Variant Concept of Transportation-Disadvantaged: Evidence from Aydin, Turkey, and Yamaga, Japan

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Abstract: Transportation-disadvantaged groups have been defined in previous studies as those who are low income earners, are family dependent, have limited access to private motor vehicles and public transport services, and are obliged to spend relatively more time and money on their trips. Additionally the disabled, young, and elderly are commonly considered to be among the transportation-disadvantaged. Although generally this definition seems correct, it is not specific enough to become a universal definition that could apply to all urban contexts. This paper investigates whether perceptions of travel difficulty vary as does the definition of transportation-disadvantaged in socioculturally different urban contexts. For this investigation, the writers undertake a series of statistical analyses in a case study of Yamaga, Japan, and compare the findings with a previous case study, in which the same methodology, hypothesis, and assumptions were applied to a culturally and demographically different settlement in Aydin, Turkey. After comparing the findings observed in Aydin with the statistical analysis results in Yamaga, this paper reveals that there can be no detailed, universal definition of the transportation-disadvantaged. The writers conclude that the characteristics of the transportation-disadvantaged are not globally identical, and policies and solutions that work in one locality may not have the same results in another sociocultural context. **DOI: 10.1061/(ASCE)UP.1943-5444.0000044.**

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Introduction

In previous research undertaken by Duvarci and Yigitcanlar (2007) focusing on a case study in Aydin, Turkey, transportation-disadvantaged (TDA) groups were found to be primarily composed of people who were disabled, young, and elderly; who were low income earners; and who had no access or limited access to private motor vehicles, urban activities, and public transport services. Duvarci and Yigitcanlar (2007) indicated that people who were spending relatively more time and money for their trips might be classified as TDA. However, some people who appear to be transportation nondisadvantaged (TND), those who are spending less time and money because they have less mobility or have discomfort using public transport services, might also be experiencing some sort of disadvantage. These uncertainties create obscurity, especially when undertaking a comprehensive statistical analysis to determine TDA groups in a locality. This problem also causes difficulty in choosing a statistical method for analysis (i.e., regression, factor, or cluster analysis) and in deciding whether the indicator variables of TDA (e.g., accessibility and mobility) or the reason-based and disadvantage indicator variables of TDA (e.g., disability and car ownership) should be employed in the analysis.

The research reported in this paper is a follow-up to a previous case study on TDA for Aydin, Turkey (Duvarci and Yigitcanlar 2007). Adding to the previous study's findings, this research hypothesizes that the definition of TDA may change from one locality to another because of the different sociocultural settings of these localities. This is to say that perceptions, which are influenced by different social settings, can be different, and this may have an immense effect on the definition of TDA. The aim of this paper, therefore, is to test this hypothesis in two socioculturally distinctive case studies, which provides an opportunity for a comparative study to reveal the sociocultural differences in determining the characteristics of TDA.

Aydin, Turkey, was selected as the first case study for the comparative study, and the findings of this case were published in a previous issue of the *Journal of Urban Planning and Development* (Duvarci and Yigitcanlar 2007). For the second case study, Yamaga, Japan, was chosen because the Japanese cultural context is one of the more divergent of the world in both sociocultural (i.e., a developed country with rigid and strict obedience to sociocultural norms) and demographic (i.e., a superaged society) terms, and also it is also significantly different from the Turkish context (i.e., a rapidly developing country with a resilient and superyoung society). As the primary statistical method of this comparative study, a cluster analysis technique was used to determine both the TDA and the TND populations in the two case studies. Similar to the Aydin study, the Yamaga study's primary data for the analysis was collected through a household travel survey.

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Transportation-Disadvantaged

Many cities around the world, particularly those in North America and Australia, are plagued by car-oriented suburbanization, which is characterized by a low-density sprawl-like development, big retailers replacing corner shops, doubled-up distances to major local activities, and removal of public transport lines from the poor districts (Lucas 2006; Yigitcanlar et al. 2008). A development-segregated view of the urban space can have an even larger responsibility for the resulting appearance of the disadvantaged (Church et al. 2000). A poor local public transport system has a role in creating barriers for TDA or so-called socially excluded groups that have become more and more inaccessible (Hine and Mitchell 2003; Yigitcanlar et al. 2007). Hine and Grieco (2003) argue that a combination of poor accessibility with low levels of mobility and sociability intensifies TDA. In such circumstances, it is more important to provide assistance to the most vulnerable groups—the poor, elderly, and disabled—particularly in rapidly aging societies (Lucas 2006).

Differences in the age structure of developed and developing countries (i.e., the aging population of developed countries versus the younger population of developing countries) have a serious impact on the determination and perception of TDA. If TDA is not accurately determined, for example, elderly people can become more vulnerable and feel disadvantaged, insecure, and less supported because of the additional physical disabilities that they possess. Another important trend in aging societies, which affects the overall view of TDA, is senior citizens' driving behaviors (e.g., reduced driving skills and acuity problems). An increased safety risk exists when older people are driving, particularly in places with high concentrations of elderly people (Davidse 2006). Yet, for most of these people, no alternative travel modes are available unless special paratransit options are provided. On the contrary, because of the low income level and high concentration of young people, most of a developing country's TDA groups are heavily dependent on public transport. The public transport dependency of TDA is a widely discussed topic in the literature in both developed and developing country contexts (Litman and Colman 2001; Hine and Grieco 2003).

