small proportion of Cantabrigians, likely because most park and ride facilities are located at the town boundary (such as Alewife) or beyond.

Table 3-2. Unweighted Mode Shares by Origin.

Mode	Cambridge	Abutting Communities	Elsewhere
Single-Occupancy Auto	11.9%	16.1%	46.5%
Multiple-Occupancy Auto	3.9%	9.4%	14.4%
Transit – Walk Access	28.1%	42.7%	21.0%
Transit – Auto Access	3.0%	4.5%	13.6%
Bicycle	34.9%	18.6%	3.2%
Motorcycle	0.5%	0.3%	0.3%
Walk	16.9%	7.9%	0.8%
Other Means	0.9%	0.5%	0.2%

Notes: Abutting Communities are Arlington, Belmont, Boston, Brookline, Somerville and Watertown. Totals may not add to 100 percent because of rounding. Other means include inline skates and skateboard.

Source: 1997 MIT Transportation Survey.

The largest proportion (almost 43 percent) of those MIT community members living in communities bordering Cambridge walk to transit. Cycling is this group's next most common choice, followed by driving alone at 16 percent. For those living beyond these communities, though, driving alone is the most popular means of coming to MIT (47 percent), followed by walking to transit. This group also exhibits considerable ride sharing and auto access of transit. The margin of error for the SOV rate is 3 percent for Cambridge and abutting communities, and 4 percent for origins elsewhere.

Weighting the Surveys

Employee Weights

Weights or expansion factors were employed to compensate for varying response rates among different types of employees. For example, it was observed that response rates among faculty, other academic, research and service staff were relatively low, compared to members of the administration and support staff (such as administrative assistants and secretaries). If the mode use characteristics of underrepresented groups differ substantially from that of the overrepresented groups, the mode shares constructed from unweighted results could be unreliable.

For example, faculty may have reasonable to generous incomes and very high demands placed on their time, and thus would be more likely to drive alone (and less likely to complete transportation surveys). However, in many cases, the potential result was unclear. For example, senior administrators may have high incomes and prefer to drive, but entry-level administrators may have more modest means. Entry-level administrators and support staff may choose to take transit to economize, or may choose to live in communities such as Nashua and Salem, NH, where housing prices are lower but transit is less accessible. Service staff may also have more modest incomes, which may be an incentive to use transit, but those who work evening or night shifts may find that no or infrequent transit is available when they need to commute. Because it was not apparent whether unweighted statistics may over or understate the true mode shares, the following weighting approach was adopted.

A list of all employees' classification, department, full- or part-time status, gender and home ZIP code was available from the MIT Personnel Office (1997). Departments at MIT are grouped into schools, such as Engineering, Architecture and Planning, Science, Humanities and (the Sloan School of) Management. Other employees may be considered part of the Provost's Office, or not in any school. Originally, a straightforward stratification scheme of classification and gender or classification and school was considered. However, these schemes appeared to be too coarse or unreliable to be usable. In some instances, strata or "cells" had too few responses to be reliable for extrapolation, while other cells has large numbers of responses that should be subdivided. We aggregated and split strata with the goal of achieving ideally 30 respondents per strata.

The final stratification scheme resulted in 44 strata based on classification, school, gender, full- and part-time status, and home ZIP code, as shown schematically in Figure 3-1. Under this scheme, the smallest stratum had 9 survey responses (women research staff in the Provost's Office or not assigned to a particular academic school; cell number 17), and the largest stratum had 87 responses (full-time women administrators in the Provost's Office or not assigned to a particular academic school; cell number 11).

Some survey respondents did not respond to some or all of the questions regarding classification, time status or gender. However, it was preferable to estimate weights for these people based on known characteristics rather than eliminating the observations entirely. Therefore, these responses were allocated among other appropriate strata. First, employees who did not disclose their gender were reallocated to the corresponding cells for their school and classification, and when necessary, their time status and origin area. These survey respondents were reallocated in proportion to the total population in the corresponding cells less the number of survey respondents in those cells who provided all the stratification variables.

Figure 3-1. Stratification Scheme for Weighting Employee Survey.

