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The Behavioral Impacts of Flexible Working Hours

Final Report
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16. Abstract
This paper presents new results on the behavioral responses to flexitime, a system o flexible work hours. Flexitime is of particular interest as a transportation syste management strategy with potentially significant impacts on work schedules, travel behavior, traffic congestion, and energy consumption. This study, based on a flexi- time experiment at a large governmental research and development facility, was de- signed to permit a rigorous assessment of individuals' activity and travel response and their implications for transport planning.

Significant changes in work scheduling were observed with a majority of workers shifting their average work arrival times and also exhibiting considerable daily variation in their work schedules. Preliminary econometric models indicate that wo scheduling responses to flexitime are strongly influenced by socioeconomic/life cyc characteristics, travel time savings, and activity patterns.

Flexitime also had a large impact on the journey-to-work. Approximately 9% of workers changed modes in response to flexitime; for those who shifted mode, there were small net changes in favor of ridesharing and public transport. A majority of workers experienced travel time savings due to flexitime, which are estimated to hav resulted in fuel savings of about 5% for vehicles driven to work. These findings suggest that flexitime may be an important strategy for reducing energy consumption.

17. Key Words
Urban Transportation, Flexible Work Hours, Work Schedules, Alternative Work Schedules, Transportation Systems Management, Travel Behavior

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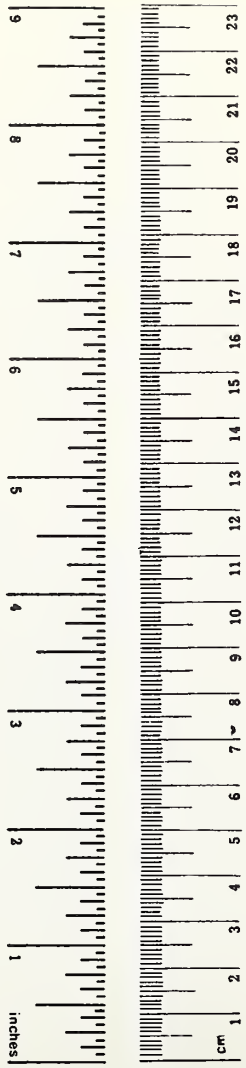
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

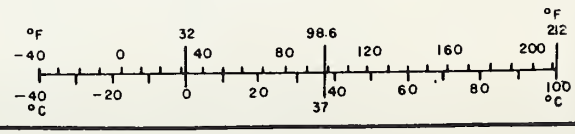
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	squsre miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Introduction

This paper presents new results on the behavioral responses to flexitime, a system of flexible working hours under which workers are permitted to select their daily schedules within certain predefined limits. Flexitime has been implemented by an increasing number of firms and institutions in Europe and the United States and is of particular interest as a transportation systems management strategy with potentially significant, but largely unknown, impacts on traffic congestion and energy consumption. By removing a constraint on the choice of work schedules, flexitime permits individuals to vary their activity patterns and travel behavior with benefits resulting from more satisfactory activity and travel choices. The timing and mode of work trips are among the principal travel choices that may be modified in response to flexitime. Assessing these impacts is essential to understand the aggregate policy consequences of flexible working hours. Consequently, this study, which makes use of an extensive data base assembled in order to evaluate a flexitime experiment at a large governmental research and development facility, was designed to permit a rigorous assessment of these behavioral impacts and their implications for transport planning.

Previous Research

Although it has generally been established in prior work that flexitime has typically been beneficial to both employers and workers (1), (2), there is some controversy among urban transportation analysts about whether flexible work hour programs are consistent with the goals of reducing congestion, energy consumption and air pollution through increased use of carpools and transit (2). Some claim that flexitime programs will encourage workers to shift from ridesharing and transit use to driving alone so they can take advantage of the flexibility afforded by such programs. Others claim flexitime actually encourages mass transit patronage and carpooling, particularly among family members. For example, the occasional delays associated with transit would be a lesser deterrent to its usage. Flexitime may also make it easier to form carpools among workers from multiple employer sites and among family members since schedules can be adjusted to make carpooling possible.

Currently, very little and somewhat conflicting empirical evidence on individuals' activity and travel responses exists (3). A study of flexitime at a suburban employment site in Reading, England (1) found few changes in activities and travel behavior, although many workers chose earlier work schedules. Their travel behavior responses, however, may have been severely constrained by short journeys-to-work and the absence of attractive alternative travel options. Similarly, a study of variable working hours in Ottawa (4) found no basis for concluding that flexitime has any impacts on mode split, but noted increased dispersion of work schedules. In contrast, a shift toward carpools was noted in a demonstration program in Toronto (5) and toward carpools and public transit in an experiment in Sacramento (2). However, the Ottawa, Toronto, and Sacramento studies were confounded by gasoline shortages and/or changes in transit service (3), which is one reason why further research is needed to establish and explain the mode split impacts of flexitime. Although it seems clear that when given the choice, individuals will choose to shift their work schedules, there has also been virtually no analysis of how their responses vary with socio-demographic characteristics, travel options, and/or activity patterns.

Another important question concerns the stability of work schedule decisions (3). The hypothesis that individuals will exhibit considerable variability in their daily work schedules when freed from fixed hours of work is suggested by a prospective attitudinal study by Tannir and Hartgen (6) which found that

favorable views toward flexitime were motivated largely by individuals' desire for increased flexibility in activity schedules. Because of its implications for transport planning, this hypothesis also needs to be examined empirically.

