IMPACT OF AGE ON COMMUTER MOBILITY

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Résumé — Dans des recherches antérieures, nous avons mis l'accent sur les rapports entre l'âge et la distance à parcourir pour aller au travail, mais à ce que nous sachions, aucune analyse n'a porté l'attention sur les réductions de cette distance à cause de l'âge. La présente étude traite des effets de l'âge sur la propension du travailleur à faire la navette entre son domicile et son lieu de travail, tout en vérifiant les schèmes de répartition des lieux de résidence et d'emploi. Les résultats obtenus montrent que la distance à parcourir pour aller au travail et en revenir a une influence négative importante sur les va-et-vient entre les diverses zones, dans le cas de tous les groupes d'âge, et que son effet relativement contraignant sur les groupes d'âge les plus jeunes et les plus vieux (c'est-à-dire les personnes de moins de 20 ans et de plus de 65 ans) est nettement plus marqué que sur les groupes d'âge moyen (de 20 à 65 ans).

Abstract — Some previous research has focused on the relationship between age and distance travelled to work but, to our knowledge, no analysis has focused on "distance decay changes" with age. The present research examines the effect of age on worker's *propensity to commute* while controlling for residential and job distributions. The results indicate that commuting distance has a significant negative influence on inter-zonal commuting for all age groups and that its relative constraining influence on the youngest and oldest age groups (under 20 years and over 65 years of age, respectively) is significantly more pronounced than for the medium age groups (20-65 years).

I. Introduction

Many demographic, socio-economic and environmental factors shape, and in turn are shaped by, the residential, job location and commuting patterns of urban areas. This paper isolates one demographic factor, that of the age distribution of the work force, to establish its implications for the urban journey-to-work. While age can certainly be considered to affect community patterns through the distribution of residences and jobs, it may also influence the *propensity to commute* — the willingness and/or ability to travel work-trip distances. With a focus upon these two relationships, then, we analyze the impact of age on the journey-to-work patterns of the working population of the Toronto Census Metropolitan Area (CMA).

II. Previous Research

The importance of the socio-economic characteristics of workers in intra-urban mobility has been examined extensively (*e.g.* Huff, 1960; Marble, 1959). Most relevant to this study, the inverse relationship between age and mobility has been documented by a number of researchers (*e.g.* Lansing and Mueller, 1967; Long, 1972; Shryock, 1964; and Speare, 1970). The importance of age in the study of commuting patterns has received only cursory attention.

In the limited research on the relationship between age and the journey-to-work (Adams and Mackesey, 1955; Thompson, 1956; Lonsdale, 1966; Gera, 1979) the former

was found to be inversely related to distance commuted. Unfortunately, data constraints limited analyses to zero-order correlations except in latter study; therefore, there may well be danger of spuriousness. Indeed, Clemente and Summers (1974) found no support for the hypothesized inverse relationship once the effects of income and marital status were controlled for; however, they admit their analysis was severely limited as the data employed were restricted to white male industrial workers who commuted by car. Although it is generally accepted that commuting distance varies as some function of the age of the worker, the effect of age on commuter mobility has not been critically examined.

It is the purpose of this study to examine the relationship between the age of the worker and distance travelled. Although it was found that the exponent of distance in gravity models varies with time (Olsson, 1965), trip purpose (Voorhees, 1955; Carroll and Bevis, 1957), and region (Taaffe, 1967), to our knowledge no analysis has focused on *distance decay changes* (relative decline in distance) with age.

III. Objective and Organization of the Study

Our aim is to describe the variation in distance travelled to work by various age groups, separating the effect of urban physical-structural constraints, the existing pattern of job and residence locations, from the influence of the propensity of different age groups to commute.

Following a brief discussion of what must be one of the most extensive data bases made available to researchers in this area of investigation, our analysis proceeds in two logical stages.

The first stage involves a brief description of the patterns of job and residence locations for different age groups in the Toronto CMA. Based on this urban *structure*, the analysis deals with the actual commuting distances travelled by workers in each of the specified age groups.

