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STUDY ON DAILY TRAVEL TIME : SOME EMPIRICAL FINDINGS AND ITS IMPLICATIONS

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Various studies have suggested that DTT(Total time spent on travel/person/day) can have variety of applications in travel forecasting & policy analysis, provided satisfactory & accurate forecasts of DTT can be made for the future. Some studies have also suggested that the average value of DTT at city level is very similar for a range of different cities. In this paper, using the city-level aggregate travel data of 131 Japanese cities from the Nation Wide Person Trip Survey 1987, we have tried to check the relationship between DTT and some commonly used measures of city-characteristics and travel conditions.

1. INTRODUCTION

The way people spend their 24 hrs on various daily activities has been of special interest to researchers from different fields of social sciences. Out of these 24 hrs, the time spent on travel (here-after called DTT (Daily Travel Time) has attracted considerable attention in transportation sciences. Various studies have suggested that DTT can be used and applied in a variety of ways for travel forecasting and policy analysis purposes (e.g. Zahavi's UMOT, Chumak, Chan & Ou, Tanner, Golob). Some of the models using DTT have been developed at city-level and have used a fixed (constant) value of DTT. They are based on the assumption that city characteristics and travel conditions have very little effect on the average value of DTT at city level. But, Is DTT, at city level independent of city characteristics ? or if not, What effect (if,any), city-characteristics have on DTT. This is the subject of this paper. The cross-sectional data from 131 Japanese cities from the Nation-wide Person-Trip Survey,1987 is used here. DTT is checked with respect to the following city-characteristics. (I) Population, Density(total & habitable), DID area. (II) Inflow & outflow population rate. (III) Car ownership & modal usage.

Keywords : *Daily travel time, City-characteristics, Travel forecasting, Nation-Wide Person-Trip Survey,1987.*

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2. CITIES TAKEN FOR ANALYSIS AND THEIR DTT

2.1 About the data : The data used here is from Nation-wide Person-Trip Survey, conducted in 1987 and covering 131 cities. A variety of cities are covered in the survey and offer a fair representation of Japanese cities. The data was collected through Home-interview survey for 360 households per city. The sample size is relatively small (esp for big cities).

2.2 Classification of cities and their DTT : Fig.1 & 2 shows the DTT(Gross, min) and Trip rate(gross) respectively on weekdays for all the 131 cities covered in the survey. From these figures & Table 1, it seems that there is large variation (cov 16%) in the average values of DTT esp. when compared with that of trip rate (cov 8%). The main reason for such large variation is not that different cities have quite different DTT but different types of cities (major metropolis, small cities, satellite/nuclear/central cities etc) are all grouped together. It is natural that such grouping of variety of cities will produce high variation and there is a need for classification of cities if meaningful relationships are to be found. Cities have been classified into the following two types.

3MMA CITIES : Cities belonging to the Three Major Metropolitan Areas (Tokyo, Osaka, Nagoya)- 3MMA (Total= 32 cities, shown by "+").

LOCAL CITIES : All other cities (Total= 99 cities, shown by "o").

From Fig 1 & Table 1, it can be seen that "3MMA cities" have higher DTT than "Local cities". The reason for such difference may be that 3MMA cities have high dispersion in land-use activities and quite different transport supply conditions. However, it is interesting to note that in case of "Local cities" the DTT's are quite similar. The coefficient of variation is quite low (cov 9%) comparable to that of trip rates (cov 8%). The rest of the analysis and conclusions drawn in this exercise are for Local cities.

TABLE 1 : Daily travel time/person & trip rate for different type of cities (Weekday)

TYPE OF CITY		No. of Cities	DTT (min)	TRIP RATE
3MMA CITIES (Tokyo, Osaka, Nagoya)	Central cities	3	68.3 (0.008)	2.742 (0.077)
	Surrounding Cities	29	73.2 (0.122)	2.540 (0.058)
Group Total		32	72.7 (0.117)	2.559 (0.063)
LOCAL CITIES	Populatin .> 400,000	18	59.3 (0.072)	2.647 (0.082)
	Other Cities	81	54.6 (0.088)	2.679 (0.079)
Group Total		99	55.5 (0.091)	2.673 (0.079)
GRAND TOTAL		131	59.7 (0.161)	2.645 (0.078)