Description of the Flexitime Experiment

Flexitime is a time-management system under which workers are permitted to exercise some degree of choice over their daily work schedules. Recent legislation has authorized federal agencies to experiment with flexitime and other variable work hour programs, such as a four-day work week, in order to evaluate the impact of variable work schedules on the efficiency of Government operations, mass transit facilities and traffic, levels of energy consumption, service to the public, increased opportunities for full-time and part-time employment, and the welfare of individuals and families. Over 90 Federal agencies across the country are now under some kind of flexitime.

The basis for this study is a flexitime experiment conducted at U.S. Department of Transportation's Transportation Systems Center (TSC) in Cambridge, Massachusetts. More than 600 persons are employed at this facility which is located in a dense and congested area of the Boston region but which enjoys high accessibility by all modes of urban transport.

The flexitime experiment commenced in March 1978 and lasted for a year, after which the system was adopted on a permanent basis. The flexible work hour program adopted has a mid-day core, 9:30am to 3:30pm, during which employees are required to be present except for their lunch period. Employees may arrive between 7:00 am and 9:30 am, and may leave after they have worked eight hours. Employees are not permitted to work through lunch in order to leave 1/2 hour earlier. The program allows employees to opt for a lunch longer than 1/2 hour as long as they work eight hours between 7:00 am and 6:00 pm. Under the program, supervisors have the authority to restrict the use of flexitime by their staff when necessary to insure appropriate conduct of Government business.

Analytical Approach

The major impacts on individuals anticipated in response to flexitime included changes in work schedules, travel behavior, non-work activity patterns, and attitudes. These changes reveal improvements in individuals' satisfaction with their travel and

activity choices and, thus, are important indicators of the benefits of flexitime realized by workers.

One measure of the benefits of flexitime to workers is the degree to which they take advantage of the opportunity to change and vary their work schedules. Before flexitime, employees were required to work from 8:15am to 4:45pm. If this were the preferable schedule for an individual, presumably s/he would continue it under flexitime. However, if employees change or vary their work schedules, then we may infer that by adjusting their behavior (according to their preferences) they are enjoying benefits from flexitime. Work scheduling is analyzed in the next section of this paper to determine the degree to which employees are benefiting from the flexibility afforded by the variable work hour program. An exploratory multivariate model of work schedule decisions is developed in order to test hypotheses concerning the significance and magnitude of the determinants of these decisions.

The impacts of flexitime on work trip travel choices are examined next. Flexitime removes an important constraint on work travel choices of timing and mode, and thus may permit workers to benefit from travel choice alternatives with more desirable characteristics such as reduced travel times. In view of the increasing national concern about energy consumption, it is also important to determine if flexitime program impacts on travel behavior are consistent with conservation policies.

Activity changes resulting from flexitime are another primary source of the benefits of the program to employees. Consequently, an attempt has been made to ascertain if flexitime has led to changes in individuals' activity patterns. Finally, attitudes toward flexitime and some of the intangible benefits perceived by individuals are examined.

The data for the analysis in this paper comes from two sources: a survey administered to all employees and arrival and departure time data for a sample of three hundred TSC employees for approximately one hundred days. The survey asked questions about mode to work and activity changes due to flexitime, as well as opinions about flexitime and work related difficulties due to it. Response to the survey was excellent. A response rate in excess of 75% was achieved with the return of the survey instrument from 479 individuals. Since not all respondents answered every question, the sample size for some results based on the survey is smaller.

For this study, only arrival and departure times for those days the employee was at TSC for a full work day (i.e. not on leave or travel for any part of the work day) were utilized. Part time employees were also excluded from the analysis. Only normal work days were used for the analysis of work scheduling under flexitime so that the effects of flexitime would not be confused with other factors, such as attendance at outside meetings or the use of leave.

Work Schedule Impacts

An important measure of the benefits to employees of the flexitime program is the extent to which they "flex". The average arrival and departure times of the staff are examined below along with measures of the variability of individual schedules. Significant benefits from the ability to vary work schedules can be inferred from the data.

The distribution of each individual's mean work arrival time is presented in Figure 1. The distribution approximates a normal curve with a mean of 7:55am and a standard deviation of 32 minutes. The fact that the distribution is approximately symmetrical means that while a majority of employees' average work schedules are close to an 8:00am to 4:30pm day, the remainder are fairly evenly distributed between early and late "flexers." The shift in the mean of the distribution makes it clear that many TSC staff have chosen work schedules which are significantly different from those prior to flexitime. Approximately 56% arrive, on average, at or before 8:00am. Another 14% arrive, on average, at or after 8:30am. These findings suggest that there are large differences in staff preferences for the choice among alternative work schedules. Importantly, the actual changes in work arrival time indicate that significant benefits accrue to workers from flexitime.

