WHAT IF THE SUPPRESSED TRAVEL DEMANDS OF THE TRANSPORT DISADVANTAGED WERE RELEASED: RESULTS OF A SIMULATION APPROACH

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Abstract: Modeling for the transport disadvantaged (TD) is relatively new subject since the 2000's. The study aimed to discuss the simulation results of what the required transportation needs would be when also presumed suppressed demand of the TD are added. The underlying assumption is that the travel conditions of those TD groups must be equated to the "normal" demand, called full release. Based on the modeling approach for the TD, this task of equity could be realized elaborating special case of the elderly and disabled groups with some interesting results such as slightly increased costs, traffic and congestion, knowing also their locations. As of early virtual results, it is concluded that, for full release of suppressed trips (about 5%), local governments must be ready for extra financial burdens, which require a coordination effort both to standardize the TD and to reduce incurring costs on the operators.

Key Words: *Suppressed Travel Demand, Transportation Disadvantaged, Disabled (Handicapped) and Elderly*

1. INTRODUCTION

There is an increasing rate both in the number of those transportation disadvantaged (TD) and the disadvantage levels in various forms and aspects, primarily due to the demographic trends (increasing rate of elderly and handicapped and young in the developing countries), the automobilization (viz. especially in the developing countries such as China) and, less focus on the coordination effort yet to be awakened. The reasons of being TD can be found in the studies by Duvarci and Yigitcanlar (2007), Hine and Mitchell (2003), Hine and Grieco (2003), Pennycook *et al.* (2001) and Church *et al.* (2000) extensively. What really matter is that the elderly and disabled (E&D) will require more assistance (Lucas, 2006). Hine and Mitchell (2003) extensively summarizes such efforts and points to policy direction for future coordination and planning, giving examples from the past that must start again. For success, transport policies must be sensitive to person type affected, and differentiate accordingly (Heggie and Jones, 1978). The analysis can fundamentally be on the basis of transport disadvantaged and advantaged person (or, household) type distinction. Despite the growing literature and interest upon the recent call of governmental policy on social exclusion matter in UK, and identified by the 2004 Transport White Paper, there is still both methodological and conceptual struggling in tackling the issue in comprehensive manner.

As Pendyala and Bhat (2006) stated, "one of the key considerations in determining the efficacy of a model is to examine the ability of the model to quantify *induced* or *suppressed travel demand*". Most studies in the literature, while locating the issue to some level and enriching discussion, failed in defining and addressing to integrate the suppressed demands comprehensively *into* the travel demand modeling, which is necessary for knowledge-base analysis of policies. In the previous study by Duvarci and Yigitcanlar (2007), the methodological issues of such integration were addressed to the extent that, at least, there is now a working model, yet with limited data. The proposed model integration here is developed to enable formulating disadvantage sensitive policies in the examples of the E&D. Though the degree to which disadvantages is known both in social and geographical terms, levels of suppressed demand were not yet investigated in the mentioned study. Thus, the special purpose of this study is, first, to determine a calculation method to quantify suppressed demand, a measurement technique for inclusion of the TD, or socially excluded (SE), to introduce a measurability through the modeling steps, and then, to find a measurability of impacts of the hypothetical release of suppressed demand as the traffic assignment results of those TD groups, with the special emphasis on the E&D. Full removal of all disadvantages of the TD means being equal to the normal population's travel characteristics. This assumption comprises the very backbone of the method, so-called "suppressed demand difference".

In the previous study, the model results showed that the TD population produced overall less trip rate per person than the normal population; 1.65 and 1.73 respectively. This study here concludes that, if all suppressed trips of the TD were released, it could have been 1.78 in total. Therefore, from now on, having fewer trips is assumed as a sign of suppression. The results of this study are virtual, yet very informative which can be used as a decision tool by planners and traffic engineers. The simulation results, first, inform that, with the addition of total release of the suppressed trips (5%), there actually appeared no serious stress on the existing capacity of the roads, with the results being very specific to the case city. Second, succeeding to the trip distribution stage, the focus zone-pairs of policy, and thus, the critical paths that the E&D overwhelmingly use could be identified, with the adjoining link-based results of what existing problems and costs (or, congestion) these groups may encounter with the release impact. The methodology-driven study concerns only the trip productions and its run-down implications up to assignment stage, addressing the operability of the scenario approach through the modeling steps. Some assumptions to be stressed here for the analytical frame are; (1) adopting the Pareto optimality principle, which means not to intervene with demands of those advantaged and of normal population. (2) requiring that the demand characteristics of normal population be the ideal target for the TD population.

In the second section, briefly the literature on the concepts of demand types in interrelation to the TD concept will be introduced. In the third section, the basic structure of the modeling for the TD from the previous paper study, and the major findings will be highlighted with emphasis on the peculiar results on the E&D. In the fourth section, both the suppressed demand calculation method and the method of integrating this calculation into the modeling to see the impacts will be shown. In the fifth section, the simulation results were discussed and evaluated for the probable policy implications. Finally, conclusions are drawn.