( ) : Coefficient of variation

FIG 1 : DTT (min) FOR 131 JAPANESE CITIES
o : 3HHA CITIES; + : LOCAL CITIES

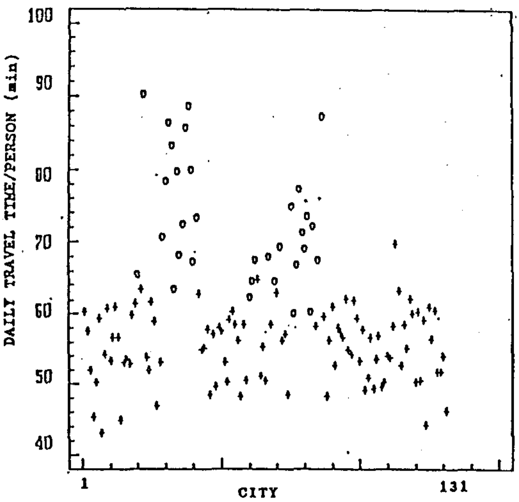


FIG 2 : TRIP RATE (gross) FOR 131 CITIES
o : 3HHA CITIES; + : LOCAL CITIES

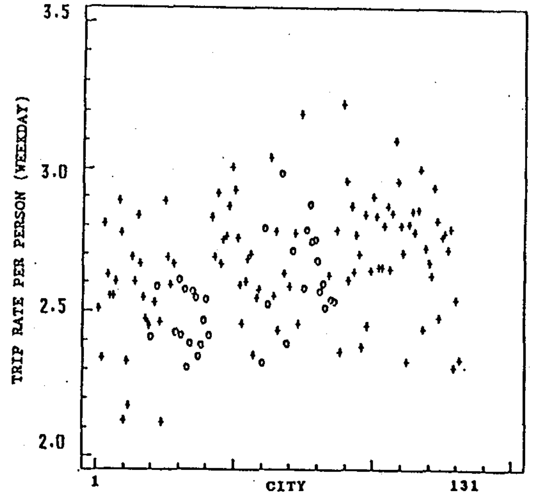


FIG 3A: DAILY TRAVEL TIME/PERSON (min)
vs POPULATION

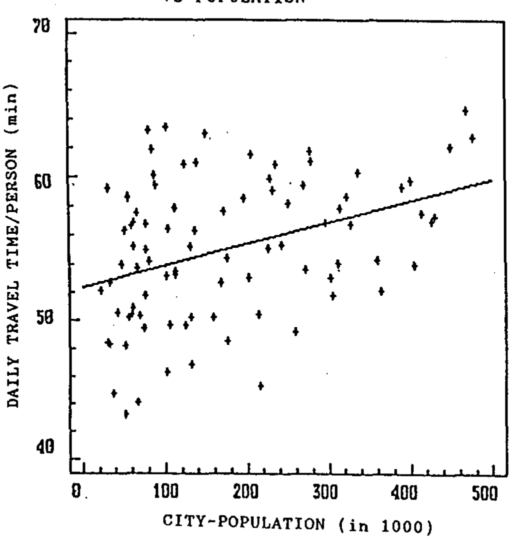


TABLE 2 : Daily travel time per person vs city population

CITY POPULATION	No. of Cities	DTT/person (min)
> 500,000	9	59.33 (5.24)
400,000 ~ 500,000	9	59.22 (3.37)
300,000 ~ 400,000	10	55.79 (3.11)
200,000 ~ 300,000	16	56.29 (4.87)
100,000 ~ 200,000	23	54.62 (4.92)
< 100,000	32	55.53 (5.06)
TOTAL	99	55.50 (5.04)

( ) : Standard Deviation

3. EFFECT OF CITY-CHARACTERISTICS ON DTT

Various studies have suggested that DTT can have variety of applications, provided satisfactory & accurate forecasts of DTT can be made in the future under changing city-characteristics and travel conditions. Some studies have also suggested that the average value of DTT at city level is very similar for a range of different cities. Here, we have tried to check the effect of some commonly used measures of city-characteristics and travel conditions. They are population, total & habitable density, DID area, inflow & outflow population rate, car ownership and trips made by cars & public transport.

3.1 Effect of City-population on DTT

From the fig 3A and Table 1&2, it can be seen that city population has an increasing effect on DTT (Correlation coefficient : $R^2 = 0.42$). Cities with similar populations may also have quite different travel conditions due to their locational status(e.g. satellite/internal cities). So, it was found that classifying the cities based on population alone is not sufficient in understanding their DTT. In order to capture the effect of the locational status of cities, the outflow population rate is used as proxy variable. Outflow rate is the % of resident population working/schooling outside the city. Satellite cities or cities near/well connected to other cities generally have high outflow rate (assumed here as greater than 10%, based on the planning data of the cities). Even after accounting for the locational status of the city, population have an increasing effect on DTT. However, cities with outflow population less than 10%, were found to have low DTT compared to cities with outflow greater than 10%.