In contrast to many other flexible working hour programs the experiment at TSC permitted staff to vary their working hours from day to day without prior notice. Analysis of the arrival-departure time data indicates that many individuals exhibited considerable variation in their daily work schedules rather than merely shifting to a different but relatively fixed work pattern. Table 1 indicates the percentage of individuals' arrival times which deviated from their average arrival times by more than 10 minutes. As is shown in the table, only 21% of TSC staff had less than one quarter of their work schedules deviate by more than ten minutes from their average work arrival time. In contrast, more than half of workers deviated from their mean work

Figure 1

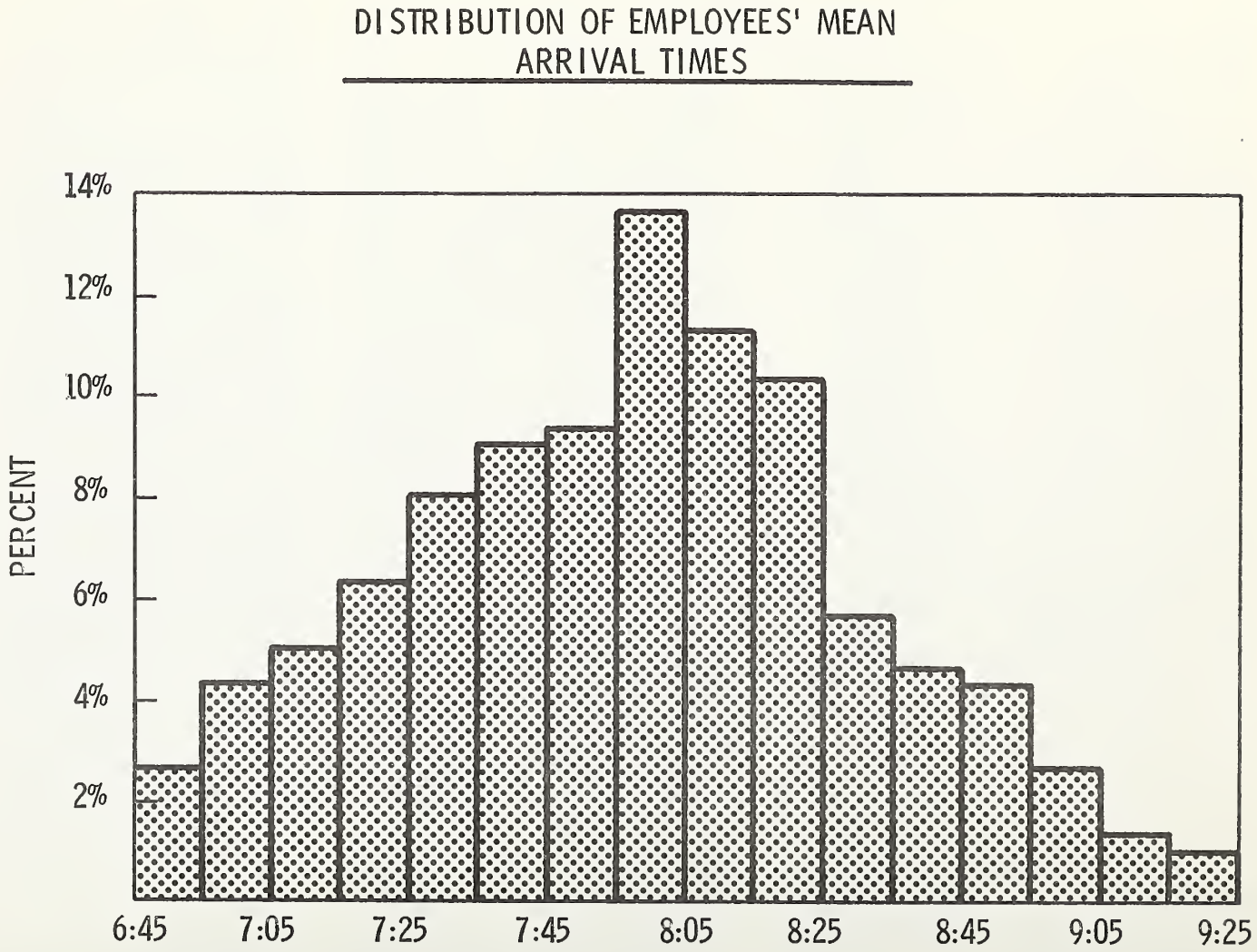

DISTRIBUTION OF EMPLOYEES' MEAN ARRIVAL TIMES
PERCENT
14%
12%
10%
8%
6%
4%
2%
6:45
7:05
7:25
7:45
8:05
8:25
8:45
9:05
9:25

TABLE 1

VARIABILITY IN INDIVIDUAL ARRIVAL TIMES

% of an individual's arrival times that deviated from his average arrival time ± 10 min.	% of TSC staff
0 - 25%	21%
25 - 50%	26%
50 - 75%	29%
75 - 100%	24%

arrival times ±10 minutes more than half of the time. This wide variability in individuals' arrival time behavior suggests that this aspect of the opportunity for flexible working hours affords them significant benefits.

In the survey staff were asked the reasons for their work schedule decisions in order to understand the nature of the benefits resulting from the introduction of flexitime. Table 2 indicates the factors ranked of greatest importance as determinants of work schedules. Almost 3/4 of the respondents reported the scheduling of after work activities as a factor in determining their work schedules. The desire to avoid congestion was also a significant factor affecting employee's work schedule and travel choices. Over 2/3 of the respondents indicated it was a factor in their work schedule decision, while about 1/3 of the survey respondents indicated it was the most important determinant. Other determinants of work hours, each mentioned by about 1/4 of the respondents, included before work activities, work-related reasons, schedules of other household members, family meal schedules, sleep patterns and carpool arrangements.