The second stage deals with a set of gravity models describing the commuting behaviour of each age group. Here, while holding the trip purpose and the distribution of jobs constant, the propensity of each age group to commute is established. Specifically, the following proposition was tested. For any workplace, the proportion of the resident labour force in any residence zone commuting to that workplace, will tend to decline as the distance between the workplace and the zone of residence increases. The rate of decline will depend on the age of the resident labour force of the zone. The rate of decline will be very high in the case of older age groups, and very low in the case of younger age groups, or inversely related to the age of the resident labour force.

IV. The Data

From the responses to the 1971 *Census of Population and Housing,* it is possible to ascertain the residential location of the employed labour force of Canada, as of June 1, 1971. That Census also collected job location information on a national basis for the first time. From these responses, journey-to-work data, consisting of the place of residence and place of employment, were coded for one-ninth of the complete population. Full population estimates were made by Statistics Canada from this sample. This study uses Statistics Canada's place-of-work data for the Toronto CMA. Although data for the Toronto CMA were available on a census tract (CT) level, the 453 CTs in the CMA were aggregated into 63 zones. For each of these zones in the Toronto CMA, information was available on the *resident labour force* (RLF) in the zone of residence; the *working labour*

force (WLF) in the zone of work; and the flow of commuters a_{ij}, and commuting distances d_{ij}, between any pair of zones.

The RLF of a zone includes all workers who are living in that zone and whose place-of-work is known and within the CMA. The WLF of a zone includes all those whose jobs are known to be located in that zone, and who reside in the CMA or within a fifty-mile radius.

The commuting flow, a_{ij}, between any pair of zones is defined as the number of workers who live in zone i and work in zone j.

The commuting distance, d_{ij}, is the airline-mile distance between any pair of zones i and j. We found that a high zero-order correlation *(r = 0.91)* existed between airline-mile distance and road-mile distance suggesting that airline-mile distance might be regarded as a reasonable proxy for the actual distance commuted.

Further, this data was disaggregated by age for this study. Six age groups are considered in this study:

Group 1:   <20 years
Group 2: 20−29 years
Group 3: 30−39 years
Group 4: 40−49 years
Group 5: 50−65 years
Group 6:   >65 years

IV. The Urban Structure: Distribution of Residences and Jobs by Age Group

To analyse the patterns of residence and job locations by age groups in the Toronto CMA, locational indices and correlation techniques are employed. Specifically, we make use of the concept of over- and under-representation, measuring the job and residence distributions of each age group relative to the overall pattern in the CMA. Over-representation of an age group in the RLF (WLF) of a zone means that this age group constituted a larger fraction of the total RLF (WLF) of the zone than it did in the RLF (WLF) of the whole CMA. Under-representation implies a lower-than-average fraction. The degree to which an age group was over- or under-represented in the RLF (WLF) of each zone is determined by calculating *location quotients*. (Duncan and Duncan, 1955; Wheeler, 1968.)

The *residence location quotient* (RLQ) of age group k (where $k = 1 \ldots 6$) in any zone i is calculated as follows:

$$RLQ_{ik} = \frac{RLF_{ik}/RLF_i}{\sum\limits_{i=1}^{63} RLF_{ik} / \sum\limits_{i=1}^{63} RLF_i} \tag{1}$$

where i $(i = 1 \ldots 63)$ denotes the zone of residence and k denotes the age category, and

RLQ_{ik} = the value of RLQ for zone i and age category k;

RLF_i = total resident labour force of zone i;

RLF_{ik} = resident labour force of zone i in age category k.

Similarly, the degree of over- and under-representation of any age group k, in the total employment available in each zone j, is indicated by a *job location quotient* (JLQ) and is calculated as follows:

$$JLQ_{jk} = \frac{WLF_{jk}/WLF_j}{\sum\limits_{j=1}^{63} WLF_{jk} / \sum\limits_{j=1}^{63} WLF_j} \tag{2}$$

where j $(j = 1 \ldots 63)$ denotes the zone of work and k the age group, and

JLQ_{jk} = the value of JLQ for zone j and age category k;

WLF_j = total working labour force of zone j;

WLF_{jk} = working labour force of zone j in age category k.

In order to analyze the residential and job location patterns of different age groups, we have computed simple correlation coefficients of RLQs and JLQs with distance from the central business district (CBD — Zone 2). This is a commonly used method for analyzing the physical structure of a metropolitan area. The results are shown in Table 1.

