Getting to Work in Israel: Locality and Individual Effects

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Abstract

We use Social Survey data for 2014–16 and Google Maps data to study the distribution of employees in Israel by their travel modes—and in particular, their dependence on private vehicles. The analysis was conducted from two perspectives: one allows geographical mapping of the localities in Israel by their accessibility to job localities via public transportation (relative to private vehicle), and the second examines, at the individual data level, the impact of the accessibility and of individual characteristics on the choice of travel mode.

Mapping Israeli localities by an index of relative accessibility via public transportation to workplaces, calculated in this paper, indicates notable gaps. The more distant home localities are from the metropolises' core, the less relative accessibility there is. In most localities in the periphery—and particularly in Arab localities—the relative accessibility is low due to the limited supply of public transit. In small Jewish localities in the periphery, accessibility is low, but high socioeconomic levels of these localities may indicate that the low accessibility derives from residents' preference for private vehicles (given the level of public transportation that can be provided to such localities). In ultra-Orthodox cities and localities, the relative accessibility is high. In many localities with a lower socioeconomic background—particularly in the Arab sector—the relative accessibility is low, while in tandem there are organized shuttle services provided by employers. This mode is efficient in the sense of distance covered in a given time. However, a lack of alternatives creates dependence on such shuttle transportation, which reduces the residents' employment possibilities and creates among them a dependence on a small number of employers.

Analyzing individual effects on the travel mode (using the Discrete Choice Model) given a limited number of alternatives indicates a small (but statistically significant) effect of the trip's travel time. However, the proximity of bus/train stations and frequency of service markedly increase the probability of choosing those modes of transportation, and reduce the use of private vehicles. In contrast, car maintenance benefits and a company car lead to the choice of private vehicles.

The findings also indicate a correlation between a low socioeconomic level (in terms of wages, schooling, and housing density) and a greater tendency to use a bus, and a low attractiveness of the bus mode for upper income deciles. The probability of choosing a bus is markedly lower among private vehicle owners and among workers who are eligible for car maintenance benefits from their employer. Concerning trains, the findings indicate a higher readiness to choose them, when the train is available, both among vehicle owners and among other commuters.

איך מגיעים לעבודה בישראל? מאפייני יישוב וגורמי פרט

טניה סוחוי, יותם סופר

תקציר

אנו משתמשים בנתוני הסקר החברתי לשנים 2014 עד 2016 ובנתוני Google Maps כדי ללמוד על התפלגות המועסקים בישראל לפי אופן הגעתם למקום עבודה ובפרט – על מידת התלות ברכב פרטי. ניתוח זה נעשה משתי זוויות: אחת מאפשרת מיפוי גאוגרפי של היישובים בארץ לפי מידת הנגישות מהם למקומות תעסוקה באמצעות התחבורה הציבורית (יחסית לרכב פרטי); השנייה בוחנת – ברמת נתוני הפרט – את ההשפעה של הנגישות ושל תכונות הפרטים על הבחירה של אופן ההגעה.

מיפוי היישובים לפי מדד הנגישות באמצעות תחבורה ציבורית למקומות עבודה שחישבנו מצביע על פערים בולטים. ככל שמתרחקים מהערים המטרופוליטניות הנגישות היחסית יורדת. ברוב יישובי הפריפריה – ובמיוחד ביישובים הערביים – הנגישות היחסית נמוכה בשל מגבלות בהיצע שירותי התחבורה. ביישובים יהודיים קטנים בפריפריה הנגישות נמוכה, אך רמתם הסוציו-אקונומית הגבוהה של היישובים עשויה להעיד כי הנגישות הנמוכה נובעת מכך שהתושבים מעדיפים להשתמש ברכב פרטי (בהינתן רמת התחבורה הציבורית שניתן לספק ליישובים כאלה). בערים וביישובים חרדיים הנגישות היחסית גבוהה. בהרבה יישובים מרקע סוציו-אקונומי נמוך – במיוחד במגזר הערבי – הנגישות היחסית נמוכה ומלווה בהסעות מאורגנות שהמעסיקים מספקים. הסעות אלו יעילות שכן ניתן לעבור באמצעותן מרחק רב בזמן נתון. אולם, בהיעדר חלופות נוצרת תלות בהן המקטינה את אפשרויות התעסוקה הפתוחות בפני התושבים ויוצרת אצלם תלות במעט מעסיקים.