Two additional groupings have also been tried.

(1) (IN & OUT) < 10% : When both, inflow rate & outflow rate is less than 10%. This is valid for those cities which are self-contained and have minimal influence of surrounding cities.

(2) (IN & OUT) > 10% : When both, inflow rate & outflow rate is greater than 10%. This is valid for those cities whose functional area greatly overlaps with that of surrounding cities (e.g. sub-center/internal cities)

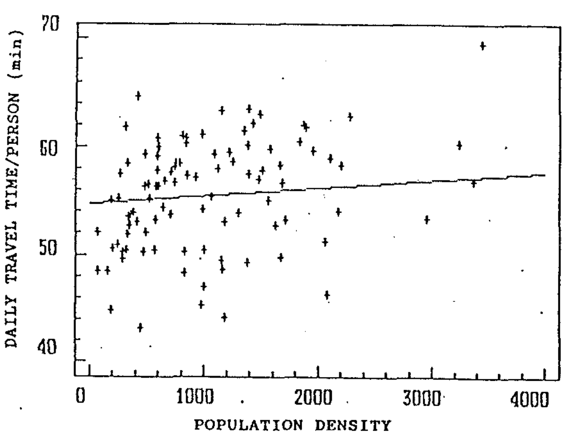
It can be seen from Table 3, that even after classifying cities based on their inflow & outflow population rates, the increasing effect of population on DTT remains. However, the cities with inflow & outflow rate less than 10% have lower DTT than other cities.

TABLE 3 : Daily travel time per person for different combinations inflow & outflow population.

CITY POPULATION	DAILY TRAVEL TIME/PERSON (min)			
	IN & OUT < 10 %	IN & OUT > 10 %	OUT < 10 %	OUT > 10 %
> 400,000	59.68 (1.96) [8]	- [0]	59.28 (4.27) [18]	- [0]
300,000 ~ 400,000	56.26 (3.53) [6]	- [0]	55.79 (3.11) [10]	- [0]
200,000 ~ 300,000	55.24 (5.57) [6]	59.03 (0.00) [1]	56.11 (4.99) [15]	59.03 (0.00) [1]
100,000 ~ 200,000	53.17 (4.21) [5]	56.48 (7.11) [5]	53.49 (4.05) [16]	57.22 (6.04) [7]
< 100,000	52.3 (4.68) [9]	55.26 (4.2) [16]	51.30 (5.09) [15]	55.5 (4.27) [17]
TOTAL	55.39 (4.77) [34]	55.71 (4.86) [22]	55.29 (5.16) [74]	56.13 (4.71) [25]

( ) : Standard Deviation
[ ] : Number of cities

FIG 3 : DAILY TRAVEL TIME/PERSON (min) vs POPULATION DENSITY



3.2 Effect of population density and DID area

The population density (total) have only a marginal effect (R^2=0.16) on DTT (Fig 3). This finding from Japanese cities is in accordance with the findings from U.K. cities (Ref.8). The habitable density (population / habitable area) and DID area, more appropriate measures of population concentration, have an increasing effect on DTT (R^2= 0.24 & 0.36 resp.)