2. LITERATURE REVIEW ON THE TRANSPORTATION DISADVANTAGED AND SUPPRESSED DEMAND

2.1 Social Exclusion and the Transportation Disadvantaged

Related to the TD concept, SE is a much broader term. "[S]ome people or households are not just poor but are additionally lost the ability to both literally (..) connect with many of the jobs, services and facilities that they need to fully participate in society". Accordingly, seven basic exclusion types were defined: physical, geographical, exclusion from facilities, economic, time-based exclusion, fear-based exclusion and space-based exclusion (Church *et al.*, 2000).

Though the term SE is many times used replacing, TD refers rather to the disadvantageous conditions of traveling (or, accessibility), while SE referring rather to a socio-economic wellness. Accessibility and transportation has vital importance in keeping contact with the rest of the society, therefore, very closely linked to the concept of TD. Thus, the transport system itself has a crucial role in creating barriers (SEU, 2003; Church *et al.* 2000). Hine and Grieco (2003) argues that combination of poor accessibility with low levels of mobility and low levels of sociability intensifies the exclusion.

Because of the multidimensionality (basically accessibility, mobility, cost, convenience, and access to information) of the TD, there arise measurement and level of analysis difficulties. Mostly UK based studies focused on measuring the accessibility and exclusion levels making largely use of GIS tools but criticized to be inefficient (Grieco, 2003) and not matured (Church *et al.*, 2000). Using the London Area Travel Survey (2001), trip making characteristics of elderly and disabled for four trip purposes using ordinal probit model technique were determined (Schmocker *et al.*, 2005). According to this study, retired people can make normal trips, but if disabilities intervene, trip rates reduce dramatically. Besides the UK government's awareness, after all, many other countries' legislation (Swedish, Canadian, Australian, etc.) required that transportation services be improved and made accessible by *all* members of population (Suen and Mitchell, 2000). It was found that low-floor buses increase bus travels of the TD groups. Special infrastructure may be required aiding especially those disabled and elderly groups, yet might mean additional cost, and funding is the biggest obstacle at which local authorities may be unwilling to if heavy financial burdens accrue. Most plausibly money charged from those who most benefit from the system is to be used for the improvement of public transport, especially on the quality of service delivery to improve those who benefit less, or suffer (Lucas, 2006; Newman and Kenworthy, 1999). The necessity for active policies and governmental *intervention* are emphasized under the recent "local transport planning" concept for repairing the exclusion (Grieco, 2003; Mokhtarian *et al.*, 2006). For the increasing rate of E&D populations, a gradual rise in the demand for demand-responsive, ITS equipped transportation services, community transport alternatives in-between private and public mode is expected to replace private car.

However, knowing required amount of such additional infrastructure and the costs depends, first of all, on the determination of the amount of the suppressed demand of those TD groups. Despite some research on the measurability of induced demand using elasticity approach (Cervero, 2003a), less focus is devoted to measuring the amount and the impacts of suppressed demand. Usually the empirical impact studies have been constrained to the added lane miles on the travel amount and length. Measuring the impacts of induced or suppressed demand is difficult due to their far-fetched, complex and longer term impacts hard to calculate, where the impacting factors and the impacted should be clearly identified. The most easily forgone trips (suppressed trips) would be of social or leisure purpose trips, or some maintenance trips, which are the travel behaviors even hard to model. Most probably the TD groups' suppressed demand would be from social and leisure activities that they most easily avoid, although leisure activities and trips are increasing in the U.S. (Mokhtarian *et al.*, 2006). The TD is more prone to depend on public modes; if the service level of public transportation is low, they are then more severely affected (Porter, 2002); the TD groups are either mostly the "peak captives" (Duvarci and Yigitcanlar, 2007); they either defer or subvert social and leisure trips which are less important to them, but strictly plan trips at household level combining with the compulsory (as work) trips into one-stop trip. Family dependence in trip-making is not only in the economic sense but also in the mobility sense, which is verified in the Srinavasan and Ferreira's study (2002) in Boston. Even for the elderly people living in suburban environments, there are not alternative travel modes and they are forced to be “mode captives” of car (Davidse, 2006). Especially, the E&D people seemed the most critical groups among other disadvantaged groups as high as 48% of all disabled and 53% of all elderly under the general category of TD (Duvarci and Gur, 2003). Thus, these groups of the TD deserve more attention in the policy analyses among others.

2. 2 Travel Demand Types

Suppressed demand and induced demand are key subjects in the identification of the TD and measurement of the disadvantages, on which a heavy emphasis was placed in the last decade, by especially the studies of Cervero (2003b), Mokhtarian and Salomon (2001) from the U.S. and Litman (2005) providing fairly vast empirical material to discuss. However, the debates have remained on the definitions of demand types, and primarily the car traffic, which yet have measurability obscurities in demand models. Thus, there is an urgent need to understand travel patterns and suppressed demands of those TD. Below are the basic demand types presented in correspondence to suppressed demand and can be relevant in identifying the travel disadvantages, and the nature of their travels:

- Generated and Induced demand
- Latent (referred to as “real” demand)
- Suppressed demand (with the “subverted” demands)