Obviously a wide variety of factors may be significant determinants of work scheduling decisions observed here through the choice of a work arrival time. In addition to the motives noted above, work schedule decisions are hypothesized to be a function of the socio-economic characteristics of the individual, the travel options available, and non-work activity patterns. Socio-economic characteristics, particularly life cycle, are felt to be an important determinant of individuals' work schedules under flexitime. In households with children, consideration of their schedules is likely to influence the individuals' work arrival time choices and, particularly if the children are on a fixed schedule, result in their arrival times being relatively consistent.

Travel options and mode choice are also felt to enter into the work scheduling decision. For example, carpoolers are apt to be relatively consistent in their work arrival times while the variability of arrival times of transit users are dependent to some degree on the reliability of the transit system.

Another determinant of an individual's work arrival time is probably non-work activities. These can include a desire to participate in a sports activity, to shop, or to enjoy entertainment and recreation both in and out of the home.

TABLE 2

FACTORS INFLUENCING THE CHOICE
OF WORK HOURS

FACTORS	FRACTION OF RESPONDENTS RANKING AS				FRACTION OF RESPONDANTS INDICATING IMPORTANT AT ALL
	1st in IMPORTANCE	2nd in IMPORTANCE	3rd in IMPORTANCE	4 or MORE	
after work activities	.18*	.24	.16	.14	.72
before work activities	.01	.03	.06	.12	.22
work related reasons	.08	.04	.06	.10	.28
child day-care arrangements	.03	.01	-	.04	.08
lunch time activities	.01	.02	.03	.12	.18
schedules of other HH members	.09	.08	.08	.14	.39
avoid traffic congestion	.31	.20	.09	.09	.69
family meal schedules	.02	.06	.07	.08	.23
sleep patterns	.12	.08	.08	.10	.38
carpool arrangements	.09	.06	.04	.04	.23
transit service	.05	.04	.04	.06	.19
other	.01	.01	.01	.03	.06

*n = 413

Arrival Time Modelling

Since there are many factors influencing an individual's work arrival time decision, multivariate analysis is necessary to determine the relative importance and significance of each. To test the hypotheses that socio-economic characteristics, travel options and non-work activity patterns are significant determinants of an individual's work arrival time, a preliminary, exploratory model of individuals' mean arrival times was developed. A linear regression model was selected for this initial analysis, although the use of more sophisticated econometric techniques is anticipated for further work on this dataset.

The independent variables used in the model are described in Table 3. The socio-economic/life-cycle characteristics include dummy variables for workers 30-39 years old, 40-49 years old and over 50 years old; the number of children under 5 years old, the number of children between 5 and 13 years old, and the number of children 14 to 18 years old; the number of full time workers in the household; the ratio of the number of autos to the number of licensed drivers in the household; and the worker's GS-level, which is a proxy for occupation and income.

The variables describing travel utilized in this preliminary analysis were dummy variables for mode choice and travel time. For the model we assume that decisions about mode choice typically precede decisions about work schedules although, of course, the characteristics of alternative work schedules enter mode choice decisions. (Consequently, some individuals will change both mode and work schedules at the same time in response to flexitime.) One way travel options enter the work schedule model is in their effect on mode choice. Travel time savings from alternative work schedules enter the model through dummy variables whose coefficients reflect the deviation from peak period arrivals for individuals who cited the desire to avoid congestion as a primary motive in making work schedule decisions. Two separate dummy variables are needed to reflect shifts to both earlier and later work schedules. Travel time to work is also included in the model in order to test for the effects of location and journey duration.

To capture the effects of non-work activity patterns, variables were constructed based on the reported primary importance to the individual of after-work activities and schedules of other household members in influencing their work scheduling decisions. As above, two dummy variables were used to

TABLE 3

MODEL VARIABLES

VARIABLE	DESCRIPTION
TRAVEL	
TRANSIT	1 if transit user; 0 otherwise
CARPOOL	1 if carpooler; 0 otherwise
TTIME	in hours
BCONG	1 if avoiding congestion is most important factor determining work schedule and mean arrival time is before 8:15; 0 otherwise
ACONG	1 if avoiding congestion is most important factor, and mean arrival time is after 8:15; 0 otherwise
SOCIO-ECONOMIC/LIFE CYCLE	
GS	proxy for income and occupation
A3039	1 if between 30 and 39 years old; 0 otherwise
A4049	1 if between 40 and 49 years old; 0 otherwise
A50	1 if 50 or older; 0 otherwise
CU5	number of children under 5
C513	number of children 5 to 13 yrs. old
C1418	number of children 14 to 18 yrs. old
FWKR	# full time workers in household
OTHH	number of others in household, not counted as children or full time workers
AUTODR	autos in household per licensed driver
SELF-REPORTED WORK SCHEDULING DETERMINANTS	
AFT	1 if after work activities were ranked as most important factor in determining work schedule; 0 otherwise
BSCHED	1 if schedules of other household members most important and mean arrival time is before 8:15; 0 otherwise
ASCHED	1 if schedules of other household members most important and mean arrival time is after 8:15; 0 otherwise

measure the effect of schedules of other household members as the major determinants of the individual's work schedule.

The results of estimation of two versions of the disaggregate work arrival time model are shown in Table 4. Model 1 does not include the dummy variables representing the factors cited by individuals as the primary determinants of work schedules. These are included in model 2. The results from these models are quite encouraging in that almost all the coefficients have the correct sign, and many of the factors hypothesized to influence work schedule decisions were statistically significantly different from zero. (For models, such as these, with a large number of degrees of freedom, t-statistics with absolute values in excess of 1.65 imply significance at the 90% confidence level). The degree of explanation achieved was acceptable, especially for a disaggregate model.