ניתוח גורמי הפרט המשפיעים על אופן ההגעה לעבודה (Discrete choice), בהינתן מבחר מוגבל של חלופות, מראה השפעה קטנה (אך מובהקת סטטיסטית) של משך הנסיעה. לעומת זאת, קרבת תחנות אוטובוס/רכבת ותדירות שירות מגדילים משמעותית את סיכויי הבחירה באמצעים אלה, ומקטינים את השימוש ברכב פרטי. לעומת זאת, הטבות אחזקת רכב ורכב צמוד מטעם המעסיק גורמות להעדפת רכב פרטי.

התוצאות מצביעות גם על מתאם בין מעמד סוציו – אקונומי נמוך (מבחינת שכר, השכלה וצפיפות הדיור) לבין נטייה גבוהה יותר להשתמש באוטובוס, ועל אטרקטיביות נמוכה של נסיעה באוטובוסים עבור עשירוני ההכנסה הגבוהים. הנטייה להשתמש באוטובוס נמוכה משמעותית בקרב בעלי רכב פרטי ובקרב עובדים הזכאים להטבות אחזקת רכב מטעם המעסיק. לגבי הרכבת, הממצאים מעידים על נכונות גבוהה לבחור בה, כאשר היא זמינה, הן על ידי בעלי רכב והן על ידי יוממים אחרים.

1. Introduction

Israel is over-dependent on the use of cars due, *inter alia*, to infrastructure restrictions and inefficient public transport. This matter has come up for discussion in recent years due to urban crowding and congestion on the roads, and given the need to reduce air pollution. The topic of public transport also came up indirectly, including in discussions of productivity in the business sector and the need for accessible, low-cost residential areas to provide an appropriate alternative to residential areas in high demand.[1]

We use data from the Social Survey conducted by the Central Bureau of Statistics for 2014-2016 to present decision makers with a picture of transport mode preferences from two perspectives. The first is geographic gaps in accessibility of work places in Israel reached from home localities by public transport compared to by car. The second is marginal effects of employee characteristics on the transport mode, given the existing service infrastructure and corresponding distribution of home and work places selected by the individuals. Some of these factors—such as proximity of bus/train station to the place of residence, employer benefits for use of a car and the income effect—are sensitive to policy measures.

In order to compare among home localities by the accessibility of workplaces via public transport, we use an index that compiles the total amount of work places in destinations to which the residents travel, based on their surveyed distribution for each home locality. Employment at these destinations is weighted in this index by travel times, reflecting the cost of reaching the destination.

Since the 1980s, accessibility indices (Koenig, 1980) have become widely used in transport geography, due to the many implications on sustainable regional planning (Levinson, 1998). In recent years, such indices have increasingly relied on high-resolution GIS systems; they have been implemented in urban planning (Benenson et al., 2010; Ford et al., 2015), international comparisons (Kawabata and Shen, 2006), monitoring accessibility over time (Kwok & Yeh, 2004), the study of spatial correlation between accessibility to public transport and socioeconomic gaps (Vieri and Haddad, 2012), and social aspects of these gaps from the viewpoint of populations with no access to a car (Currie, 2010).

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[1] Knesset Research and Information Center: Public transport in Israel – status and ways to promote (2009); and Public transport in Israel – background material (2018); OECD Economic Survey 2014, page 31; OECD Economic Survey 2016, page 27; Bank of Israel (2018), 2017 Annual Report, Chapter 2.