Wider definitions were provided in VTPI’s website by Litman (2005). Generated demand definition is largely based on the assumption that the traffic is analogous to the behavior of gas; it tends to expand if the network capacity is increased simultaneously (Litman, 2001). When new roads are opened, the traffic quickly fills them and the expected marginal utility of the new facility declines. On the other hand, induced demand is a sort of topping onto the generated one: By the changes made, more travel is attracted and the total volume of trips is also increased usually derived from land use impacts (Litman, 2001; Cervero, 2003a). Thus, total generated demand includes the induced demand as a substantial part of it. Cervero (2003a) criticizes the Hansen’s famous finding that each added 10% infrastructure spurs 9% traffic as “overstated” because the mentioned 9% increase must not totally (but partially) be due to the induce impact but to the release of the *once suppressed demand* that had not been come true until the conditions of transport infrastructure are improved. However, pursuing the inducement equilibrium in reality would not be cost-effective. For example, huge suppressed demand for private car in China does not seem satiable, and building enormous infrastructure required to satiate this demand cannot be justified at all. Especially mode choice is affected by the physical infrastructure available such as existence of sidewalk and topography (Rodriguez and Joo, 2004). Thus, the demand of the TD is clearly the suppressed type since they are not provided accessibility and transportation service due to various reasons. The possible release of this suppression could be interpreted as if the “induce” impact, as a way of analysis in equating them to normal population.

3. DESCRIPTION OF THE MODELING APPROACH ADOPTED FOR THE TD

3.1 The Data and Case City: Aydin

Together with the usual transport network data including the 2000 census data, a household survey was conducted with 326 randomly selected households, with 932 persons interviewed and the sampling ratio of 0.7 per cent. Questions related to individual household members aim to determine individual travel patterns to reveal disadvantage-related information (see Table

1) (Duvarci and Yigitcanlar, 2007). The model was tested in the Turkish city of Aydin, which is near Izmir with the then population of 135,365 (2000).

3.2 Brief findings of the Previous Model

The model structure contained two basic stages after processing data; (a) determining disadvantaged population through cluster analysis; and (b) modeling and comparing the model results of the disadvantaged and normal populations. 11 major disadvantages (variables) were identified which constitute the criteria in the clustering process to split the sample population into two groups (for details see Duvarci and Yigitcanlar, 2007). The persons with relatively low scores belonged to the disadvantaged, and the ones with high scores to the advantaged clusters. Consequently, the number of disadvantaged persons was 629 and advantaged was 303. The modeling approach required separate model runs for both the disadvantaged and normal population. The data variables used in TD definition are provided briefly in Table 1 (of which details can be examined in the respected study). These are largely the attitudinal and perceptional data from the people surveyed as in combined index values that can later be used easily as parameters, or policy intervention domains. But also other usual parameters are solely used in the modeling steps such as travel cost. The modeling study showed that the disadvantage is largely due to a lack of motor vehicle access and poverty. This analysis also demonstrated that it was possible to determine zone clusters of the disadvantaged by the cluster analysis (Fig. 1). Apparently, the most disadvantaged zone is the 8th zone, which has also very low figures of socio-economic status (Duvarci and Yigitcanlar, 2007).

Table 1 Data variables used in the modeling for the TD

Category	Category name	Notes
ACCESS	Accessibility	Determines the number people with poor accessibility level to the basic urban amenities
DEPEND	Economic dependency	Measures the economic dependency of the family members
EDU.FAM	Education level	Indicates household level education status that reflects individual travel generation
INC.PER	Income level	Income per person
IMPED.MP	Mode and peak impediment	Represents combined effect of mode and peak captivity together with the emphasis on the disabled
IMPED.PT	Public transit impediment	Indicates public transit conditions (i.e. physical conditions of the bus stops, service frequencies, number of transfers)
IMPED.CU	Cumulative impediment	Represents the cumulative effect of basic impedance elements (i.e. travel time, cost and distance to stop or car park)
COM.PUB	Comfort level of public transit	Measures passenger density and comfort conditions of the public transit
SCH.TRIP	Journey to school	Indicates travel conditions of students with various measures
VEH.AVA	Motor vehicle availability	Determines the number people with no motor vehicle
COM.VEH	Comfort level of private motor vehicle	Private motor vehicle comfort level (i.e. odour, air condition, noise, cleanness, seat comfort).