FIG 4 : DAILY TRAVEL TIME/PERSON (min) vs HABITABLE DENSITY

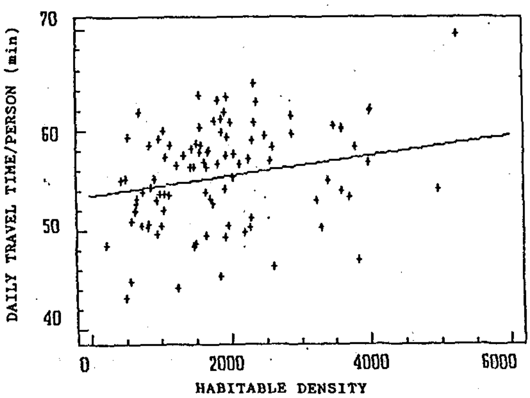


FIG 5 : DAILY TRAVEL TIME/PERSON (min) vs DID AREA

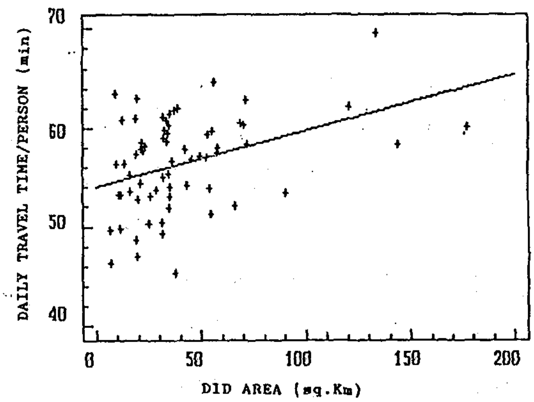


FIG 7 : DAILY TRAVEL TIME/PERSON (min) vs OUTFLOW POPULATION RATE

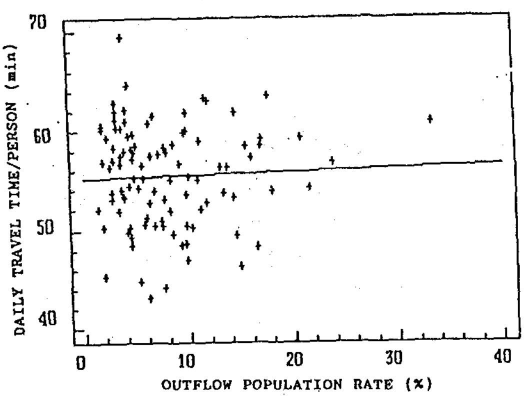
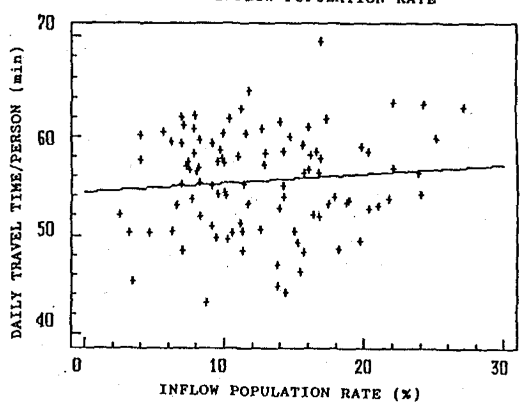


FIG 6 : DAILY TRAVEL TIME/PERSON (min) vs INFLOW POPULATION RATE



3.3 Effect of inflow & outflow population rate

Outflow rate is the % of resident population whose place of work/school is outside the city. It is a reflection of the dependency of the city on near-by cities. Outflow rate can also be high when the functional area of the city does not lie within its administrative area. It can be seen from fig 7 that outflow rate has almost no effect on DTT (R^2= 0.036).

Inflow rate is the % of population coming to a city for work/school. It is a reflection of the intensity of the economic activities in a city. Inflow population have very little effect (R^2=0.102) on DTT.

(The effect of various combinations of inflow & outflow rate by city population is discussed in section 3.1 & Table 3).

3.4 Effect of car-ownership & modal usage

Car-ownership : For estimating trip rates, it is an important explanatory variable even at aggregate levels (e.g. Perl & Chan, using aggregated data from 150 American cities have developed the following regression equation : T= 1.26+6.7x ; T=trips/household, x=car ownership). But in case of 131 Japanese cities car-ownership had no effect on DTT (R^2=-0.01) as well trip rates (R^2=-0.06). The insensitivity of car-ownership to DTT has also been confirmed by other studies.

Modal usage : Trips made by car have a marginal decreasing effect (R^2=-0.14) on DTT (Fig 8). However, the trips made by public transport(rail & bus) have an strong increasing effect (R^2=0.53) on DTT. This suggests that the supply of public transport is a crucial factor affecting the average value of DTT. The importance of public transport in affecting the DTT can also be seen from Fig.9 in which the increases in Total DTT are mainly due to increases in time spent on public transport.