We take advantage of the Social Survey data for 2014–16 to provide a nation-wide picture of employees' work-purposed trips on a weighted basis. In terms of travel distances, this picture may provide a wider range of choices than those constrained by the framework of urban transport planning (Mavoa, 2012). The distribution of work-purposed destinations introduces "competition" between home localities regarding work opportunities, which reflects the equilibrium created between places of residence and places of work, given the current service level of public transport. On the other hand, there is a difficulty in a detailed comparison of the accessibility of workplaces in public transport between localities in Israel at high resolution, in the absence of detailed national statistics at the intra-locality level of the characteristics of the trip.[2]

The macro approach we have applied estimates the cost $f(C_{ij})$ of travel between home and job localities, based on a gravity model seeking a statistical link between travel flows by a specific transport mode and the corresponding travel times. This methodology is based on a declining decay function, as described in Halleford and Jornsten, 1986; Simma and Axhausen, 2003; De Grange et al., 2009; and Duran-Fernandez and Santos, 2014.

Differences in accessibility of work destinations via public transport reveal prominent gaps that may be associated with peripherality of home localities, their socioeconomic status, supply of public transport services, and involvement of employers in providing transport to the employees. We show that accessibility indices are not necessary correlated with service frequency, but rather these features are complementary. According to our findings, high accessibility indices, along with high service frequency, are mostly typical of cities with a high rate of in-town travel; this correlation is weaker when out-of-town travel is involved.

In the second part of this paper, we rely on employee characteristics available from the Social Survey to study individual factor effects, given the current infrastructure and distribution of places of residence and places of work created at the equilibrium, which also reflects the availability of public transportation. Based on the "Discrete choice" methodology, developed in studies by McFadden (1974), Ben-Akiva and Lerman (1985), Simma and Axhausen (2003), Buehler (2011), Eluru et al. (2012), Duran-Fernandez and Santos (2014), and Hoogendoorn et al. (2015), we

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[2] "The need for reliable data about public transport" (quote) was mentioned in the report "Public transport in Israel – background material", written by Ehud Becker (January 2018, page 10) and submitted to the Knesset's Economics Committee. In particular, this notes the absence of a regular publication that analyzes public transport supply and demand and the composition of the population using public transport by various attributes.

evaluate the marginal effect of various factors, such as proximity of bus/train stations to the place of residence and car ownership, on the choice to use public transport and on differences in attractiveness of bus and train service. We also study the effect of employer-provided benefits for owning a car. When we control for these attributes, we find that difference in travel time across alternative modes of transport have little effect on the choice. When the number of alternatives available to an individual is limited and is taken into account, we find that travel time has a significant, negative effect—but this is only half of the parameter estimated in a similar study by Hoogendoorn, et al. (2015) for the Netherlands (Panel data 2013–15).

The rest of this article is arranged as follows: Chapter 2 presents descriptive statistics, as derived from the Social Survey data that is then cross-referenced with Google Maps data. Chapter 3 describes the data and methodology for the first part of this study – comparison of localities by accessibility indices (geographical aspect). It also presents and discusses the estimation results and prominent geographical patterns. Chapter 4 addresses the marginal effect of individual factors on the employee's choice of transport for travel to work, describes the explanatory variables in the Discrete Choice models and discusses sensitivity of the results to different specifications. Chapter 5 summarizes.

2. Descriptive statistics

Table 1 shows the modal split of employees in Israel in work-purposed trips and the average commute times, based on the 2016 Social Survey. According to this table, 60 percent of employees in Israel are employed outside their town of residence, of which two-thirds reach work by car, 20 percent–by public transport and 10 percent–by transport provided by their employer.