TABLE 1   CORRELATION OF RLQ AND JLQ INDICES WITH DISTANCE OF ZONE
FROM THE CBD FOR EACH AGE GROUP, TORONTO CMA, 1971

Age Groups		Simple Correlation Coefficient (RLQ and Distance of Zone from CBD)	Simple Correlation Coefficient (JLQ and Distance of Zone from CBD)
Group 1:	<20	0.63**	0.58**
Group 2:	20 - 29	-0.41**	0.00003
Group 3:	30 - 39	0.37**	0.28*
Group 4:	40 - 49	0.45**	0.22
Group 5:	50 - 65	-0.24	-0.53**
Group 6:	>65	-0.38**	-0.37**

  * Significant at the 95 per cent level
** Significant at the 99 per cent level

Source: Based on 1971 Census place-of-work data,
          Statistics Canada.

Looking at the simple correlation coefficients relating RLQs by zone with distance from the CBD, we find that for all age groups except group 5 (50-65 years) there is a significant relationship to the zonal distance from the CBD. These results suggest that there was a significant tendency for the residences of age groups 2 and 6 to be most concentrated near the CBD. To a lesser degree, residence centralization was evident, although not strong, for group 5. Age groups 1, 3 and 4 have significant positive correlation with distance suggesting decentralization in their respective residential distributions.

The job location patterns of various age groups tend somewhat to resemble their residence location patterns. The simple correlation coefficients relating JLQs by zone with zonal distance from the CBD suggest that while the trends in job decentralization are not as strong as we found with respect to residential distribution, there was still a significant tendency for the jobs of age group 1 to be over-represented in the suburbs of the CMA. A lesser degree of job decentralization was evident for age group 3 (30-39). Groups 5 and 6 (50-65, and over 65) showed significant centralization in their respective job distributions.

These patterns of job and residential locations by age give rise to different and complex commuting patterns for various age groups. We now direct our enquiry towards the question of average commuting distances travelled by the members of different age groups.

V. Age and Journey-to-Work Distance

First, we describe and provide some preliminary analysis of the variations in the actual distances travelled by each age group. Second, we explore the forces underlying these trends through an application of gravity models to commuter flow data.

The mean actual distances travelled to work for all destination trips are given in Table 2. Looking at the overall trends in work travel distance by age group in the CMA, an inverse U-shaped η relationship between age and distance travelled emerges. The longest average distances travelled were undertaken by age groups 3 and 4 (30-39, and 40-49), and the shortest distances by those under 20 and over 65 (age groups 1 and 6).

TABLE 2   AVERAGE COMMUTING DISTANCE BY AGE, TORONTO CMA, 1971

Age Groups	% of Toronto CMA Working Labour Force[a] in the Age Group	Mean Distance Travelled (Miles) All Destinations
Group 1: <20	6.20	3.62
Group 2: 20 - 29	28.74	4.98
Group 3: 30 - 39	21.96	5.49
Group 4: 40 - 49	21.84	5.36
Group 5: 50 - 65	19.31	4.82
Group 6: >65	1.95	3.60
All Age Groups	100.00	5.03

a   Includes only those workers who live and work in the CMA.   The total working labour force of the Toronto CMA was estimated to be 1,037,595 as of June 1, 1971.

Source: Based on 1971 Census place-of-work data, Statistics Canada.

A more detailed picture emerges from the *distance profiles* for each age group, given in Table 3 and plotted in Figure 1 to 6. These profiles show the percentage of an age group's workers whose journey-to-work distance fell within each 2-mile distance band (0-1.99 miles, 2-3.99 miles, etc.). The CMA average profile is given in each of the figures for comparison. Considering Figures 1 to 6, the distance profiles for workers under 20 (Figure 1) and over 65 (Figure 6) are weighted more towards shorter distances than are the profiles of other age groups and the CMA average profile. This suggests that the average commuting distances shown in Table 2 do not provide the full picture of the distribution of the distances travelled by most members of age groups 1 and 6. For example, while the average CMA commuting distances for age groups 1 and 6 were 3.62 and 3.60 miles respectively, the profiles (Figures 1 and 6) and Table 3 show that about 40.88 per