In recent years, a number of studies have been conducted to determine a TDA population more accurately. For example, Duvarci and Yigitcanlar (2007) sought the integration of TDA analysis with mainstream travel demand models by employing perceptional data, in which TDA could be neatly determined through a cluster analysis focusing on the community travel conditions in Aydin, Turkey. Some UK-based studies used accessibility measures to determine TDA (Church et al. 2000). For example, Schmocker et al. (2005) determined the trip-making characteristics of the elderly and disabled for four key-trip purposes by analyzing the 2001 London Area Travel Survey. Wu and Hine (2003) provided a classification for TDA by deprivation domains of income, employment, health, disability, education, geographical access to services, social environment, and housing. Church et al. (2000) defined seven basic TDA types: physical; geographical; exclusion from facilities; and economic-, time-, fear-, and space-based exclusions. Despite the growing interest in and literature about the recent call for governmental policy about social exclusion, such as in the UK [Social Exclusion Unit (SEU) 2001], both methodological and conceptual problems still exist in tackling the TDA issue comprehensively.

Almost all the widely accepted parameters in measuring TDA do not determine TDA populations accurately in every sociocultural context. For example, TDA may spend less time on and money for their trips because of their low mobility. Likewise, travel is assumed to be an impediment, which is true especially for work trips, and a cost to be reduced whenever possible (Salomon and Mokhtarian 1998; Ory and Mokhtarian 2005). Similarly, increasing leisure activities and the time allowed for such trips may not be considered costly, thus, accurately modeling leisure trips becomes more critical, especially for TDA groups. It is useful if TDA groups are determined for trip purposes (e.g., journey to work, school, shopping, and leisure). Inequity also arises between people who own a car and those who do not own or have access to a car. Yet the cost of driving in some developing countries (i.e., in Turkey) is quite high because of higher fuel prices and ever-increasing congestion. Owning a car does not necessarily make people TND in developing countries, which is not the case in the United States or in Australia, where driving is more affordable with lower fuel prices, cheaper cars, and poor and relatively costly public transport services. Additionally, peak-hour congestion is often perceived as the biggest problem, but the perception is relative and tolerance of the congestion changes from one culture to another and from metropolitan areas to remote settlements. Income levels may also influence difficulty perceptions. Moreover, even disabled or elderly people may feel nondisadvantaged, if they are provided with easy accessibility and mobility options.

TDA is a dynamic and multidimensional issue involving physical, temporal, economic, spatial, and psychological dimensions (Hine and Mitchell 2001; Schonfelder and Axhausen 2003). Because of the multidimensionality of TDA (e.g., accessibility, mobility, cost, comfort, and convenience), serious measurement and level of analysis difficulties arise (Yigitcanlar et al. 2007). Whereas most of the recent research managed to locate the problem and enrich the discussion and convergence successfully, they have failed to determine TDA accurately. As Cervero and Mason (1998) identified, travel behaviors may show a variety in different cultures and even from one TDA group to another because of the cultural significance of the issue. Thus, determination of TDA can be highly place-, culture-, and context-dependent.

Cross-Cultural Comparative Transportation Disadvantage Analysis

This research performed a comparative, cross-cultural study of two urban settlements (Aydin and Yamaga) and used the methodology described in Duvarci and Yigitcanlar (2007). As Duvarci and Yigitcanlar (2007) did, this research used a cluster analysis technique to clearly separate the population into two clusters (i.e., TDA and TND), on the basis of not only a single variable, but many. For both of the case studies, first, a generic TDA group was defined. Second, the distance or membership degrees of surveyed individuals, considering their demographic, socioeconomic, and travel characteristics, to this group's delimitation boundary, were measured. Third, as a result, a metric gauge was obtained to determine TDA accurately. The results of both case studies' findings are compared and discussed.

Case of Aydin, Turkey

The Aydin study was undertaken in 2005, and the findings of it were reported in Duvarci and Yigitcanlar (2007). The generic TDA definition used in the case study of Aydin was developed on the basis of the following factors: income, car availability, accessibility, demographic characteristics (i.e., age, gender, disability, family size, and structure), and the existing transportation service

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Table 1. Variables of the Aydin Study (Duvarci and Yigitcanlar 2007, ASCE)

Category	Category name	Notes
Acc. Lev.	Accessibility level	Determines accessibility of basic urban services and amenities
Com. Pub.	Comfort level of public transport	Determines passenger density and comfort conditions of public transport services
Com. Veh.	Comfort level of private motor vehicle	Determines private motor vehicle comfort levels
Cum. Imp.	Cumulative impediment	Determines the cumulative effect of basic travel impedance elements—This variable has two subvariables of travel time impediment (Imp. Tim) and travel distance impediment (Imp. Dis)
Edu. Lev.	Education level	Determines household education levels that reflect individual trip generation
Fam. Dep.	Economic dependency	Determines economic dependency levels of the family members that affect trip generation
Inc. Lev.	Income level	Determines individual income levels that affect trip generation
Mop. Imp.	Mode and peak impediment	Determines combined effects of mode and peak captivity together with an emphasis on the disabled population
Ptr. Imp.	Public transport impediment	Determines public transport service, both quality and quantity, conditions
Sch. Trp.	Journey to school	Determines travel quality and conditions to and from school for students
Veh. Ava.	Motor vehicle availability	Determines the number of people with no access to motor vehicles
Trp. Fre.	Trip frequency	Determines the frequency of all trip types, i.e., commuting, education, leisure, health, and social

and facilities (i.e., frequency and quality). The variables employed to determine TDA in the Aydin study are summarized in Table 1.