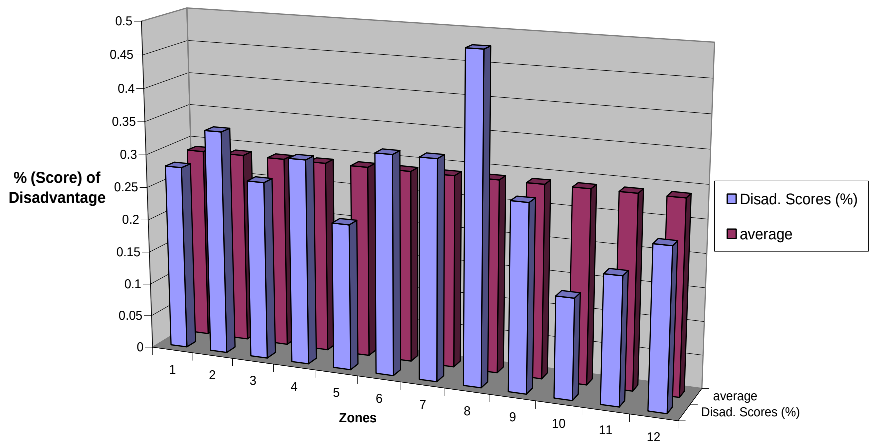

Figure 1 Aggregate disadvantage levels by zones

TRANUS™, an integrated land use and transport modeling software, is used for the transport modeling of Aydin. As the public transport (PT), only one mode available at the pilot study area, which is the contracted-out bus service that runs on 14 routes. For trip generations, using multiple regression analysis, best fitting variables were educational level, income level, and household economic dependency for normal population. For the disadvantaged, the following variables were significant: vehicle comfort, comfort level of PT, and economic dependency (being common variable for both). R^2 values were 0.78 for normal and 0.69 for the disadvantaged. The overall average daily trip rate per person for the normal population was 1.73, compared to 1.65 for the disadvantaged. Trip production results for both disadvantaged and non-disadvantaged are presented in Table 2, which will be used in the suppressed demand calculation later. Still, the TD's trip rates of few zones (as 2, 5 and 11) are greater than the Normal's, but such deviations do not much affect the general situation. These higher rates may be due to the different level of economic participation of the disadvantaged in some zones (also relating to accessibility, residential conditions or work types), etc., but the issue will be examined in detail within the limited scope of this study. For trip distribution stage, singly-constrained gravity model was used to determine the distributions. For mode split stage, with binomial utility approach, the utility function for the disadvantaged could be explained solely by the combined impediment variable. The mode choices in favor of PT (Public Mode) were 0.43 for the disadvantaged (for private 0.57) and 0.37 for the normal population (for private 0.63). To see the final traffic results and performance indicator results for user disutility levels, the assignments are run by TRANUS.

3.3 The findings peculiar to the disabled and elderly in the base model

The previous modeling also provided the proportions of both the elderly (people older than 65 years old) and the disabled per zone under the general category of TD (see Table 3). These will be used in evaluating the special place of the E&D in the suppressed demand release analysis later and in determining the priority areas and critical OD paths in policy making. Accordingly, the most significant zones are 8, 4, 3, 2, 12, 10, 6, of which 8, 2 and 6 had already been defined to be seriously disadvantaged. However, mostly those E&D may overlap (old persons have higher probability to become disabled) but, for easy calculation and unknown information, we assume they are exclusively separate groups.

Table 2 Trip rates and productions of the normal and the disadvantaged

zones	Normal population				Disadv'ed population			
	Model's trip Rate	Survey's trip rate	population	Trip Product.	Model's trip rate	Survey's trip rate	population	Trip product.
1	1.81	1.88	12,261	23,075	1.72	1.93	7,802	15,042
2	1.75	1.51	11,378	17,147	1.77	1.59	9,510	15,111
3	1.87	1.61	9,107	14,626	1.14	1.17	5,657	6,624
4	1.94	1.94	10,136	19,694	1.95	1.88	7,659	14,437
5	1.88	1.94	13,477	26,132	1.99	2.3	7,067	16,268
6	1.74	1.89	15,359	29,090	1.71	1.49	11,384	16,985
7	2.02	2.08	11,938	24,807	2.02	1.9	8,661	16,499
8	1.23	1.33	13,046	17,312	1.24	1.31	12,042	15,799
9	1.54	1.4	9,251	12,924	1.48	1.3	5,829	7,601
10	2.12	2.15	9,683	20,828	1.73	1.94	3,289	6,394
11	1.4	1.28	9,899	12,710	1.64	1.39	5,377	7,452
12	1.51	1.61	9,830	15,816	1.4	1.51	5,990	9,063
total	**1.72**	**1.73**	**135,365**	**234,162**	**1.64**	**1.65**	**90,267**	**147,275**

4. THE METHOD OF ACCOUNTING THE SUPPRESSED DEMAND OF THE TD

Observing pure impacts of the "once-suppressed" but now released demand (trip rate increase only) can be handled in two basic steps: first, calculating the demand surplus (difference) to be released by the transportation disadvantaged and, second, integrating this released demand to the mainstream model structure and observing the impacts as assignment results.

4.1 The method of calculating "suppressed demand difference"

It is not easy task to measure a hidden fact because of simply being not apparent at sight, but also of the uncertainties in definition and delimitation of what is to be measured. Handling suppressed demand in four-step modeling is difficult due to the difference between the conditions drawing general trip making behavior due to socio-economic conditions and the conditions at actual trip making. The measurement process requires an assumption to start with, and a "yardstick" to which measurements are done as well. The calculation arithmetic will be different than the mentioned elasticity measurements. As the sum of disadvantaged and advantaged together make the normality, the suppressed demand of the TD can be found on the very reason of this "completion" assumption; suppressed demand is the "deviance" (difference) of the disadvantaged from the normality by all means. In the following, the method of how to derive the released "suppressed demand difference" will be shown for the case city model results.