		Administration		Faculty, Medical		Oth. Acad. Staff		Research Staff		Support Staff		Service Staff
		Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	
Provost or not listed	Part Time		1	12	13	14	15	16	17		18	29
	FT - Boston	2	3							19	20	
	FT - Cambridge	4	5							21	22	
	FT - Surrounding	6	7							23	24	
	FT - Inside 128	8	9							25	26	
	FT - Outside 128	10	11							27	28	
Engineering			30				31	32	33		34	
Science, Whitaker	Part Time		35				36	37	38		39	
	Full Time									40	41	
Architechture, Planning, Humanities, Management			42						43		44	

Notes: FT = Full Time. Senior Officers are included with Administration. Medical Staff are included with Faculty. Surrounding Communities are Arlington, Belmont, Brookline, Somerville and Watertown. Communities Inside 128 are Beverly, Chelsea, Dedham, Everett, Lexington, Lynn, Malden, Manchester, Marblehead, Medford, Melrose, Milton, Nahant, Newton, Quincy, Revere, Salem, Saugus, Stoneham, Swampscott, Wakefield, Waltham, Winchester, Winthrop, and Woburn, but not Boston, Cambridge, or Surrounding Communities, which are listed as separate categories.

For example, consider research staff in the School of Science plus Whitaker College. This population consists of about 150 females and 200 males. Of these, the transportation survey contains responses from about 30 women, 50 men, and 2 people who did not respond to the question about gender. (The example numbers are rounded from actual results.) This means that of the science researchers, the 2 responses without gender could have come from the remaining 120 (=150-30) females or 150 (=200-50) males. Therefore, the male and female science researcher survey counts would be increased by the amount of the 2 responses expected to belong to each category – 0.89 women (=2*120/(120+150)) and 1.11 men.

Next, employees who did not disclose their time status were reallocated in a similar fashion. Finally, those omitting their staff classification were reallocated among their school.

Expansion factors were produced by dividing the number of employees in each stratum by the number of survey responses in the corresponding stratum. Normalized weights were then constructed by dividing each expansion factor by the total number of employees (7,763) and multiplying by the total number of survey responses received (1,381).

Weights for individuals who didn't disclose their gender, classification or time status were constructed by taking a weighted average of the weights for all the strata such individuals could belong to. The same proportions that were used to allocate non-responses were used to construct their composite weights. Returning to the example above, if the weight for the women researchers in the School of Science was 0.8 and the weight for the men was 0.7, then the composite weight for a science research staff member who did not answer the question on gender would be 0.744 (=0.8*120 / (120+150) + 0.7*150 / (120+150)).

Student Weights

The off-campus student survey was weighted according to gender and undergraduate or graduate status. Survey respondents who did not disclose their gender or status were allocated to the four gender and status combinations using a procedure similar to that used for the employee survey. This allocation was done by first reducing the total population counts by the number of students in each category who had responded to both demographic questions. Then students who indicated whether they were undergraduates or graduates, but who did not disclose their gender, were allocated to corresponding categories in proportion to the genders of the non-respondents.

After students who responded regarding undergraduate / graduate status but not gender were allocated to the four categories, students who provided their gender but not their classification were allocated in a similar manner. Finally, students who provided neither gender nor classification were allocated among all four categories.

Expansion factors were produced by dividing the number of students in each category by the number of survey responses in the corresponding category. Normalized weights were then constructed by dividing each expansion factor by the total off campus student population (5,144) and multiplying by the total number of survey responses received (574). Weights for individuals who didn't disclose their gender, classification or both were constructed by taking a weighted average of the weights for all categories such individuals could belong to. As with the employee survey, the same proportions that were used to allocate non-responses were used to construct their composite weights.

Weighted Mode Use

Weighting the survey data has a marginal impact on mode shares. SOV and bicycle shares increase among each population considered, while high-occupancy vehicle shares decrease in each category. Most modes maintained their rank by each population considered. Table 3-3 shows mode shares of employees, off-campus students and the two populations combined, and is comparable to Table 3-1. Table 3-4 shows mode shares by origin, in the same format as Table 3-2.

Table 3-3. Weighted Mode Shares.