The model developed for the Aydin study was capable of precisely determining the trips of the TDA by multivariate modeling using the knowledge derived from the differences between the TDA and TND. The pilot study revealed that travel patterns could be accurately determined through the steps of this model, the TDA concentrations could be geographically determined, and the degrees and the types of disadvantages could be defined straightforwardly (Duvarci and Yigitcanlar 2007).

Case of Yamaga, Japan

Yamaga is a town located within the Kumamoto prefecture, about 25 km north of Kumamoto on Kyushu Island, Japan, with a population of almost 60,000 people, a total area of about 300 km^2, and a population density of approximately 200 persons/km^2. Currently, females make up 53% of the population, and the average household size is 2.8 persons with a slow annual gradual decrease. Yamaga is one of the regional cultural and natural attraction locations in the Kumamoto prefecture and is known for its famous traditional theaters and various hot spring baths. Yamaga was chosen for this case study for several reasons. First, it is a content town very close to Kumamoto University and has quite a large number of elderly and typical TDA populations. Second, it was chosen for its suitability for examining TDA groups in a locality with sociocultural characteristics different from those of Aydin. Last, Yamaga was chosen for this case study because of the opportunity to use the data from a recently conducted 2008 household travel survey.

Generally in Japan, and particularly in Yamaga, people do not suffer adversely from the negative impacts of transportation systems (e.g., poor public transport services, low accessibility levels, or inefficient transportation infrastructure). The primary problem is the inadequate space allocation for pedestrians, cyclists, and even cars (e.g., narrowness or absence of streets, footpaths, bikeways, and parking lots). Interviews with the residents of Yamaga revealed that most of the population is happy with what is provided, and seems to be not bothered much by the aforementioned inefficiencies. This is probably attributable to cultural reasons (i.e., a noncontentious, respectful, and patient people), which is an indication that the TDA concept is perceived significantly differently in Yamaga than in Aydin.

Japan is a superaging society, with those aged 65 and older composing 21% of the current population and projected to become 25% of the population in 2013; about one-third of the society will be older than 75 in 2050 [National Institute of Population and Social Security Research (NIPSSR) 2007]. In addition to having a superaging population, Yamaga has a strong economy and technology-driven way of life and does not have the transportation infrastructure and service problems observed in Aydin. Many public transport facilities are provided for the elderly and disabled. In most places, traffic is guided through intelligent transport systems, and public transport always has priority over private motor vehicles Yamaga's primary transportation-related problem originates from the lack of space, which results in narrow roads without separate bike lanes. However, cultural norms in Yamaga do not allow intolerance or the showing of explicit anxiety, and because it is a patient, understanding, and respectful society, perceptions of transportation difficulty in Yamaga are significantly different from in Aydin. Such strong cultural qualities and peculiarities make Yamaga a very interesting case study to compare with the previous study of Aydin.

Data

Secondary data was collected from the Transport Department, Census Bureau, and Kumamoto University. The primary data for the Yamaga case study was collected by using semistructured interviews and a household travel survey. Interviews were conducted with experts and residents to ensure a broad understanding of how TDA was generally perceived in Yamaga. A household travel survey was also undertaken, as in the Aydin case, to collect data to calculate a spatial analysis model to determine the TDA populations. Of 655 household surveys in Yamaga, 335 of them had reliable responses that met the sampling ratio target of 1% for a disaggregate data analysis. About 45% of the surveyed population were male and 55% were female. Nearly 6% of the population was under the age of 18, 65% was between 18 and 65, 19% was between 65 and 75, and 10% was older than 75. Survey data described the typical profile of the Japanese demographic structure, indicating a superaging society (i.e., 29% of Yamaga residents are older than 65) in which 75% of them had a valid driving license. Salient travel characteristics for Yamaga in nine categories of trip purposes and their differences by mode choice, which have a significant impact on the definition of having a disadvantage, are included in Table 2. In modal choice, car use, together with the mode of

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Table 2. Salient Travel Characteristics of Yamaga by Trip Types

	Commuting	Business	Daily shopping	Weekly shopping	Doctor's surgery	Hospital	Social visits	Leisure	Sightseeing
Time (min)	21.2	25.5	11.8	35.25	13.47	59	23.1	52.2	78.38
Distance (km)	9.67	15.6	4.87	18.5	6.07	30.4	11.78	29.52	63.47
Mode (%) car driver	74	87	78.9	81.6	74.6	81.2	79.2	80.1	74.8
Mode (%) car passenger	5	5.3	9	13.5	10	15	9.1	12.5	16.9
Mode (%) taxi	1.2	0	0	0	1.2	0	1	0	2.9
Mode (%) public transport	3.7	0	0	3.3	0	2.5	2.4	5.9	4.7
Mode (%) walking and cycling	15.7	7.5	12	1	13.7	0	8.3	0	0

car passengers, were dominant in Yamaga; public transport and taxi modes were negligible for such a small town, and not surprisingly, walking and cycling modes were quite popular. The use of the public transport and walking and cycling modes seemed to indicate variations in different trip purposes. Interestingly, the public transport mode was the preferred mode for both commuting and social-recreational activities, whereas it was not the case for business, shopping, or health-related trips. Similarly, there was a large difference observed between daily and weekly shopping trips for the walking and cycling modes, although walking and cycling were not the preferred modes for leisure and sightseeing trips. Travel time also fluctuated by the purpose of the trip.