Table 3 Proportions of elderly and disabled among the total disadvantaged population

Zones	elderly %*	disab'd %*	total (%)
1	3	11	14
2	**28**	3	**31**
3	**21**	**18**	**39**
4	9	**34**	**43**
5	2	8	10
6	**20**	5	25
7	**19**	3	22
8	**31**	**19**	**50**

9	5	**15**	20
10	9	**17**	26
11	6	4	10
12	12	**16**	28

*percentages above the city averages of %14 and %12 are highlighted for elderly and disabled respectively

4.2 Method of Integrating Suppressed Demand into Modeling

The study is constrained only to the impacts of trip rate increases to observe, viz. the additional released suppressed demand of the disadvantaged. Since the previous modeling study used the singly-constrained (O_i) trip distributions approach, only the productions will be introduced to the trip distribution modeling, and their sole run down impacts to the assignment stage, specifying no any other value throughout the model stages. The integration is reflected at four steps finally ending up at the trip distribution stage as;

1. **Calculating "Released" Productions of the Disadvantaged** ($\mathbf{O}_i^{dis}{}_{(rel)}$)**:** Multiply the population (P_i^{dis} for each zone) of the disadvantaged by the normal populations' trip production rates;

$$\boldsymbol{O}_i^{dis}{}_{(rel)} = P_i^{dis} \, . \, t_i^{norm} \qquad (1)$$

2. **Calculating Released Trip Distributions of the TD** ($\mathbf{T}_{ij}^{dis}{}_{(rel)}$)**:** Previous attraction factors of the normal population's trip distribution calibration is directly multiplied by the above found (step 1) released productions ($\mathbf{O}_i^{dis}{}_{(rel)}$) (as if future productions);
3.

$$\boldsymbol{T}_{ij}^{dis}{}_{(rel)} = \boldsymbol{O}_i^{dis}{}_{(rel)} \, . \, \boldsymbol{a}_{ij}^{norm} \qquad (2)$$

   where, $\boldsymbol{a}_{ij}^{norm} = \boldsymbol{d}_j \, . \, \boldsymbol{f(c_{ij})} \, / \, \Sigma_j \, \boldsymbol{d}_j \, . \, \boldsymbol{f(c_{ij})}$, viz, calibrated for the normal population. The reason for taking normal population's attraction factors, instead of the TD's is that normal's values are the ideal for the TD. $\boldsymbol{d}_j$ here means attractions by j^{th} column zone.

4. **Run of all model steps on TRANUS (or, any other software available) as the two separate models, and finally getting the no-release Assignment Results** ($\mathbf{T}_{(base)ijkl}$ **and the released demand Assignment Results** $\mathbf{T}_{(rel)ijkl}$) **for comparison:** This requires first the run of the base year model, and then, the run of the suppressed demand's released trips, without changing any other parameter in the models.

5. **Running of the Reporting Programs of TRANUS for the Analysis of the Assignment Results, the Performance Indicators, such as Disutility, Cost and Service Levels:** General indicator outputs are derived from the Reporting Programs (IMPTRA and MATESP) to compare the basic results of the two models.

The results are to be discussed in the next section. There, what these results mean for those disadvantaged E&D is analyzed. In the analysis, those issues can be addressed; (a) the costs or additional burden by having the TD released suppressed demand, then, (b) what costs and difficulties will the E&D encounter by the increased traffic, and, (c) what infrastructure improvement and facilities are required according to the needs of these special groups. The process is briefed as the steps of the chart in Fig. 2. In this chart, also the joint released demand integration of the E&D (JDED) (explained later) is shown. In simulations, different from traditional modeling, the relevant parameters to focus can be PT comfort and service quality parameters (as proxi to car ownership and income).

4.3 The Simulation Results and Comparison with the Base "No-release" Case

To obtain the released suppressed demand impacts, simulation results of the released trips as of assignment results were evaluated on the TRANUS software. Both display results and general (summary) performance indicators for both the "release" and "no-release" (base) cases were contrasted. The total suppressed trip releases of the disadvantaged from the previous section is 103,930 while this was once 101,317, excluding the intra-zonal trips, which meant almost only 3% (5% with intra-zonal) increase in the release (Table 4). In Table 4, the negative values are out of concern, which are capsulated in parentheses meaning there occurs literally no released trip. The most significant releases (bold and underlined) are to be the policy concern zone-pairs. Those with no high joint demands of the E&D, as shown in Table 6, are excluded since no relevance to policy analysis. The net release can be denoted as:

$$D_{ij(rel)} = \boldsymbol{T}_{ij}^{dis}{}_{(rel)} - \boldsymbol{T}_{ij}^{dis}{}_{(base)} \tag{3}$$