Mode	Employee Share	Off-Campus Student Share	Combined Share
Single-Occupancy Auto	38.2%	8.4%	26.3%
Multiple-Occupancy Auto	10.6%	5.9%	8.7%
Transit – Walk Access	31.9%	33.5%	32.5%
Transit – Auto Access	7.2%	5.3%	6.4%
Bicycle	7.5%	33.3%	17.7%
Motorcycle	0.3%	0.6%	0.4%
Walk	4.4%	11.9%	7.4%
Other Means	0.1%	1.1%	0.5%

Notes: Totals may not add to 100 percent because of rounding. Other means include inline skates and skateboard. Combined share calculated based on 7,763 employees working at the main Cambridge campus and 5,114 commuting students.

Sources: MIT Transportation Survey (1997).

Among employees, bicycling and auto access to transit traded places after weighting. With weighted observations, bicycling becomes the employees' fourth popular mode. SOV, walk access to transit and ridesharing remain the employees top three modes, in that order. Walk access to transit remains off-campus students' top choice, still followed closely by bicycle. The employees' 38 percent SOV share and students' 8 percent SOV share (both with a 3 percent margins of error) combine to form a 26 percent overall SOV share (with a 2 percent margin of error). Walking to transit remains the most popular mode overall, with a 32.5 percent share.

Table 3-4 shows a similar pattern as Table 3-2. Cambridge residents prefer bicycling most, then walking to transit, walking all the way to MIT third, and SOVs fourth. Residents of abutting communities prefer walking to transit, then bicycling, and SOVs third. SOVs are the top choice of residents from more distant cities and towns, followed by walk access to transit and ridesharing. The roughly 13 and 16 percent SOV shares for Cambridge and abutting community residents, respectively, both have 3 percent margins of error. The 51 percent share for more distant residents has a 4 percent margin of error.

Table 3-4. Weighted Mode Shares by Origin.

Mode	Cambridge	Abutting Communities	Elsewhere
Single-Occupancy Auto	12.8%	16.2%	50.6%
Multiple-Occupancy Auto	3.6%	8.5%	12.7%
Transit – Walk Access	27.2%	44.1%	19.3%
Transit – Auto Access	2.3%	4.7%	11.8%
Bicycle	35.5%	18.7%	4.0%
Motorcycle	0.8%	0.3%	0.3%
Walk	17.0%	7.2%	1.0%
Other Means	0.9%	0.4%	0.3%

Notes: Abutting Communities are Arlington, Belmont, Boston, Brookline, Somerville and Watertown. Totals may not add to 100 percent because of rounding. Other means include inline skates and skateboard.

Sources: MIT Transportation Survey (1997).

Adjustment for Number of Days Commuting

MIT allows considerable flexibility to a large proportion of its staff, faculty and students. Community members may often work at home, taking advantage of telecommunications and internet capabilities. Those with part-time appointments may choose to work a compressed work week. To examine the effect of schedule flexibility on mode share, a second survey weight was created. First, the percentage of days each respondent would commute during a typical five-day work week was estimated. (Respondents were asked to provide the number of days each week they came to campus, and the number of weekend days they came to campus.) This percentage was then multiplied by the survey weight described above. Therefore, the second survey weight, which adjusts for the number of weekdays a person commutes, would be less than or equal to their original weight.

The revised mode shares, which account for days commuting, are shown in Table 3-5. The biggest percentage change is that the share of employees driving alone drops 0.6 percent from 38.2 percent in Table 3-3 to 37.6 percent. Shares of employees who cycle, access transit from autos, or walk increase marginally. Among students, driving alone, shared rides and walking increase at most 0.2 percent, while walking to transit, auto access to transit, and bicycling fall by similar amounts. The overall result is that SOV has a 26.0 percent mode share (compared to 26.3 percent before adjusting for days commuting), while shared ride, bicycle and walking make marginal gains.

The margin of error for the employee and student SOV shares is 3 percent, and the margin of error for the combined SOV rate is 2 percent. Therefore, the mode shares after adjusting for days commuting are not significantly different from the unadjusted weighted mode shares. For this reason, we do not tabulate adjusted mode shares by origin.

Table 3-5. Weighted Mode Shares, Adjusted for Commuting Days.