The coefficients for both model 1 and model 2 are quite similar and convey important findings with respect to work schedule behavior under flexitime. Specifically, the models indicate that socio-demographic characteristics are important determinants of flexitime impacts, suggesting that these impacts may vary considerably from place to place as a function of the distribution of the characteristics of workers and their households.

Mean arrival times are later for individuals having longer travel time, higher salaries, and using transit. Mean work arrival times are earlier with higher numbers of children and of other members of the household. The models also indicate that older individuals have earlier arrival times than others. Interestingly, workers with children under five years old choose earlier schedules than those with older children. This perhaps reflects the early feeding and bedtime schedules of young children and their parents' desire to spend time with them. Participation in a carpool and the number of autos per driver were not significant explanatory variables in either version of the model.

With fuller specification of model 2, the explanatory power of the model, as measured by R^2, was substantially increased. The congestion variables' coefficients are significantly different from zero, and their magnitudes suggest relatively large shifts are made in some individuals' mean arrival times to avoid congestion. Similarly, schedules of other household

TABLE 4

MODELS OF INDIVIDUALS
MEAN ARRIVAL TIME (IN HOURS)

VARIABLE	COEFFICIENTS	
	MODEL 1	MODEL 2
CONSTANT	7.615 (41.385)*	7.884 (47.632)
TRANSIT	.112 (1.133)	.123 (1.402)
CARPOOL	-.045 (-.607)	.043 (.662)
TTIME	.164 (1.232)	.131 (1.150)
GS	.047 (3.793)	.027 (2.476)
A3039	.075 (.716)	.059 (.652)
A4049	-.141 (-1.303)	-.122 (-1.305)
A50	-.457 (-3.888)	-.351 (-3.447)
CU5	-.244 (-3.434)	-.168 (-2.769)
C513	-.081 (-1.931)	-.057 (-1.605)
C1418	-.059 (-1.579)	-.062 (-1.929)
FWKR	-.035 (-.739)	-.052 (-1.290)
OTHH	-.049 (-1.218)	-.045 (-1.314)
AUTODR	.025 (.266)	.008 (.104)
BCONG		-.376 (-5.659)
ACONG		.655 (5.777)
AFT		-.072 (-.919)
BSCHED		-.127 (-1.061)
ASCHED		.451 (3.479)
R^2	.1809	.4236

*t-statistic

members, particularly for those with late arrival times, are significant determinants of work scheduling.

Models were also developed with the same specifications in an attempt to account for the variability of individual work schedules. These models, which have the standard deviation of individual work arrival times as the dependent variable, are presented in Table 5.

The explanatory power of these models is not as great as that of the mean arrival time model. However, the signs of the significant coefficients are in the direction expected. Carpooling decreases variability in arrival times. The models indicate work schedule variability decreases with age; in fact, the magnitudes of the coefficients suggest that persons 50 years old or older are much more consistent in work schedules than other employees. The coefficient of the number of children under five years old, is negative, significant, and relatively large, possibly reflecting the constraints young children impose on schedule variability. The model indicates that other factors reducing the variability of work arrival include the number of full-time workers, the number of older children, and earlier arrival times either to avoid congestion or because of the schedules of other household members.

The variables significant in increasing work schedule variability are GS level (income) and later arrival times to avoid congestion. The number of children 5 to 13 also contributes to work arrival time variability. This may be due to parents' accommodating the busy extra-curricular schedules of many pre-teens.

Before examining the travel and activity choice impacts suggested in the above discussion of individuals' work schedule decisions, we first consider some of their aggregate consequences on work schedule patterns at TSC. This aggregate data is relevant to forming a management perspective on flexitime and also offers some additional insights into individual decisionmaking.

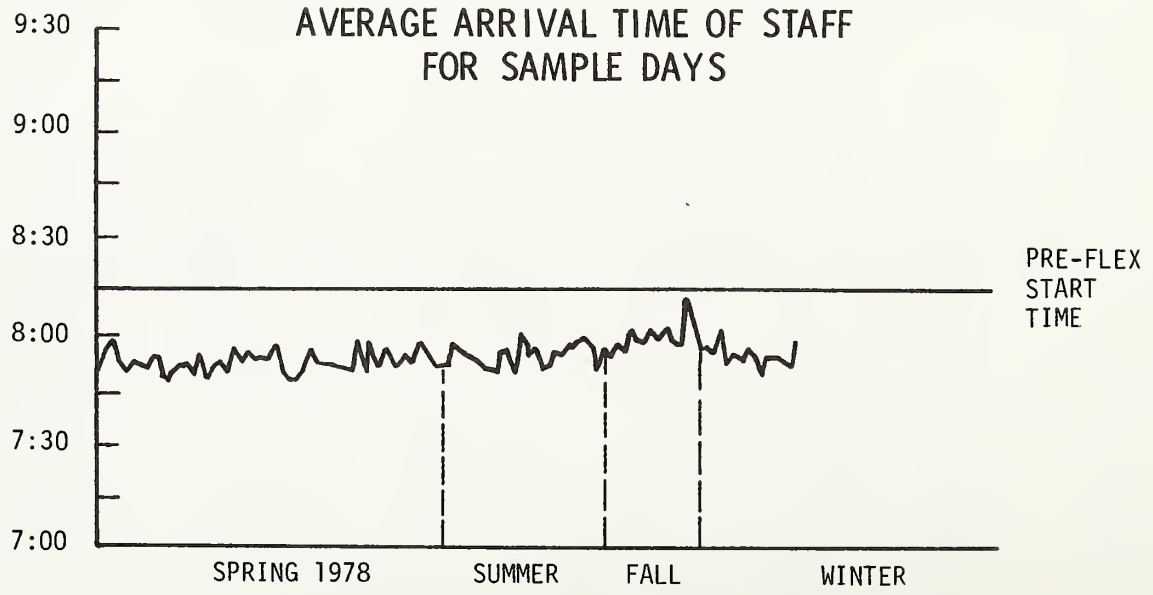
Figure 2 illustrates the mean arrival time at TSC for each day in the sample. Note that for most days, the average arrival time of employees at TSC is a little earlier than eight o'clock. The daily average arrival time is relatively consistent; almost all the average arrival times fall within a 15 minute interval.