Surveyed household size was around 2.2 persons, of which only seven-year-olds and older were surveyed. Trip rates for each day of the week were observed as: Monday 1.25, Tuesday 1.20, Wednesday 1.25, Thursday 1.23, Friday 1.25, Saturday 1.32, and Sunday 1.22. The overall distance traveled and the travel time averages of all trip purposes were 21.1 km and 35.2 min, respectively, yet they were not weighted with the trip frequencies for each trip purpose. The following number of individual observations were evaluated for each trip purpose: 81 business trips ($81/335 = 24\%$ of all trips), 106 commuting trips (31%), 162 doctor's surgery trips (48%), 87 hospital trips (26%), 182 daily shopping trips (54%), 155 weekly shopping trips (46%), 102 leisure trips (30%), 152 social visit trips (45%), and 98 sightseeing trips (29%). Shopping and social and recreational trips constituted for more than half (61%) of all trips (Fig. 1).

Methodology

Because the Yamaga study aims to examine whether the findings of the Aydin study are applicable elsewhere and whether the structure of the TDA definition is variant from one culture to another, the Yamaga study adopts the same methodology as the Aydin study, which is a sophisticated clustering technique. Cluster analysis is a statistical technique that is used for grouping similar cases (i.e., TDA and TND). Clustering algorithms are methods to divide a set of observations into groups so that the members of the same group are more similar to one another than they are to the members of a different group (Ripley 1999; Hauser et al. 2000). Cluster analyses are used to divide the population on the basis of the nearest neighbor rule. All variables and value scales are assumed to have equal weights in the clustering process and all variables are assumed to be scaled so that the downward values represent TDA and the upward values represent TND. Cluster center values indicate the total central value of all values measured, in Euclidian terms, per each cluster for all variables and concerning all values assumed in the clustering process. Thus, the distance between the two cluster values shows the severity of disparity between the clusters and the severity of having a disadvantage. This method uses K-means type clustering.

The Aydin study enabled a clear definition of two distinct clusters by K-means cluster analysis with positive sign direction assumptions of variables. The Yamaga study, by using the same method, determined whether the same technique and assumptions were applicable in a culturally different setting. Thus, the same type of data used in the Aydin study was collected and clustered for the Yamaga study, and the results were analyzed to determine whether the same type of clustering, K-means, yielded a clearly defined TDA. Additionally, different types of trip purposes were also compared.

The clustering method was analyzed with *SPSS* software (*SPSS Statistics 19.0.0* 2010) with no threshold values introduced. Prior to the cluster analysis, all variables were converted to rate values between 0 and 1 in a value standardization process by using the sigmoid function for noncategorical data. Calculations to determine the usual conversion function for variables were

$$z = (x_i - x_{\min})/(x_{\min} - x_{\max})$$

where z = the standardized value between 0 and 1; x_i = any observation value to be standardized; and, $x_{\min} - x_{\max}$ = the difference between minimum and maximum values in the data set of the variable.

Some categorical or Likert scale value standardizations (e.g., car ownership, mode captivity, trip frequency, satisfaction, and comfort-safety variables) do not require a sigmoid function but a direct conversion from a categorical value assignment. A conversion example of a weekly trip frequency is as follows:

$z = 0.01$ (for 0 can not be used) if t (trip rate) $= 0$ (category 4)

$z = 0.33$ if $t = 1$ trip in a week (category 3)

$z = 0.67$ if $t = 2$ or 3 trips in a week (category 2)

$z = 1$ if $t =$ at least 1 trip everyday (category 1)

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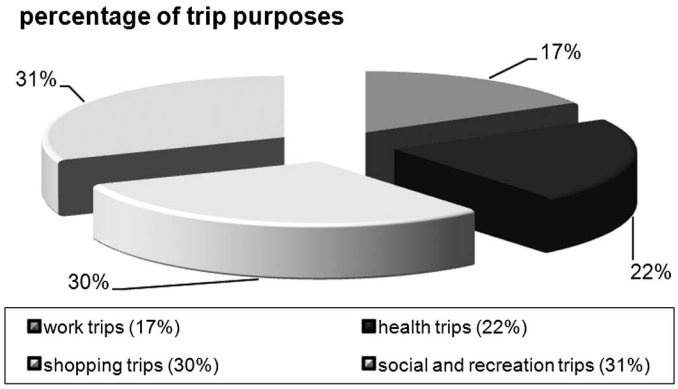

Fig. 1. Percentages for major trip purposes in Yamaga

Different from the others, the mode captivity index value determination is prepared by considering all trip purposes rather than calculating each trip purpose separately. An example is as follows:

$$z = u_p/u_k$$

where u_p = the choice of public modes (e.g., public transport, and walking and cycling options combined) for all purposes of a person's weekly trips; and u_k = the total of all modes used for all trip purposes.

The positive utility sign assumption setting is a key step before the clustering process commences. Therefore, in a sound, multivariate clustering procedure, it is important to decide which variables represent a positive meaning when their observation values increase, and which others represent the negative. For the positive direction, negative variables should be converted to positive simply by subtracting the values from 1. In the Yamaga study, the directions for each variable were accepted as defined in the Aydin study.

Before the clustering process, as an important step, 335 observations were analyzed for each trip purposes. Only those having trips clearly for the purpose concerned (e.g., 106 observations were for commuting trips) were considered for one cluster analysis, then other cluster analyses were conducted consecutively for the other trip purposes (e.g., sightseeing trips).