Table 1
Modal split of employees in work-purposed trips and average travel times

Transport mode	Share of employees using the mode (percent)			Average travel time (minutes)*		
	Total	Inside the locality	Outside the locality	Total	Inside the locality	Outside the locality
Private vehicle	60.7%	21.7%	39.0%	26.4	13.9	33.3
				[12.3]	[10.9]	[12.5]
Bus	17.5%	7.8%	9.8%	41.7	27.6	53.1
				[15.0]	[13.0]	[13.0]
Train	3.4%	0.3%	3.1%	65.9	31.4	68.8
				[13.0]	[12.5]	[12.9]
Shuttle arranged by the employer	7.8%	1.7%	6.0%	36.2	15.9	41.8
				[12.7]	[11.3]	[12.7]
Bicycle	1.7%	1.3%	0.3%	13.5	11.8	20.1
				[3.7]	[3.0]	[3.8]
Walking	7.6%	7.2%	0.4%	11.2	10.8	18.5
				[3.2]	[3.0]	[3.5]
Other	1.3%	0.6%	0.7%	31.3	22.8	37.7
				[13.6]	[9.6]	[14.6]
Total	100%	40.60%	59.40%			

*Out of total employed people who reported their mode of travel to the workplace excluding those who reported that they work from home.
** The average travel times are calculated on the basis of travel times within time frames in the survey questionnaire, on the assumption that the travel times in each range are uniformly distributed. In square brackets—standard deviations calculated using the bootstrap method.
SOURCE: The Social Survey conducted by the Central Bureau of Statistics for 2016.

Table 2 provides estimated average distances between home and work localities traveled by employees, calculated by retrieving from Google Maps the distances between the center of the origin town and the center of the destination town for each respondent to the 2016 Social Survey.

Table 2

The average distance (in kilometers)* traveled to work in Israel, by transport mode

Panel A: Average distance, total and by gender			
Transport mode**	**Total**	**Men**	**Women**
Private vehicle	17.7	18.4	16.9
	[1.5]	[1.6]	[1.2]
Public transport (bus)	18.7	21.3	18.2
	[1.6]	[1.7]	[1.5]
Shuttle	24.5	28.3	23.0
	[1.6]	[1.7]	[1.3]
Panel B: Average distance in a given time frame			
Mode of transit	**Up to 30 minutes**	**Up to 60 minutes**	**Up to 90 minutes**
Private vehicle	11.3	18.7	21.7
	[1.2]	[1.3]	[1.4]
Public transport (bus)	7.3	15.7	19.6
	[1.1]	[1.3]	[1.4]
Shuttle	10.0	24.1	29.6
	[1.2]	[1.5]	[1.6]
Panel C: Average distance traveled on employer-provided shuttle, by intensity of shuttle use in a locality			
Percentage of shuttle users (of all those reporting in the locality)	**Average distance (kilometers)**		
Up to 2%	[7.6]	19.3	
2%-14%	[6.3]	19.5	
14%-32%	[8.6]	24.7	
> 32%	[10.0]	37.0	

* In square brackets—standard deviation of average distances.

** Some of those surveyed responded that they get to work on foot, by bicycle, or other mode. In those cases the distance cannot be calculated using Google Maps, as there are no data on point of departure or destination in the localities.

SOURCE: Based on the Social Survey conducted by the Central Bureau of Statistics for 2016, and Google Maps.

As shown in Panel A, employees travel, on average, a similar distance (of 18-19 kilometers) whether they use a car or public transport. However, for a given timeframe (Panel B), say 30 minutes, greater distances are covered by car. The table also shows that on average, distances covered by employer-provided shuttles are greater than those covered by car or public transport. Panel C shows that relatively long trips by shuttle are prevalent in a few localities that make intense use of this mode. The analysis that follows shows that such intensive use is common in peripheral localities with a low socioeconomic level that are especially prone to lack of public transport.