TABLE 3 PERCENTAGE DISTRIBUTION OF WORKERS BY WORK-TRIP LENGTH, BY
AGE, ALL DESTINATION COMMUTERS, TORONTO CMA, 1971

"Distance Band" Number	Trip-Length (miles)	Percentage of Working Labour Force						
		Age Group 1 (<20)	Age Group 2 (20-29)	Age Group 3 (30-39)	Age Group 4 (40-49)	Age Group 5 (50-65)	Age Group 6 (>65)	All Age Groups (Total CMA)
1	0- 1.99	40.88	26.85	26.33	26.82	27.80	37.33	27.96
2	2- 3.99	27.35	27.17	24.11	23.37	25.21	26.40	25.30
3	4- 5.99	12.97	16.06	15.30	15.67	17.55	17.45	15.91
4	6- 7.99	6.79	10.33	10.03	11.29	11.17	8.02	10.45
5	8- 9.99	6.26	8.73	9.58	9.79	8.42	5.76	8.82
6	10-11.99	2.10	3.83	4.74	4.26	3.18	2.18	3.81
7	12-13.99	1.62	2.80	3.82	3.42	2.74	1.40	3.07
8	14-15.99	.80	1.49	1.83	1.63	1.29	.62	1.52
9	16-17.99	.22	.73	1.06	.93	.78	.16	.79
10	18-19.99	.46	.89	1.48	1.15	.81	.23	1.04
11	20+	.56	1.11	1.72	1.67	1.05	.55	1.32
	Total[a]	100.00	100.00	100.00	100.00	100.00	100.00	100.00

a Totals may not add due to rounding

Source: Based on 1971 Census place-of-work data, Statistics Canada.

cent of group 1 workers and 37.33 per cent of group 6 workers travelled less than two miles to work. The profiles for age groups 2 and 5 (20-29 and 50-65) are very close to the CMA average, while those for age groups 3 and 4 (30-39 and 40-49) are slightly above average. In general, the tendency for the distribution of workers to be concentrated in the shorter-distance classes is apparent for every age group; over half have trip lengths under four miles.

The variations in work-trip distances from one age group to another leads us to enquire into the relevant underlying factors. We now assess the relative effects of distance and of distribution of jobs on work-trips of each age group.

We employ a set of gravity models which describe the commuting behaviour of each age group. This technique, widely employed in transportation planning, involves a regression model to estimate the flow of commuters between any pair of zones as a function of the *attractiveness* of the zones and the distance between them. In essence, this model proposes that the interaction between zones occurs as a result of *gravitational attraction;* that is, for example, the percentage of workers aged 30-39 (group 3) living in zone i and travelling to work in zone j is a function of the number of jobs in zone j, and the distance between zone i and zone j.

We estimate a series of modified gravity models of the following form:

$$\frac{A_{ij}^{k}}{RLF_{i}^{k}} = f\left(WLF_{j}/WLF_{CMA}, d_{ij}\right) \tag{3}$$

where i denotes the zone of residence j, the zone of work $(i, j = 1 \ldots 63)$ and k denotes the age group $(k = 1 \ldots 6)$:

A_{ij}^{k} = the flow of commuters in age category k from zone i to zone j

RLF_{i}^{k} = the residental labour force of zone i in age category k

WLF_{j} = the working labour force of zone j;

WLF_{CMA} = the working labour force of the CMA;

d_{ij} = the airline distance in miles between zone i and zone j.