Mode	Employee Share	Off-Campus Student Share	Combined Share
Single-Occupancy Auto	37.6%	8.5%	26.0%
Multiple-Occupancy Auto	10.6%	6.0%	8.8%
Transit – Walk Access	31.9%	33.4%	32.5%
Transit – Auto Access	7.3%	5.1%	6.4%
Bicycle	7.6%	33.1%	17.9%
Motorcycle	0.3%	0.6%	0.4%
Walk	4.6%	12.1%	7.6%
Other Means	0.1%	1.1%	0.5%

Notes: Totals may not add to 100 percent because of rounding. Other means include inline skates and skateboard. Combined share calculated based on 7,763 employees working at the main Cambridge campus and 5,114 commuting students.

Sources: MIT Transportation Survey (1997).

Faculty, Staff and Students to Occupy the Stata Center

The 1997 Transportation Survey asks respondents to identify the department, center or office they work or study in. The MIT Transportation and Parking Committee and the Planning Office have expressed an interest in the mode shares of employees and students who will use the Stata Center when it is completed. The department codes in the 1997 survey allow us to identify the respondents who would work in the Stata Center: The Artificial Intelligence (AI) Lab, the Lab for Computer Science (LCS), the Lab for Information and Decision Sciences (LIDS), and the Department of Linguistics and Philosophy intend to occupy the Stata Center after its construction.

Weighted mode shares for the subpopulation who will occupy the Stata Center are shown in Table 3-6. However, caution must be used in interpreting this table because it is based on a relatively small number of responses – 70 employees, and 24 off-campus students. The low number of responses results in a large margin of error. For employees' SOV share, the margin of error is just over 11 percent. For students, the nominal confidence interval has a width of 18 percent; however, this is asymmetrically distributed about the 5 percent mean, because the SOV share must be non-negative. For students, the margin of error for a proportion closer to one-half, such as the 48 percent bicycle share, is 20 percent. The combined SOV rate has a margin of error of 8 percent.

Table 3-6. Weighted Mode Shares, Stata Center Occupants.

Mode	Employee Share	Off-Campus Student Share	Combined Share
Single-Occupancy Auto	32%	5%	23%
Multiple-Occupancy Auto	24%	8%	18%
Transit – Walk Access	32%	24%	30%
Transit – Auto Access	3%	0%	2%
Bicycle	1%	48%	18%
Motorcycle	0%	5%	2%
Walk	7%	10%	8%

Notes: Totals may not add to 100 percent because of rounding. Combined share calculated based on expansion factors that assume 7,763 employees working at the main Cambridge campus and 5,114 commuting students.

Sources: MIT Transportation Survey (1997).

Therefore, although there appear to be some shifts in the mode use patterns of the Stata occupants (for instance, employees appear to prefer shared ride, and students bicycling, more than the general population), these differences do not appear to be on the whole statistically significant.

(Note that in this situation, a formal statistical test of different SOV rates between the Stata occupants and general MIT population is difficult to perform, because the standard errors of the SOV shares for both groups are estimated. Statisticians call such a situation a *Behrens-Fisher problem*, and debate over appropriate test statistics continues in the literature. See for example, Christensen and Rencher (1997) and DeGroot (1989). Instead, we assume that SOV rates for the general population are selected from within the confidence interval and are then treated as known constants, against which the Stata SOV rates are tested.)

Strengths and Limitations of the Survey

Strengths of the 1997 Transportation Survey include the fact that it's recent, and the broad range of variables available for analysis. The MIT Planning Office reports that the 38 percent SOV use among employees reported here is consistent with past surveys and calculations based on parking sticker allocations and available spaces, which placed the employee SOV rate at 36 percent. Note that the 36 percent rate is within the margin of error for the 1997 survey.

One disadvantage of the 1997 survey is that its length may have discouraged more people from completing it. Response rates among employees were 16.9 percent, and 11.2 percent among students living off campus. However, weighting survey responses is a widely-used procedure to compensate for the effects of differential response rates.

As with the Journey to Work, the 1997 survey also records only the usual route. While the 1997 survey did ask respondents to say how often they may use another mode or route, the length of the survey precluded collecting information about secondary or alternative routes.

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4

Comparison of Travel Data

1990 Journey to Work and the 1997 Survey

This chapter considers the issue of whether the data sources described in previous two chapters present a consistent picture of travel patterns to MIT, or, if not, what the sources of the differences might be. Since single-occupant vehicles have a considerable environmental impact, the following analysis will give particular attention to SOV shares.