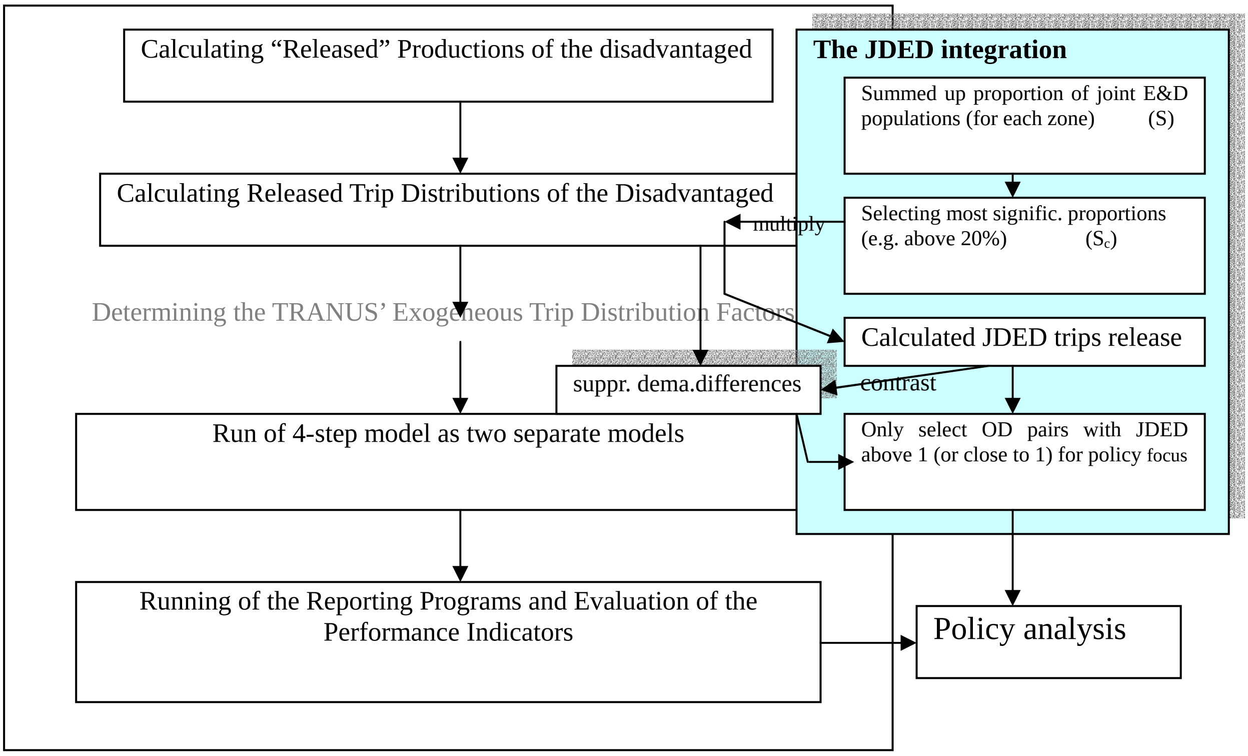

Figure 2 Steps of released demand calculation together with the JDED integration

The basic differences were evaluated for three basic display indicators (public and private mode equivalent vehicles, LOS and waiting time all with the same scaling) that showed literally no significant difference. Slight differences in LOS were observed on previously congested links (because of the available capacity to accommodate more traffic) (Fig. 3). Similarly, utilizing the IMPTRA reporting program of TRANUS, the numerical results of basic cost and mobility related indicators could be obtained (Table 5). Details of comparison between the release case and non-release (base) case are provided in the Discussions section.

4.4 Results Peculiar to the E&D and the Policy Zone-pairs

Based on the information provided from the previous modeling study for the TD, and the joint proportions of the disadvantaged E&D given in the previous section, the "Joint trip Demand of the Elderly and Disabled" (JDED) within the overall released demand can *approximately* be found and special travel needs of the E&D be captured. The JDED were calculated in three steps as follows (See also the chart in Fig 2);

1. first, sum up previously found (Table 3) E&D population proportions for each zone, and find a joint total percentage value for each zone (p_i^j).
2. then, multiplying these joint proportions (p_i^j) by the trip distributions with releases (i.e., $\mathbf{T}_{ij}{}^{dis}{}_{(rel)}$). Proportions are assumed the same all throughout the raw taken and evenly distributed to each cell because of the data insufficiency
3. finally, as a metric of significance, the trip distribution shares of JDED can be observed along with the trip distributions found before. The E&D releases are found in comparison to release differences. The S_{ij}^j values are expected to be positive and assumed critical (S_c) if exceeds 1, showing the significance of elderly and disabled trips among general release difference if exceeds 1.

$$S_{ij}^j = (\boldsymbol{T}_{ij}{}^{dis}{}_{(rel)} \,.\, p_i^j\,) / D_{ij(rel)} \qquad (4)$$