Figure 1

Age Group 1 -- Under 20
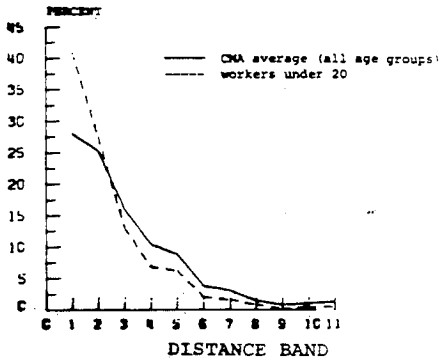
Figure 2

Age Group 2 -- 20-29
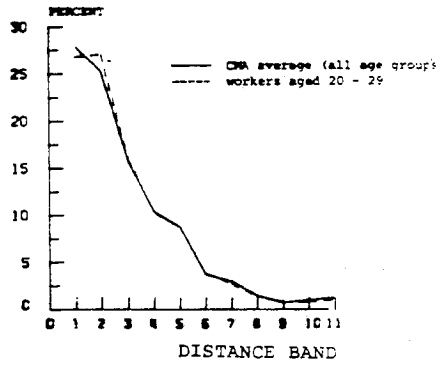
Figure 3

Age Group 3 -- 30-39
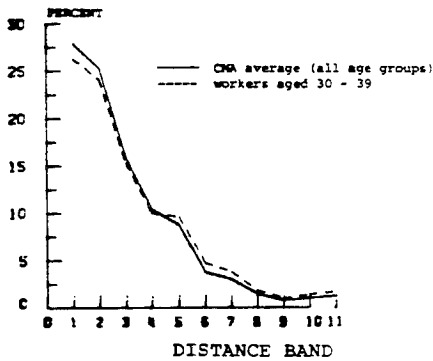
Figure 4

Age Group 4 -- 40-49
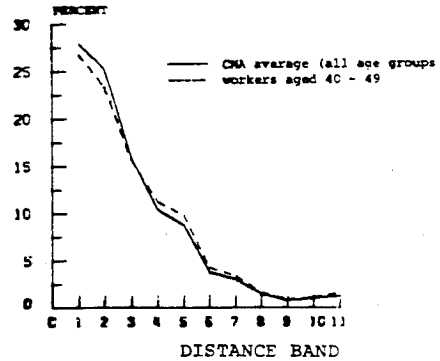
Figure 5

Age Group 5 -- 50-65
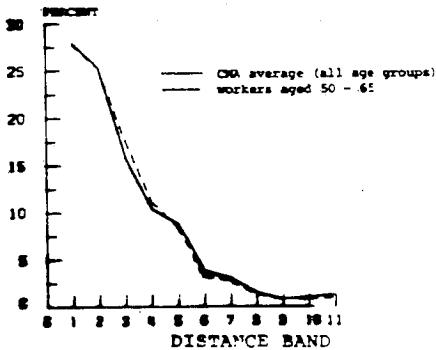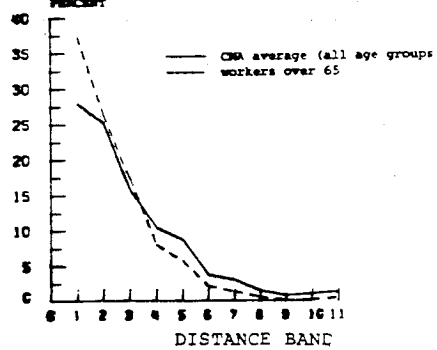
Figure 6

Age Group 6 -- Over 65

NOTE: See Table 3 for definitions of "distance band" and source.

FIGURES 1-6   DISTANCE PROFILES: ALL COMMUTERS, BY AGE,
TORONTO CMA, 1971

This gravity model allows us to estimate the effects of both distance and the distribution of job opportunities upon the tendency of each age group to commute, while controlling for the residential distribution by age (by dividing A_{ij}^k by RLF_i^k). These effects can then be compared across the age groups. The model was also converted into log form as gravity models are usually expressed in that way in order to normalize the variables and to yield a linear model. However, somewhat better results were obtained and reported here for each age group with untransformed data. Comparison of the distance coefficients (which measure the extent to which commuting flows deteriorate with distance) yields interesting results.

The models were estimated separately for each age group and the results are given in Table 4. Though the $\bar{R}^2$ figures are low, there are 3966 degrees of freedom. Thus, all of the statistical prerequisites are met.

TABLE 4   GRAVITY MODEL RESULTS BY AGE, TORONTO CMA, 1971

Age Groups		WLF Coefficient	Distance Coefficient	$\bar{R}^2$	F-Statistics	The Size of the Population Sample
Group 1:	<20	0.41 (21.40)	−2.24 (−16.86)	0.15	359.93	64,331
Group 2:	20-29	0.54 (45.57)	−1.71 (−20.40)	0.38	1217.97	298,205
Group 3:	30-39	0.48 (39.92)	−1.64 (−19.30)	0.33	959.32	227,856
Group 4:	40-49	0.48 (37.98)	−1.69 (−18.90)	0.31	877.67	226,611
Group 5:	50-65	0.50 (36.84)	−1.77 (−18.61)	0.30	830.74	200,360
Group 6:	>65	0.43 (21.10)	−2.06 (−14.50)	0.14	318.32	20,232
All Age Groups		0.50 (40.68)	−1.74 (−20.06)	0.34	1003.46	1,037,595

Notes -- Values in parenteses are t-ratios.
    -- All coefficients are significant at the 99.5 per cent level.
    -- Number of observations for each age group (n) = 3,969.