Comparison of SOV Rates

It is possible to compare the Journey to Work and the 1997 Transportation Survey at the aggregate level, or by origin. In all cases, the Journey to Work reports a higher share of trips by driving alone. The overall rate is 49 percent for the Journey to Work, but 26 percent according to weighted 1997 survey results. The difference is considerably greater than the 2 percent margin of error for the 1997 survey. (Assuming the 49 percent Journey to Work share to be a given constant, we can conclude that the difference is statistically significant.) This result is surprising considering that the Journey to Work includes students living on campus, who are precluded from driving across campus by MIT policy. The results from Chapter 3 exclude on-campus students. Therefore, if on-campus students were included in the summaries of mode use from the 1997 survey, we would expect the SOV share to decrease from that presented in Chapter 3, and thus the difference between the 1997 survey and the 1990 Journey to Work would be even greater.

Among Cambridge residents, the Journey to Work reports that 21 percent drive alone, while the 1997 survey shows only 13 percent. For residents living in abutting communities, the Journey to Work SOV rate is 40 percent, while the 1997 survey's rate is 16 percent. Residents living beyond these communities have higher SOV shares, but again, the 73 percent reported by the Journey to Work is considerably higher than the

51 percent from the 1997 survey. In all cases these differences are statistically significant.

Potential Causes of Differences

Differences of Survey Methodology

We have already suggested some possible sources of the differences between the Journey to Work data and the 1997 survey results. The Journey to Work considers a much wider area of destinations than just MIT buildings. The Census may have undersampled students, leading to an overestimate of modes less likely to be used by students, such as SOV. The Journey to Work and the 1997 survey provide different definitions of mode – the Journey to Work presenting the mode used for the greatest distance, while the 1997 survey retains multimodal segments, so the mode of entry to the MIT campus can be determined. However, perhaps the greatest source of disparity between the two samples is the number of years between the two data collection efforts.

Changes in Financial Incentives

Since the Journey to Work data were collected in 1990, MIT has significantly increased its annual parking fee – from $20 to $300 in some cases – and started a $10 per month transit pass subsidy program. We would expect to see such policies reduce the number and share of single-occupant drivers. (MIT appears to be continuing its policies of auto restraint; in September 1999, parking permits that cost $300 for the 1998-99 academic year will to increase to $360 per year.)

Changes in Regional Economic Activity

Further, when the 1990 Journey to Work data were collected, Massachusetts was in the midst of a recession. Economic activity is a general determinant of regionwide travel and therefore of automotive congestion. As the Massachusetts economy recovered, we would expect to see more drivers on the roads, more congestion, and some – but not all – of the increased volumes shifting to other modes. That is, we expect the relative SOV *share* to be greater during a recession than under normal economic conditions. A simple numerical example will illustrate this phenomenon.

Consider a particular corridor, where during the recession of 1990, 8,000 people wanted to travel during a typical hour of the morning commute.

For simplicity, assume these commuters have the option of driving alone on a freeway, or riding the subway. Suppose the freeway was designed to carry 6,000 vehicles per hour in the morning peak direction, towards Boston and Cambridge. (Such a capacity is typical of a three-lane freeway. For illustration purposes, consider I-93 from the north, which runs parallel to the Orange Line.)

The freeway's "design capacity" is not the strict physical limit to the number of vehicles the roadway can handle, but rather a critical level after which travel times begin to degrade rapidly. That is, the relationship between flows and travel times on a roadway is not linear, but rather exponential. (Typical transportation planning models assume exponents in the range of 4.0 to 5.5.) For volumes below the design capacity, travel times are close to that experienced under free-flowing conditions. However, once volumes exceed the design capacity, travel times increase substantially as maneuvering between lanes becomes increasingly difficult and queues form behind bottlenecks such as lane merges.

Now assume that for this corridor in 1990, the transit mode share was 20 percent – similar to the overall mode share to tract 3531 in Cambridge. This means that during the peak hour, 6,400 people used the freeway, and 1,600 people rode the subway. The freeway is operating at congested conditions, but the delay is not significant enough to convince drivers to divert to transit, which may be perceived as slower or less convenient.