Cluster analysis accommodates a number of variables to identify the disadvantaged population, and in a comparative study, using the same variables is important. The Yamaga study, therefore, used eight of the 12 variables of the Aydin study in determining TDA, which is necessary to determine whether different local and cultural settings made a difference in identifying TDA populations (Table 3). However, as the literature suggests, criteria or variables used in one place may not necessarily be applicable elsewhere because of the specific sociocultural and economic conditions of each community and location. Therefore, the sociodemographic indicators of the Aydin and Yamaga studies were not assumed to be variables in measuring disadvantages; they were considered as the dimensions of TDA rather than the core factors. Only eight variables were used to compare both case studies. TDA was defined as a multifaceted term in the Aydin study; that is, TDA can be determined by entering simultaneous input of various measurable criteria in a cluster analysis model. The subsequent section details the Yamaga case study and the study methodology. For more information about the Aydin case study, see Duvarci and Yigitcanlar (2007).

In the cluster center results, those downward values (i.e., those approaching 0) indicated disadvantage. For example, calculations for the values of family dependence included the total number of older (i.e., those older than 65) and younger (i.e., those younger than 7) people. As the number of family members from these two age groups increased, indicating a clear disadvantage, it would be considered an upward value for these indexes. Therefore, the value needed to be converted to upward utility values (i.e., those approaching 1) by subtracting the value from 1. The standardization of values conversion was necessary for a sound clustering process. The calculations were for six variables; those approaching a value of 1 indicated a nondisadvantage, and those approaching 0 indicated a disadvantage. The remaining variables of comfort- and satisfaction-related variable results were already upward utility values; therefore, there was no need for a conversion.

As shown in the cluster center results of the Aydin study in Table 4, the variable cluster center values were in accordance with their utility sign assumption settings: low values appear in the left column, and high values appear in the right column in a scale bar of 0–1. Thus, in the Yamaga study, similar assumptions for each variable are made as follows:

Table 3. Variables of the Aydin and Yamaga studies

Variables of the Aydin study	Variables of the Yamaga study	Notes
Fam. Dep.	Family dependence	Aydin and Yamaga studies employ the same family-dependence variables
Veh. Ava.	Car availability	Aydin and Yamaga studies employ the same car-availability variables
Mop. Imp.	Mode captivity	Aydin and Yamaga studies employ the same mode-captivity variables
Ptr. Imp.	Satisfaction	Aydin and Yamaga studies employ the same trip-satisfaction variables
Trp. Fre.	Trip rate	Aydin and Yamaga studies employ the same trip-rate variables
Cum. Imp. (Imp. Tim.)	Time	Travel-time impediment subvariable of Aydin's cumulative-impediment variable and Yamaga's travel-time variable are equivalent variables
Cum. Imp. (Imp. Dis.)	Distance	Travel-distance impediment subvariable of Aydin's cumulative-impediment variable and Yamaga's travel-distance variable are equivalent variables
Com. Pub. and Com. Veh.	Comfort	As the Comfort variable of the Yamaga study concerns both public transport Com. Pub. and private motor vehicle Com. Veh. comfort levels, both Aydin and Yamaga studies employ the same travel comfort variables
Acc. Lev.	—	A variable indicating accessibility levels was not employed in the Yamaga study
Edu. Lev.	—	A variable indicating education levels was not accommodated in the Yamaga study
Inc. Lev.	—	A variable indicating income levels was not accommodated in the Yamaga study
Sch. Trp.	—	A variable indicating school trip levels was not accommodated in the Yamaga study

- *Family dependence*: Family dependence data showed a downward value for the Yamaga residents by approaching 0, indicating disadvantage or TDA concentration. As Fujii et al. (1999) stated, elderly and young people potentially create a mobility dependence on the other members of the family, and a lower level of mobility. Therefore, the variable values for family dependence must be subtracted from 1 to convert them into upward values indicating nondisadvantage.

$$z_i = 1 - [(n_o + n_y)/n_h]$$

where z_i = the scaled and sign-converted value for the ith person; n_o = the number of elderly (i.e., older than 65 yr old); n_y = the number of young (i.e., younger than 7 yr old); and n_h = the household size.

- *Car availability*: Those who do not have access to a private motor vehicle are most likely disadvantaged. Therefore, it is expected that the first cluster's center values would be greater than the second cluster's center results. Categorical data values are converted as

$$z_i = 1 - x_i^s \qquad \begin{cases} x_i^s = 0.16, & \text{if } x_i = 1 \quad \text{(survey data value for having a car each)} \\ x_i^s = 0.5, & \text{if } x_i = 2 \quad \text{(survey data value for having a car in the family)} \\ x_i^s = 0.83, & \text{if } x_i = 3 \quad \text{(survey data value for not having a car)} \end{cases}$$

where x_i^s = the scaled data value; and x_i = the raw survey data (i.e., the categorical value).

- *Time*: Travel time is generally accepted as an impediment factor, although not necessarily for leisure trips. Therefore, the value obtained from the raw survey data was subtracted from 1 to be converted into an upward value. Open-ended values were converted as

$$z_i = 1 - x_i^s \qquad x_i^s = (x_i - 1)/(90 - 1) \qquad (x_{\max} = 90 \text{ min})$$

- *Distance*: Similar to travel time, distance traveled is also considered to be an impediment, but in some cases, it is also an indicator of being nondisadvantaged. This causes a problem in defining the direction sign for trip distances. Hence, obtained data results were subtracted from 1. Open-end values were converted as

$$z_i = 1 - x_i^s \qquad x_i^s = (x_i - 1)/(50 - 1) \qquad (x_{\max} = 50 \text{ km})$$

- *Mode captivity*: Mode captivity values did not need conversion because they already had values close to 1.

$$z_i = (n_p/n_a)$$

where n_p = the total of all public modes chosen by trip purposes; and n_a = the number of all modes chosen. If private modes were chosen for all trip purposes, a value of 0.01 was assigned instead of 0 for the ease of calculation.