Table 4 Differences Between the Base and Released Trip Distributions of the TD

	1	2	3	4	5	6	7	8	9	10	11	12	sum
1		1053-1873 820	5265-4058 (1207)	2633-3121 489	527-312 (214)	3159-2653 (506)	97-47 (50)	97-47 (50)	527-312 (214)	790-312 (478)	263-312 49	97-312 215	14507-13360
2	556-412 (144)		556-421 (135)	2223-2104 (120)	1112-1262 150	556-1262 706	556-841 286	102-64 (39)	1112-1262 150	1112-841 (270)	1946-1683 (263)	1946-1683 (263)	11776-11836
3	54-29 (25)	879-774 (105)		1554-1026 (528)	54-387 333	54-581 527	586-581 (6)	54-194 140	293-387 94	54-194 140	54-348 294	54-736 682	3691-5236
4	97-51 (46)	1053-706 (348)	1211-1518 (306)		527-1059 532	1580-1059 (521)	790-1059 269	97-53 (44)	685-1518 833	158-106 (52)	527-459 (68)	2265-2224 (41)	8991-9811
5	1453-756 (697)	484-264 (221)	89-264 174	2421-2108 (313)		1937-1581 (356)	2421-1318 (1103)	89-40 (49)	968-1054 86	89-264 174	1211-922 (288)	2179-1713 (466)	13342-10284
6	494-433 (61)	91-629 538	988-839 (149)	3460-3776 316	988-1259 270		988-839 (149)	91-63 (28)	494-1259 764	494-420 (75)	1236-1175 (61)	1730-2014 284	11055-12705
7	56-252 196	56-489 433	303-367 63	3640-3423 (217)	910-1467 557	1759-1711 (48)		56-37 (19)	303-244 (59)	303-489 186	1972-2078 108	2427-2567 141	11785-13125
8	328-46 (282)	60-45 (16)	328-591 263	656-1182 526	656-591 (65)	525-473 (52)	984-886 (97)		754-680 (75)	656-591 (65)	984-886 (97)	656-591 (65)	6586-6561
9	63-37 (26)	343-228 (115)	686-1141 455	343-1141 798	63-34 (29)	63-34 (29)	686-456 (230)	63-34 (29)		686-456 (230)	63-228 165	63-34 (29)	3124-3826
10	99-32 (66)	99-218 119	535-1090 554	535-763 227	535-436 (100)	535-33 (502)	99-436 337	99-33 (66)	99-436 337		803-654 (149)	803-981 177	4241-5110
11	66-25 (42)	359-172 (187)	66-1031 965	1796-1598 (198)	1078-1031 (47)	66-172 106	66-172 106	359-172 (187)	359-172 (187)	359-172 (187)		898-1083 185	5474-5800
12	420-227 (193)	420-241 (180)	77-481 404	1261-1203 (58)	420-481 61	1261-722 (539)	77-481 404	77-36 (41)	840-722 (119)	210-120 (90)	1681-1563 (117)		6745-6277

Note: the external trips are not added to these figures

Having such a metric makes it possible to know how far the released trip is comprised of the E&D trips, if their travel conditions are to be improved. Those with high (S_{ij}^j) ratios should draw the policy-maker's attention to those zone-pairs, and the paths between these zone pairs that must have a high priority for probably denser disabled and elderly travels. The results showing the most significant shares (close to 1 or over) are observed in those zone-pairs with associated share values; 1-4(0.9), 2-5 and 2-9(2.6), 4-3(2.1), 4-7(1.7), 6-4(2.9), 6-5(1.2), 6-12(1.8), 7-11(4.3), 7-12(4.0), 8-3 and 8-4(1.1) and 10-12(1.4). It is checked whether the E&D releases at those paths collide with any impediment caused by the additions of the general suppressed demand releases of the TD, such as increased volumes, thus, generalized costs, LOS and waiting time durations for public transportation services.

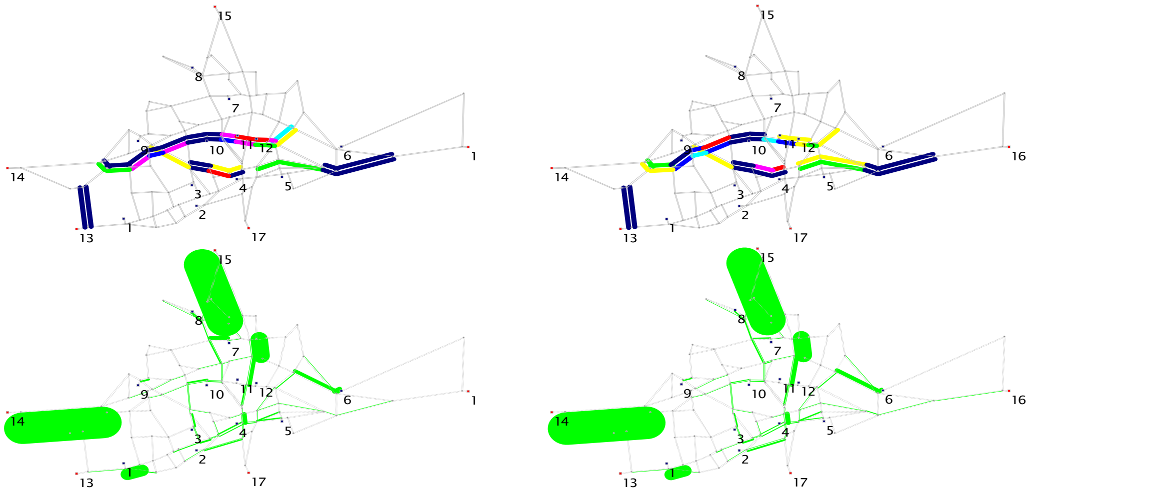

Figure 3 Comparison of release (left) and no-release (right) LOS and wait time (down)

5. DISCUSSION AND THE POLICY IMPLICATIONS

As the general outcome of the method approach, the total trip demand of the disadvantaged, 147,123 changed to 154,009 trips, with the extra 6,886 trips which is supposed to be the latent demand, increasing the total new trip rate to 1.78. A slight increase in trip numbers actually has not brought a serious burden on the existing roadway capacity, with only 3%. Even this additional demand might not mean additional costs and burden onto the existing infrastructure but returns in case the existing network and transport system capacity is underutilized.