Source: Based on 1971 Census place-of-work data, Statistics Canada.

An inspection of the results in Table 4 seems to indicate that the combined effects of the distribution of jobs and of distance differ according to age in important ways. Indeed, two main observations can be drawn from Table 4.

(a) The coefficients of WLF are highly significant with the expected sign in all cases and they provide a weight indicating the degree of inter-zonal commuting. These weights very strongly suggest a correspondence to age, and they may be interpreted as the tendency of an age group to interact between different zones, holding distance constant.

(b) Age has significant direct effect on a worker's *propensity to commute*. If we take the regression coefficients of distance at their face value, the effect of distance varies among the age groups, but contrary to expectations the friction of distance

does not change very much among age groups 2 to 5 (20-65 years). Comparing across the several age groups, we note that the negative distance coefficients for age groups 1 and 6 (under 20 and over 65) are higher than for the remaining groups. This suggests that these two age groups, holding the distribution of jobs constant, tend to travel shorter distances to work. This implies that they have a lower *propensity to commute*. Clearly, workers under 20 years of age (group 1) may well be less mobile in their job search because of greater reliance on public transportation and perhaps because they are less selective in their job choice, given inexperience in seeking and evaluating possible job options; on the whole, these factors would lead them to travel shorter distances. Workers over 65 years of age (Group 6) may also be less mobile for different, but expected, reasons; the reluctance of older workers to travel long distances to work is well documented. On the other hand, the distance coefficients for the remaining four age groups indicate that the propensity to commute is relatively higher for these groups, implying both a greater willingness and/or an ability to commute higher distances. Another explanation for these findings could be that non-job-related factors enter into residence location choices for the 20-50 age groups—*e.g.*, spouse's preferences, schooling for children, commitment to an area, *etc.*

VI. Conclusions

A worker's age appears to be closely related to the length of his or her journey-to-work. It was noted that the average commuting distance tends to increase from age 20-39 and to decrease thereafter. In the case of the youngest workers (under 20 years of age), one may also note the strong link between decentralized home and work locations which suggests, given the decentralized residential pattern of the principal parental age group (40-49), that they seek and establish jobs from a *fixed* residential location. The oldest workers, above 65 years of age, clearly reflect a relatively close matching of residence and job location as well. These two age groups, of course, are exceptional in that their need or ability to work may not be as crucial from a family support perspective as it is for individuals in the medium age groups, 2 to 5 inclusive.

The distribution of jobs has a significant influence on inter-zonal commuting for all age groups, holding distance constant. As well, the results clearly indicate the strong negative influence of commuting distance on the interaction between the zones for all age groups. Our analysis illustrates that, despite the fact that the medium age groups (2 to 5) have longer average commuting distances, the constraint to commuting posed by distance is most strongly felt by the youngest and oldest groups (1 and 6).

A priori, however, we anticipated that, *within* the age groups 2 to 5 (between 20 and 65 years of age) the propensity to commute might well vary. Despite variations in patterns of residence and job locations and journey-to-work distances among these four age groups, *no significant variation in the propensity to commute was found*. This finding has an interesting implication with respect to the changing age distribution of the work force in Canada. While the median age of the work force declined from 1961 to 1971 (Canada: 38.9 to 37.8 years; Toronto: 39.5 to 37.7 years) as a result of the coming onto the market of the leading edge of the post-war *baby boom* and the dramatic influx of relatively young immigrants during the pre-1970 period, this trend has reversed in recent years. In the coming two decades the work force will continue to age. Our findings suggest, therefore, that this trend towards a higher median age will not, over the next 20 years, impose serious additional constraints on urban planning and development through extended demands for accessibility nor, of course, will it reduce them.

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