Table 4. Variable Cluster Center Values of the Aydin Study (Duvarci and Yigitcanlar 2007, ASCE)

	Cluster's center values	
	1	2
Acc. Lev.	45.88	**50.48**
Com. Pub.	68.17	**68.47**
Com. Veh.	37.59	**38.41**
Cum. Imp.	**86.51**	85.05
Fam. Dep.	58.53	**64.81**
Edu. Lev.	36.68	**43.41**
Inc. Lev.	9.43	**18.63**
Mop. Imp.	73.40	**73.94**
Ptr. Imp.	95.89	**96.07**
Sch. Trp.	63.78	**69.70**
Veh. Ava.	6.37	**54.73**
Trp. Fre.	29.69	**41.11**

- *Trip rate*: The number of trips or average trip frequency throughout the week did not need a positive sign conversion, because it already had higher values. Categorical data values were converted as

$$\begin{cases} x_i^s = 0.01 \quad \text{(instead of 0)} & \text{if } x_i = 0 \quad \text{(no trip)} \\ x_i^s = 0.33 & \text{if } x_i = 2 \\ x_i^s = 0.67 & \text{if } x_i = 3 \\ x_i^s = 1 & \text{if } x_i > 3 \end{cases}$$

- *Satisfaction*: General transportation system satisfaction perceived before commencing travel, such as convenience, reliability, and system quality, required conversion. Categorical data values were converted as

$$\begin{cases} x_i^s = 0.0834 \quad \text{if } x_i = 1 \quad \text{(highly dissatisfied)} & x_i^s = 0.417 \quad \text{if } x_i = 3 \\ x_i^s = 0.251 \quad \text{if } x_i = 2 & \\ x_i^s = 0.583 \quad \text{if } x_i = 4 & x_i^s = 0.75 \quad \text{if } x_i = 5 \\ x_i^s = 0.917 \quad \text{if } x_i = 6 \quad \text{(highly satisfied)} & \end{cases}$$

where x_i^s values = the mean values for each category between 0 and 1.

- *Comfort*: The travel comfort perception usually refers to the comfort and quality levels of in-vehicle and travel conditions. Similar to the transportation system satisfaction, travel comfort requires conversion. The standardization process of the values for comfort is identical to the transportation system satisfaction's process.

In the Yamaga study, four basic trip purposes, each having a major (e.g., hospital trips) and a minor (e.g., doctor's surgery trips) activity, were analyzed: work-related trips consisted of commuting and business trips; health-related trips consisted of doctor's surgery and hospital trips; shopping-related trips consisted of daily and weekly shopping trips; and recreational trips consisted of leisure, social visit, and sightseeing trips.

The Aydin study accommodated 12 variables (see Table 1) whereas the Yamaga study employed only eight variables to determine TDA populations. All the variables used in the Yamaga study were identical to the equivalent variables in the Aydin study, and only these eight variables were used for the comparison. For example, the Family Dependence variable in the Yamaga study was same as the Fam. Dep. variable in the Aydin study. Similarly the Car Availability variable in Yamaga was same as the Veh. Ava. in Aydin, and so on. The travel time impediment subvariable

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in the Aydin study's cumulative impediment variable and the Yamaga study's travel time variable were equivalent variables. In the same way, the travel distance impediment subvariable of the Aydin study's cumulative impediment variable and the Yamaga study's travel distance variable were equivalent variables. Only the Comfort variable of the Yamaga study, because it includes both public transport and private motor vehicle comfort dimensions, was equivalent to the two variables of the Aydin study, Com. Pub. and Com. Veh. Four of the variables of the Aydin study were not adopted by the Yamaga study, Acc. Lev., Edu. Lev., Inc. Lev., and Sch. Trp. for the reasons explained previously (see Table 3).

Variables of the analysis worked efficiently to determine the disadvantaged cluster. For example, the interdependence of household members (i.e., Fam. Dep. in the Yamaga study and Family Dependence in the Aydin study) to each other attributable to their demographic status (i.e., those who have children, the elderly, and the disabled) was very critical in organizing daily trips. The daily travel pattern of members of a family became severely dependent on each other, especially children depending on their parents not only from an economic but also from a mobility angle. This was clearly verified in the Srinavasan and Ferreira study (2002) which scrutinized a transport survey analysis of almost 4,000 households in Boston. According to Srinavasan and Ferreira, children and the number of workers in a household did affect the mode choice.

The generalized cost was the most important determinant for TDA and was usually considered as a key factor with the distance (i.e., accessibility) to a car park for car users or to a bus stop for public transport users. According to a 2007 National Center for Transit Research report, huge differences are evident in distance according to the differences in urban size, ethnicity, income, and car ownership, which are key to determine TDA groups. For example, fewer than 40% of Americans have access to public transport services within a quarter-mile walk from home, making a significant impact on their modal choice. The time cost is generally the summation of the access to a stop or a car park whereas walking, the waiting time at a bus stop, and travel duration or access time to a destination. In the Aydin study, the generalized cost Cum. Imp. was not an effective divider between the two clusters, nor was mode and peak captivity with an emphasis on the disabled or the elderly. Public transport and peak captivity may be added to disadvantage variables because one's dependency on a single mode of transportation and travel time affects travel quality. Peak-hour congestion adversely affects both public transport users and car drivers but not equally (Downs 1992). Personal disabilities and weaknesses are the magnifiers of the level of disadvantages of those peoples' travel experiences rather than separate factors, per se. The demographic dimension also adds to this as the number of disabled and elderly people is increasing throughout almost all nations (Blaser 1996; Deakin 2003).