Table 5 Comparison of the base case and the simulated released demand

Criteria	no-release	released suppr.	% change
general costs (priv)	14593131	14829517	1.61
general costs (publ)	11506755	11759606	2.19
revenue (publ)	19590252	20014686	2.16
monetary cost (gen)	51293628	52343596	2.05
wait time (all aver.)	8.22	7.5	-8.76

Once the critical zone-pair paths are clarified according to the special results of the E&D out of the simulation, examining the impacts by paths (one direction) on the Paths property of TRANUS, policy observations can be made. The specific analysis results are not provided here due to the limited space, but most common conclusions can be drawn as; the absence of, or extremely long and indirect PT lines can be the major cause of disadvantages, as far as observed for the concerned zone-pairs. Second, most of the various PT choices at the beginning of travel diminish to one or two choices. Many times either the access or the egress distances to the nearest stop are far. Third, travels are interrupted with degraded quality of Level of Service on some links and waiting times which may be due to the infrequent or unreliable bus services. It may be better to re-design the transit service routes, or many other solutions can be thought. In the Fig. 4, two examples indicate one of the most important factors causing the disadvantage; excessively indirect PT lines (i.e., PT service quality) in the existing situation, even the path choice of walk (if straight, around 1km long) becomes more beneficial in terms of generalized cost on the critical paths selected (walkway facilities related). Basic differences between the no-release case and release case are; around 2% increase in costs on operators though a general 5% increase in trip rate was observed, where costs and revenues even out each other (assuming ticket price is not discounted for the E&D).

It is interesting to have a general 5.4% less waiting time, which is a good indicator. Looking at the per user (average) results, there are more dramatic decreases in waiting time (8.8%) (probably due to increased frequency), disutility (17.4%) and travel time (9.1%).

Table 6 Joint Released Demands of the E&D (JDED)

zones	1	2	3	4	5	6	7	8	9	10	11	12	sum
1	0	**262**	**568**	**437**	44	**371**	7	7	44	44	44	44	1870
2	128	0	130	**652**	**391**	**391**	**261**	20	**391**	**261**	**522**	**522**	**3669**
3	11	**302**	0	**400**	151	**226**	**226**	75	151	75	136	**287**	2042
4	22	**304**	**653**	0	**455**	**455**	**455**	23	**653**	46	197	**956**	**4219**
5	76	26	26	**211**	0	158	132	4	105	26	92	171	1028
6	108	157	**210**	**944**	**315**	0	**210**	16	**315**	105	**294**	**503**	**3176**
7	55	108	81	**753**	**323**	**377**	0	8	54	108	**457**	**565**	**2888**
8	23	22	**295**	**591**	**295**	**236**	**443**	0	**340**	**295**	**443**	**295**	**3281**
9	7	46	**228**	**228**	7	7	91	7	0	91	46	7	765
10	8	57	**283**	198	113	9	113	9	113	0	170	**255**	1329
11	2	17	103	160	103	17	17	17	17	17	0	108	580
12	64	67	135	**337**	135	202	135	10	**202**	34	**438**	0	1757

What can be done in practice with these results is also of the policy making process and planning taking into account the coordination issue. First of all, complying with the newly arisen amendments that already launched in many countries, along with the street design, the use of advanced technology is very possible to aid those vulnerable groups such as elderly and disabled right after all their demands and the paths they use are known in the very first place. Funding issue is another point to be resolved urgently for relatively the ITS-based costly applications but which are, in a sense, the compensation to provide the TD's right back and to restore its deteriorated accessibility conditions.

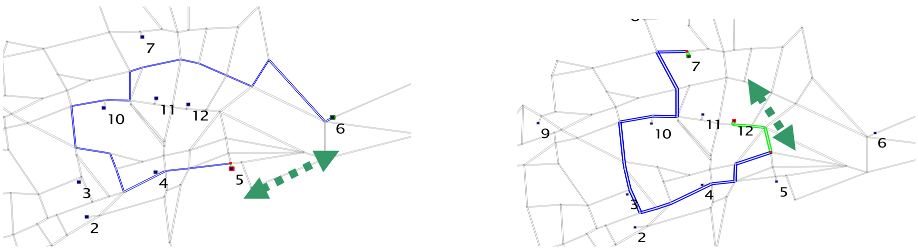

Figure 4 Path examples (6-5 and 7-12) of extremely indirect PT routes as major impedance

The issue of measuring the impacts of the hypothetical releases of the suppressed demand, specifically of the TD through simulation-based approach was the subject of this study. Under the assumption that the clustering-based modeling approach for the TD groups can have a high potential to be also used as a yardstick in measuring suppressed travel demands of these groups, the release impact could be observed. Here, a metric was developed based on "what if" approach in the measurement of both the suppressed demand and the would-be impacts if they were to be released. The main purpose was to answer whether the impacts and costs of such additional trips, which are assumed the human rights of those TD, are heavier than the local government's and the existing infrastructure's capability.

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