TABLE 5
MODELS OF THE STANDARD
DEVIATION (IN HOURS) OF AN
INDIVIDUALS' MEAN ARRIVAL TIMES

VARIABLE	COEFFICIENTS	
	MODEL 1	MODEL 2
CONSTANT	.462 (4.424)*	.5392 (4.984)
TRANSIT	-.013 (-.233)	.017 (.299)
CARPOOL	-.054 (-1.250)	-.019 (-.438)
TTIME	.0127 (.166)	-.009 (-.128)
GS	.0235 (3.291)	.019 (2.625)
A3039	-.038 (-.627)	-.039 (-.658)
A4049	-.092 (-1.489)	-.085 (-1.382)
A50	-.209 (-3.101)	-.191 (-2.874)
CU5	-.148 (-3.633)	-.135 (-3.398)
C513	.019 (.808)	.026 (1.118)
C1418	-.036 (-1.705)	-.036 (-1.702)
FWKR	-.022 (-.793)	-.029 (-1.114)
OTHH	.009 (.373)	.006 (.246)
AUTODR	.017 (.321)	.008 (.163)
BCONG		-.077 (-1.769)
ACONG		.287 (3.811)
AFT		-.016 (-.304)
BSCHED		-.083 (-1.064)
ASCHED		-.038 (-.448)
R^2	.12497	.1991

*t - statistic

FIGURE 2


AVERAGE ARRIVAL TIME OF STAFF
FOR SAMPLE DAYS
9:30
9:00
8:30
8:00
7:30
7:00
PRE-FLEX
START
TIME
SPRING 1978
SUMMER
FALL
WINTER

The graph of average daily arrival times suggests that there is a trend to later arrival in the fall, and earlier arrival in the spring. This trend is correlated with and may be due, at least in part, to seasonal variation in the hours of daylight.

In addition to the seasonal trend, there also appears to a day-of-the-week trend in work schedules. As illustrated in Figure 3, the average daily arrival times for Mondays are later than Fridays. This difference, statistically significant at the 98% confidence level, suggests that work schedules are modified in order to extend the duration of the weekend.

Travel to Work Impacts

Consideration of the effect of flexitime on employee travel to work is important both as a indicator of travel-related benefits to employees and because travel changes due to flexitime may have important consequences for the goals of reduced energy consumption and reduced congestion. Results from the survey show that flexitime has had a very significant impact on employee travel to work.

Based on the results of the survey administered to employees, it is estimated that 9% of TSC workers shifted modes to work due to flexitime. Table 6 presents the before and after flexitime modal split for their trip to work. The percentage of respondents driving alone dropped from 42.4% to 39.5%, while carpool participation increased from 35.4% to 37.4%. Transit patronage also increased slightly. Interestingly, those who switched modes due to flexitime have a significantly higher average GS level than those who did not and they were predominantly female.

Survey evidence also suggests flexitime may have had an impact on auto ownership. About 6% of the respondents indicated that flexitime had influenced the number of motor vehicles operated by their household. For most of these households, flexitime enabled them to decrease the number of vehicles operated.

As indicated in Table 7, many TSC employees reported travel time savings due to flexitime. Over sixty percent of the auto drivers and carpoolers who had not changed modes reported travel time savings due to flexitime. All of those switching to driving alone and carpooling reported travel time savings; this suggests travel time savings were a major factor influencing these mode shifts.