When the results of the clustering analysis of the Aydin study were examined (see Table 4), it was evident that the disadvantaged cluster center values were less than the nondisadvantaged cluster's, with an exception for the cumulative impediment variable Cum. Imp. showing the generalized travel costs for individuals. Therefore, contrary to what was hypothesized, a TDA group is not necessarily disadvantaged in all categories. It was for only three variables that significant differences were observed: vehicle availability Veh. Ava., income Inc. Lev, and education level Edu. Lev. For the remaining variables, the difference between the two cluster center values was negligible, and as hypothesized, the disadvantaged cluster had lower center values, which shows the robustness of the methodology.

Comparison of the Aydin and Yamaga Case Study Findings

The cluster center results of the Aydin study indicated that the second cluster center values compared to the first cluster became almost always greater, with the one exception of the cumulative impediment variable (see Table 4). Car availability, income, accessibility, and education levels played an especially crucial role in the formation of two distinct clusters (Cluster 1 and Cluster 2). That is to say, there was a clear distinction between these two clusters, except what was obtained from the obligatory trips (i.e., journey to work and school) in the Aydin case.

Contrary to the case of Aydin, the Yamaga case findings provided very different cluster center results, which is an unclear distinction between the two clusters. However, in Yamaga, if the utility directions for each variable were differently hypothesized, then the results may have provided two distinct clusters. But, under either circumstance, profiles of the TDA would be different for Aydin and

Table 5. Yamaga Work-Related Trips Cluster Center Results

	Business trip clusters		Commuting trip clusters	
	1	2	1	2
Family dependence	**0.76**	0.43	0.71	**0.72**
Car availability	**0.77**	0.60	**0.77**	0.63
Time	0.83	**0.92**	0.60	**0.91**
Distance	0.85	**0.95**	0.67	**0.94**
Mode captivity	**0.96**	0.70	**0.88**	0.73
Trip rate	0.65	**0.82**	0.92	**0.94**
Satisfaction	**0.47**	0.29	**0.50**	0.17
Comfort	0.60	**0.79**	**0.65**	0.24

Table 6. Yamaga Shopping-Related Trips Cluster Center Results

	Local shopping trip clusters		Weekly shopping trip clusters	
	1	2	1	2
Family dependence	0.39	**0.64**	0.60	0.60
Car availability	0.42	**0.75**	0.47	**0.74**
Time	**0.90**	0.89	0.67	**0.72**
Distance	**0.96**	0.89	0.76	**0.78**
Mode captivity	0.16	**0.93**	0.12	**0.93**
Trip rate	**0.75**	0.74	0.45	**0.54**
Satisfaction	0.34	**0.39**	0.57	0.57
Comfort	**0.72**	0.70	**0.64**	0.55

Table 7. Yamaga Health-Related Trips Cluster Center Results

	Doctor surgery trip clusters		Hospital trip clusters	
	1	2	1	2
Family dependence	0.38	**0.62**	0.34	**0.81**
Car availability	0.41	**0.75**	0.59	**0.78**
Time	**0.90**	0.86	0.51	**0.56**
Distance	**0.93**	0.85	0.48	**0.54**
Mode captivity	0.13	**0.92**	**0.86**	0.79
Trip rate	**0.48**	0.42	**0.33**	0.14
Satisfaction	0.29	**0.38**	**0.49**	0.38
Comfort	**0.71**	0.62	**0.49**	0.39

Table 8. Yamaga Leisure-Related Trips Cluster Center Results

	Leisure trip clusters		Social-visit trip clusters		Sightseeing trip clusters	
	1	2	1	2	1	2
Family dependence	**0.64**	0.50	0.47	**0.65**	0.63	**0.65**
Car availability	**0.74**	0.43	0.42	**0.75**	**0.73**	0.54
Time	0.65	**0.74**	0.83	**0.85**	**0.59**	0.56
Distance	0.69	**0.81**	**0.84**	0.83	0.91	**0.94**
Mode captivity	**0.91**	0.18	0.15	**0.93**	**0.93**	0.14
Trip rate	0.39	**0.40**	0.40	**0.45**	**0.45**	0.31
Satisfaction	0.52	**0.68**	**0.71**	0.65	0.57	**0.67**
Comfort	0.57	**0.73**	**0.68**	0.61	0.55	**0.68**

Yamaga because of their contradictory sociocultural contexts. When the findings listed in Tables 5–8 were analyzed, sometimes Cluster 1 and sometimes Cluster 2 behaved like TDA depending on the particular variable's cluster center results. In these tables, bold figures indicated higher values than the other cluster's values, and underlined figures indicated distinctly separated values. The behavioral shift between the two clusters was a polar shift, which creates ambiguity and does not clearly explicate distinctly separated clusters (i.e., TDA and TND). Even when the obligatory trips (i.e., journey to work and school) of the Yamaga study were compared with those from the Aydin study, no resemblance between the two could be observed.