Now imagine the same corridor in 1997. The recession has ended. Unemployment rates have fallen, so more people are commuting during peak hours. People have more disposable income, and thus are making more shopping and other trips. To meet the increased demand for goods, more delivery trucks are on the roadways. Suppose the increased economic activity results in a 12.5 percent increase in travel volumes, so our corridor's peak hour demand increases from 8,000 to 9,000 trips.

If the transit share stayed at 20 percent, this would mean 7,200 vehicles per hour on the freeway, and 1,800 subway riders. However, 7,200 vehicles per hour is considerably beyond the design capacity of the freeway. Significant delays would develop, greatly increasing auto drivers' commuting times. Other roadways regionwide would be experiencing the same increased travel demand, so there would be no incentive to changing which route one drives. However, some travelers would be diverted to transit. (Time of day shifts are possible, as are shifts to suburban and exurban destinations to take advantage of less congested corridors in those locations. However, in Boston, congestion typically lasts for longer than a single peak hour. Also, we observe that the MIT campus has not changed location since 1990 – or in fact, since 1916, when MIT moved from Boston's Back Bay to its present Cambridge location.)

Suppose some drivers switch to transit in response to the increased congestion that results from greater economic activity. When these drivers have diverted, the resulting volumes might be 6,750 vehicles per hour on the freeway, and 2,250 subway riders per hour. The freeway is still operating under congested conditions. Travel times are longer than they were in 1990, when only 6,400 people per hour were using the facility, but travel times are more bearable than if 7,200 people per hour were on the freeway. The new transit share is 25 percent. The result is that although greater *volumes* of people are driving when the economy rebounds, the *share* of SOV drivers has decreased (from 80 percent to 75 percent).

Of course, the real world is more complicated than this example. Drivers with various origins and various destinations all share the same roadways. SOV drivers may choose to form carpools instead of switching to transit to avoid the hassle of congestion. Unlike subways, buses share roadways with autos, and therefore bus travel times are also affected by auto congestion. However, the same general result – that SOV shares will be higher during periods of relatively lower trip making, such as during a recession – will hold

Construction Delays

A final potential source of the difference between the Journey to Work data and the 1997 Transportation Survey results involves construction of the Central Artery/Tunnel. Since 1990, considerable construction on the project has begun downtown and around the Tobin Bridge ramps to I-93. The congestion and decreased speeds associated with construction could be expected to discourage commuters from the South Shore, North Shore, and Northern suburbs near I-93 – who would otherwise take routes through the area – from driving.

Conclusions

Both of the travel data sources considered have some advantages and some drawbacks. The Journey to Work is a consistent and thorough data collection effort; however, the results are now dated, and Census geography may not identify individuals affiliated with MIT in a straightforward manner. The 1997 Transportation Survey was a large data collection effort tailored to the MIT community; however, survey length depressed response rates. Still, the 1997 Transportation Survey seems a more plausible data source because it has been sufficiently analyzed to edit inconsistent records and have weights developed for it, and the travel patterns reflected in the 1997 survey seem to be realistic in light of the changes in the economic climate, MIT policies and transportation system construction since 1990.

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Appendix A

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Appendix B

Census Long Form

Description

The following pages contain the Informational Copy of the Census 2000 long form, which is available at the Bureau of the Census web site, http://www.census.gov/. Minor revisions were made to the 1990 long form to produce this questionnaire; however, none of the questions relating to the Journey to Work (questions 21 through 24) were changed.

Appendix C

JTW for Tract 3531

Description

The following pages are available from the City of Cambridge's web site (Cambridge Community Planning Division, 1999). The first printout shows a map of the census tracts in Cambridge. MIT's campus is located in tract 3531. The second printout shows mode shares compiled for tract 3531 from the 1990 Census Journey to Work survey. Separate summaries are provided for people commuting to tract 3531 and for residents of tract 3531.

Click here to see diagram of Census Tracts.

Click here to see a diagram of Tract 3531.

Appendix D

1997 Employee Questionnaire

Click here for the Employee questionnaire.

Appendix E

1997 Off-Campus Student Questionnaire

Click here for the Student questionnaire.