FIGURE 3

AVERAGE DAILY ARRIVAL TIME BY DAY OF THE WEEK

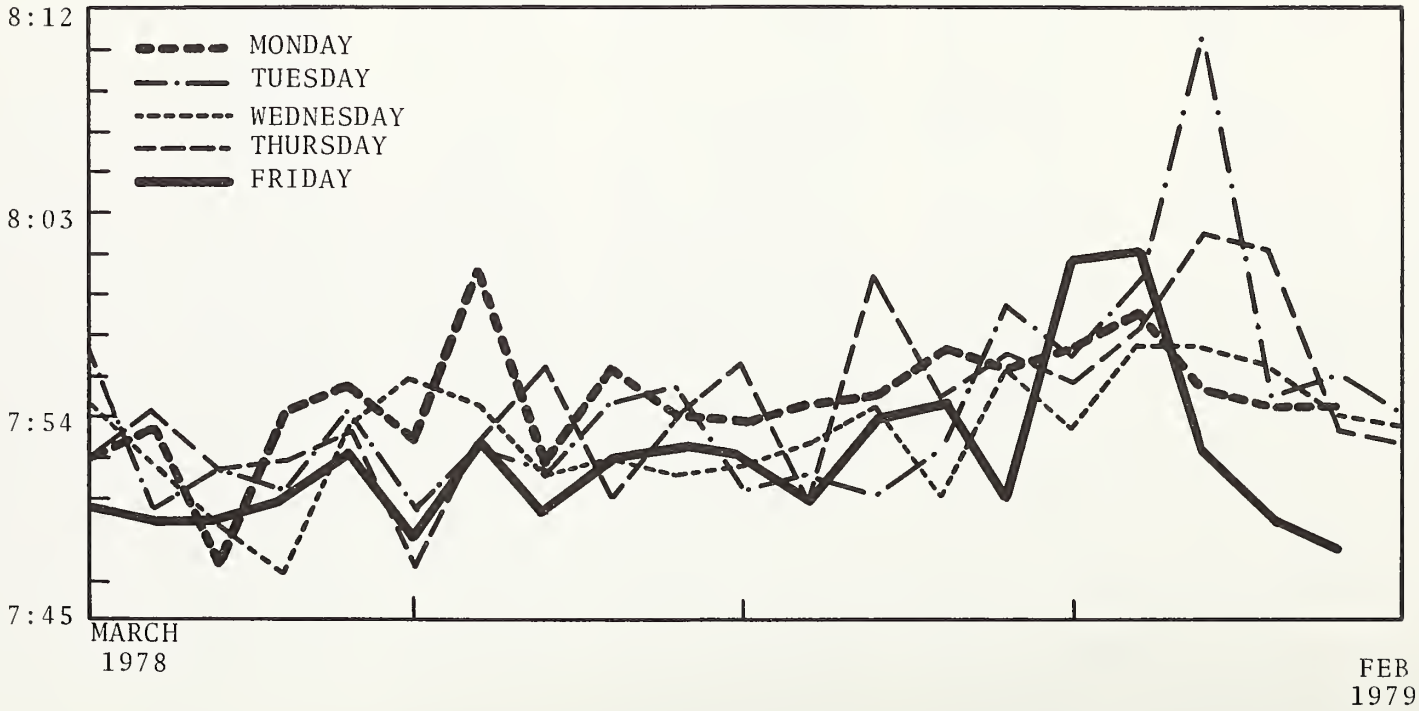


TABLE 6

MODE TO WORK CHANGES RESULTING FROM FLEXITIME

MODE	% BEFORE FLEXITIME	% AFTER FLEXITIME
Drive alone	42.4%	39.5%
Carpool/Rideshare	35.4	37.4
Public Transit	21.5	22.5

Has flexitime had an effect on the number of motor vehicles operated by your household?

Yes	6%
No	94%

TABLE 7

TRAVEL TIME SAVINGS BY MODE

What has been the effect of flexitime on your average travel time to work?

For those who did not change modes

	drive alone	carpool	transit
increase it	2%	2%	3%
no effect	34%	28%	65%
decrease it*	63%	68%	30%
do not know	1%	2%	2%
*For those who decreased their travel time, the average decrease was:	13.7 min.	10.74 min.	11.37 min.

For those who changed modes due to Flexitime

	drive alone	carpool	transit
increase it	-	-	44%
no effect	-	-	-
decrease it+	100%	100%	56%
do not know	-	-	-
+For those who decreased their travel time, the average decrease was:	18.23 min.	13.0 min.	11.4 min.

A very small percentage of TSC staff who drive to work alone or carpool reported an increase in travel time to work. Of course, travel time increases due to flexitime are freely chosen and thus presumably offset by other benefits to each traveller. Some transit users (30%) also reported travel time savings. Of those who did not change modes, very few reported travel time increases. Interestingly, over forty percent of those switching to transit as a result of flexitime reported an increase in travel time.

The shift to temporally dispersed work schedules also implies further significant impacts on travel from flexitime. Since many TSC employees are travelling to work outside the peak of the commuting peak, they have reduced their contribution to peak period congestion on the highway and transit networks. In addition, those who are now driving during periods of less congestion are using less energy because they travel at more fuel efficient speeds and with less stop-and-go driving.

For the range of urban driving speeds (up to 35 m.p.h.), an increase in speed generally improves fuel efficiency. Based on the travel time savings due to flexitime reported in the survey and the travel time reported for the day of the survey, average travel to work speeds from before and after flexitime can be estimated for a rough calculation of energy savings. For those auto drivers reporting a decrease in travel time due to flexitime, average speed increased from 20.6 miles per hour to 27.2 miles per hour.

Using data developed at the Oak Ridge National Laboratory (7) on energy efficiency by speed which takes account of the vehicle fleet mix and the range of urban driving conditions, the improvement in fuel efficiency can be estimated. For those reporting improvements in travel time, fuel efficiency improved 11.7% (from 14.9 mpg to 16.6 mpg) and fuel consumption was reduced 9% (from 1 gal per trip to .9 gals per trip). This implies a 7.6% overall fuel efficiency improvement for vehicles driven to TSC, and an overall 5.8% savings in fuel.

Scheduling/Activity Changes

Flexitime was expected to allow workers greater opportunities for participation in non-work activities. Results from the survey indicate that employees have indeed taken advantage of flexitime to make their personal schedules more convenient and to increase their participation in non-work activities.