The following observations and findings from the Aydin and Yamaga case studies are worth mentioning:

- In daily shopping and work-related trips, especially in the cluster's center results of mode captivity and car availability variables, vast differences were observed. A polar shift occurred between the two clusters (i.e., higher values appeared in the second cluster).
- Those who were dependent on public modes were found to be more disadvantaged in work, shopping, and school trips. However, disadvantages could vary by trip purposes. For example, disadvantage from mode captivity appeared in the first cluster for work-related trips, whereas the same kind of disadvantage appeared in the second cluster for shopping-related trips.
- The mode captivity variable was dominant in distinguishing two clusters, but many times, polar shifting of the clusters was necessary.
- The satisfaction variable was the indicator in which vast differences were measured in work-related trips.
- For health-related trips, equivocally family dependence and car availability variables were the primary reasons for the large differences.
- Family dependence requires scrutinized trip planning at the household level, and played a crucial role in timely access to health facilities. Access to a car was considered a better option for urgent health-related trips.
- In social and leisure trips, mode captivity played a key role. Polar shifting of the clusters was necessary for social visits and leisure trips when using satisfaction, comfort, and mode activity variables.
- Variables, such as trip rate, in hospital, and sightseeing trips, and time and distance in commuting trips, were not significant dividers but only showed discernible differences between the two clusters.

Aydin's clustering was only calculated for work trips and hence, only compared to the work-related trips of the Yamaga study. The cluster center values for the eight variables for both Aydin and Yamaga show large variations (see Tables 4 and 5). The mode captivity for the Yamaga study seemed to be an especially important divider between TDA and TND, whereas this was not the case for the Aydin study. In the Aydin study, the comfort variables of Com. Pub. and Com. Veh. and their TDA cluster center values did not differ clearly from TND, whereas this observation was opposite for the Yamaga study. There was not much difference in all impediment variables (i.e., Cum. Imp., Mop. Imp., and Ptr. Imp.) between the two clusters for the Aydin study, whereas there were considerable differences for time and distance, mode captivity, and satisfaction in the Yamaga study. The clustering results of car availability showed similar significant differences between the two clusters in both Aydin and Yamaga.

Contrary to Aydin, in Yamaga, people feel more disadvantaged by driving a car than by using a form of public transport, primarily because public modes are more convenient for work-related trips in Yamaga. Generally passengers in Yamaga find public modes much safer, less costly, and more comfortable. However, not having access to a car in health-related and shopping trips was a disadvantage. In weekly shopping trips, there was a clear distinction between the two clusters.

The results of the research reported in this paper reveal that the hypothesis was verified, as the clustering findings in the Yamaga study were quite different than the findings in the Aydin study. In contrast to Yamaga, in Aydin, two clusters (TDA and TND) were determined discretely. The findings for the Yamaga study did not indicate two significantly separated clusters, and thus, a clear determination of a TDA group was not possible despite the use of the same variables in both studies. TDA seemed so variable, hence, it could not be said that TDA could clearly be determined in every sociocultural context by using the same variables and methodology because the observed TDA definitions needed to be local and case-specific as proved in this cross-cultural comparative study.

Conclusion

The literature indicates that it is not possible to develop and implement policies to solve acute problems of disadvantage, unless TDA groups are clearly determined. This paper, therefore, examined a statistical model used to determine TDA in Aydin in trying to determine TDA in the different sociocultural environment of Yamaga. Clustering results of the Yamaga study did not yield a distinctly separated TDA and TND cluster structure, as was the case in Aydin. Additionally, the variations of different trip purposes for Yamaga were investigated, but no clear conclusions could be drawn from this investigation. The research found that the definition of TDA was quite different in Yamaga than it was in Aydin. The results of the comparative study confirmed that perceptions under the influence of dissimilar sociocultural settings could be diverse, and may affect the methods and variables accommodated to determine TDA in different localities. It was very difficult to define TDA clearly by using the exact methodology in every sociocultural context. This research also proved Cervero and Mason's (1998) claim that characteristics of transportation disadvantage are not globally identical, and policies and solutions that work in one locality may not show the same results in another sociocultural context. Characteristics of TDA are not globally identical, and tailored policies and solutions are necessary for different sociocultural contexts. However, the methodology developed in this paper on the basis of cluster analysis was found to be a suitable method to distinctively divide the population into TDA and TND, of course, if appropriate variables were carefully selected for each socioculturally different case.

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The research findings indicated that technicians and policymakers must be aware of the sociocultural differences when determining TDA and developing policies to overcome disadvantages. Therefore, it is essential to define a generic, universal set of variables and criteria for determining TDA globally, albeit in its sociocultural nature. This may help the standardization of a cross-cultural generic TDA definition. Developing a broad, general definition without culture-sensitive parameters of TDA would be beneficial to local authorities as a customizable template for local needs in which to integrate local sociocultural parameters. Such customized TDA models would be useful in supporting urban and transport planning and development, in which TDA-integrated policy-making is critical to provide equity in the provision of public transport infrastructure and services. In other words, local governments and transport authorities would benefit greatly from TDA-sensitive models with embedded local sociocultural aspects and by deploying the most relevant policy measures for the community. Therefore, further research is currently being conducted by the writers to develop generic variables to determine broad TDA communities in different sociocultural contexts. At the same time, the writers acknowledge that to specifically pinpoint TDA clusters, case-specific variables need to be defined for each locality under scrutiny. Another case study in Brisbane, Australia, is being investigated to test the effectiveness of generic as well as locally sensitive variables. The writers are also aware of the importance of improving the statistical methodology for determining TDA accurately by considering particularly the inclusion of a factor analysis technique to the methodology.

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