FIG 8 : DAILY TRAVEL TIME/PERSON (min) vs CAR OWNERSHIP

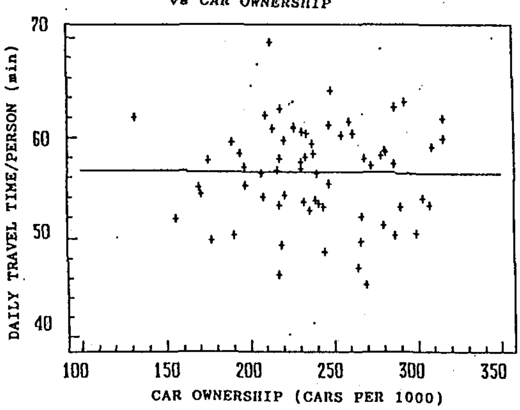


FIG 9 : DAILY TRAVEL TIME/PERSON (min) BY CITY-POPULATION & MODE +: Total; ^: Car; o: BUS

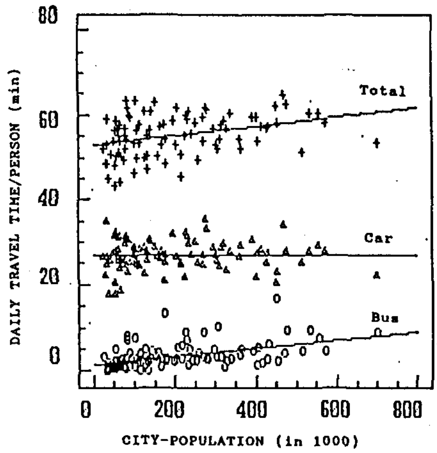


FIG 10 : DAILY TRAVEL TIME/PERSON (min) vs TRIPS MADE BY CAR

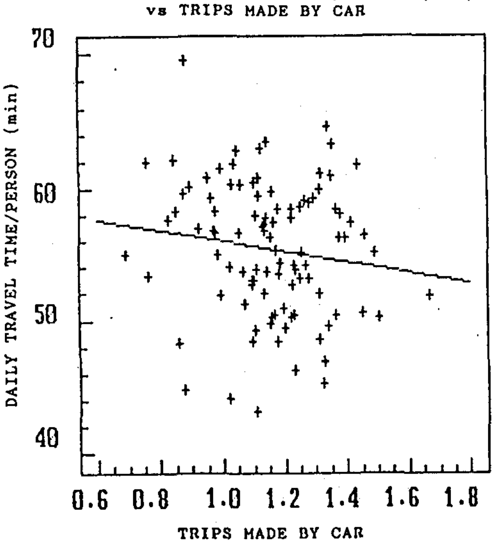
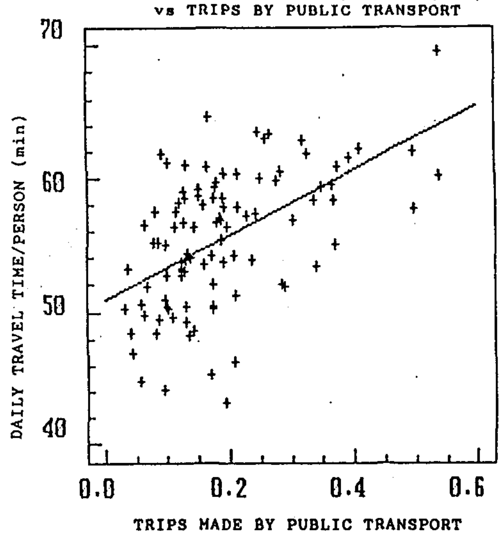


FIG 11 : DAILY TRAVEL TIME/PERSON (min) vs TRIPS BY PUBLIC TRANSPORT



4. CONCLUSIONS & POINTS FOR FURTHER STUDY

(1). The cities belonging to "3MMA" (i.e. Three Major Metropolitan Areas : Tokyo, Osaka, Nagoya) have high average value of DTT (Daily Travel Time/person) compared to "local cities". However, in case of local cities, the average values of DTT are very similar. The coefficient of variation is quite low (cov=9%) and similar to that of trip rates (cov=8%) [TABLE 1]. It remains a future task to explore the reasons why 3MMA cities have high DTT than "Local cities". This will in general, lead to better understanding of the DTT.

(2). In case of Local cities, it is found that the population size, density, DID area and the supply of public transportation have an increasing effect on DTT but car ownership and usage of cars (trips made by car) have no effect on DTT at city level.

(3). The present analysis is done at a highly aggregate(city) level, using cross-sectional data. But it is also well understood that socio-economic factors (age, sex, occupation, income, household structure, stage in life-cycle etc) may have strong effect on DTT. The analysis of DTT at individual level is a further point of study. The study of DTT using time-series data will further improve the understanding of DTT and need to be explored.

(4). In case of Local cities, the average values of DTT are very similar. Moreover, the city characteristics checked in the present analysis have either no effect or marginal & systematic effect on DTT. This suggest that satisfactory and accurate forecasts of DTT can be obtained for the future and thus can be used as an external input in travel forecasting.

5. REFERENCES

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