As indicated in Table 8, most employees reported that flexitime enabled them to spend more time with their families and to participate in more activities. Only 29% reported that flexitime had little or no effect on increasing the amount of time they were able to spend with their families. More than 75% of those surveyed claimed flexitime allowed them to increase participation in non-work activities.

Apparently flexitime's impacts on activity pattern decisions have also resulted in significant decreases in the use of sick leave and short-term annual leave. Thirty-six percent and fifty percent of employees reported reductions in these leave categories, respectively. In addition to the benefits to staff from the ability to substitute varied work schedules for leave, benefits also accrue to the Government from the reduced use of sick leave.

Attitudes Toward Flexitime

Flexitime is extremely popular with employees. As Table 9 shows, approximately 95% of the respondents like flexitime and would like to see it continued; this feeling is shared by supervisors and non-supervisors.

Flexitime has also improved employee job satisfaction. Sixty five percent of the employees responding report that flexitime has increased their job satisfaction; only one percent reported that their job satisfaction had decreased due to flexitime. Reasons given for flexitime improving their job satisfaction included that it is convenient, it is more professional, it allows them more responsibility and independence, that the work environment is more relaxed under flexitime, and that it is evidence that management cares about employees.

Over twenty percent of the respondents to the survey indicated they would like additional flexibility in work schedules. The option most frequently mentioned (by 13%) was a flexible work week or pay period. Some (4%) suggested a four day work week and some (4%) wanted the flexible arrival interval to be expanded.

Organizational Impacts

Perhaps the biggest benefit of flexitime to TSC is its positive effect on morale; over 85% of the respondents felt that morale had improved as a result of flexitime. In addition,

TABLE 8

FLEXITIME'S IMPACT ON INDIVIDUAL'S ACTIVITIES

RESPONSES TO SELECTED SURVEY QUESTIONS

To what extent does flexitime allow you to spend more time with your family?

to a very great extent	26%
to some extent	45%
to little or no extent	29%

To what extent does flexitime allow you to participate in outside activities?

to a very great extent	29%
to some extent	48%
to little or no extent	23%

What has been the effect of flexitime on the amount of sick leave you use?

decreased	36%
no effect	60%
increased	1%
do not know	3%

What has been the effect of flexitime on your use of annual leave in small amounts, e.g., less than half a day at a time?

decrease	50%
no effect	37%
increase	10%
do not know	3%

TABLE 9

ATTITUDES TOWARD FLEXITIME

	All	Super-visors	Non-super visors
Do you like flexitime?			
yes	94%	89%	95%
no	3%	6%	2%
no opinion	3%	5%	3%
Do you want to see flexitime continued?			
yes	95%	91%	96%
no	2%	4%	2%
no opinion	3%	5%	2%
How has flexitime effected your job satisfaction?			
increased it	65%	45%	68%
little or no effect	33%	55%	31%
decreased it	2%	0%	1%

results from the survey suggest that flexitime has improved productivity. This assessment revealed no significant work related problems due to flexitime. Only fifteen percent of the respondents indicated on the survey that they had experienced any work-related difficulties whatsoever due to flexitime. The most often cited problems were difficulty scheduling meetings (cited by 5% of the respondents) and difficulty interacting with co-workers (6%).

Flexitime is as popular with supervisors as it is with their staff. Supervisors share the assessment that flexitime has improved morale and that it has increased productivity. However, larger percentages of supervisors than staff reported work-related difficulties due to flexitime. Many had difficulty interacting with co-workers (25%) and scheduling meetings (20%). Flexitime has virtually eliminated the problem of tardiness. This has reduced the burden on supervisors to discipline tardy employees and is inferred to have increased the number of hours worked by previously tardy employees. Furthermore, flexitime has reduced the number of work hours missed due to inclement weather since travel delays are made up at the end of the day.

An unanticipated impact of flexitime is reflected in the fact that over one-fourth of the professional staff indicated that they voluntarily increased the average numbers of hours they work in response to flexitime; the average increase was reported to be about 30 minutes. Reasons stated for the increase included the desire to finish a task and a reluctance to leave while project co-workers remain. Only 3% of the respondents felt that flexitime led to a reduction in the number of hours they worked. Among the reasons given were bus schedules and clock watching.

The costs of flexitime have been minor. It was expected that overhead would increase by a small amount due to the need to keep the building open for a longer period of time each day. However, due to revised operating procedures, any costs accruing from flexitime were offset, and the cost of facilities operation during the flexitime experiment remained about constant. Flexitime has not significantly impeded the ability of the staff in the in-house functions to interact with each other, other TSC units, or outside organizations.

Future Work

This analysis has indicated that flexitime has potentially large and socially beneficial impacts on individuals' activity and travel choices. Further research, therefore, seems warranted

to investigate the applicability of flexitime to a wide variety of different (non-governmental) work settings, to explore the potential of flexitime programs to achieve energy conservation in the large, severely congested urban areas, and to corroborate the empirical findings on behavioral impacts obtained in this study.

Improvements in modelling individual responses to flexitime are also warranted because of the models' usefulness in understanding and predicting behavior in other settings. Currently, it is planned to refine the models presented in this paper in several ways. In particular, model forms more appropriately reflecting the underlying choice structure will be investigated; variables describing the travel options available to workers will be incorporated; and daily arrival times will be modelled with seasonal and day-of-the-week effects included.

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