Given the low use of public transport compared to cars, Table 3 indicates that trains are more attractive than buses, and the choice of train is not made for lack of another choice. This table shows—over the three years covered by the survey—the modal split of work-purposed trips, conditional on car availability (i.e., ownership of a car and a driver's license). Data show low use of buses and shuttles as soon as the private car alternative is available—but not so for trains: The share of employees taking the train is between 2 to 3 percent, regardless of car availability; this share reaches 5 percent for employees working outside their home locality. Our model also predicts (Section 4.3) that 13 percent (for men, 17 percent) of commuters who own a car and have access to train in both home and job localities, will choose the train; thus indicating high willingness to use the train when available.

Table 3
The distribution of those traveling to work according to transport mode, by access to a private vehicle (Yes/No)

Transport mode	Is there access to a private vehicle (yes/no)	2014		2015		2016	
		Out of total employed people	Out of those working outside residential locality	Out of total employed people	Out of those working outside residential locality	Out of total employed people	Out of those working outside residential locality
Private vehicle	No	13.40	18.15	15.13	19.15	15.12	19.16
	Yes	75.80	77.40	74.84	76.57	75.18	76.07
Bus	No	43.26	45.75	43.51	43.55	46.10	48.02
	Yes	8.42	9.50	8.66	9.23	8.47	9.13
Train	No	**2.57**	**4.35**	**1.98**	**3.83**	**2.91**	**5.51**
	Yes	**2.05**	**2.99**	**2.32**	**3.53**	**3.33**	**4.96**
Shuttle arranged by employer	No	15.89	27.60	16.08	25.81	13.52	22.03
	Yes	6.71	8.27	6.61	8.68	6.09	8.06
Bicycle	No	2.65	1.32	3.96	1.61	3.57	1.10
	Yes	0.84	0.35	1.00	0.32	1.16	0.47
Walking	No	19.98	0.95	17.37	2.62	16.43	1.32
	Yes	5.35	0.57	5.55	0.45	4.82	0.42
Other	No	2.25	1.89	1.98	3.43	2.35	2.86
	Yes	0.81	0.92	1.03	1.22	0.95	0.89

* Based on ownership of a private vehicle and driver's license. The question in the survey was, "Is a private or commercial vehicle available for your use?" Thus, no distinction can be made between an individual's ownership and a household's.

** These essentially choose private vehicle as passengers.

SOURCE: The Social Survey conducted by the Central Bureau of Statistics for 2014–16.

3. Accessibility indices – geographic aspect

3.1 Methodology of relative accessibility index

The accessibility index A_i of locality i is a sum of all potential workplaces L_j in destinations to which residents of i travel, weighted by the cost of travel depending on the transport mode and travel time between i and j as follows:

$$A_i^{(\mathrm{mod}\,e)} = \sum_{j \in D^{(\mathrm{mod}\,e)}} L_j \, f^{(\mathrm{mod}\,e)}(t_{ij}) \qquad (1)$$

Where:

- $A_i^{(\mathrm{mod}\,e)}$ – accessibility of public transport (*mode*=PT) or private car (*mode*=car) in locality i;
- L_j – the total number of work opportunities in destination j, in terms of employment size;
- $D^{(\mathrm{mod}\,e)}$ – destinations accessible from home-locality i for work-purposed trips, by *mode* (car or public transport)[3];
- $f(t_{ij})$ – weights that follow an impedance function negatively depending on travel time between localities i and j.

The impedance function $f(t) = \exp(\alpha t)$ expresses the intensity of work trips between i and j, while the parameter $\alpha < 0$ can be evaluated through the gravity equation:

$$\ln\left(\frac{M_{ij}}{Pop_i \cdot Pop_j}\right) = c + \alpha \ln(\bar{t}_{ij}) + fe_i + fe_j + \varepsilon_{ij} \qquad (2)$$

Where:

- M_{ij} – the number of travelers from locality i to locality j (according to the survey);
- Pop_i, Pop_j – the population sizes of the home and job localities (according to administrative population data);
- $\bar{t}_{ij}$ – average travel time[4] (weighted according to the survey sample) from i to j;
- c, α – parameters for statistical evaluation;

[3] The group of relevant target towns for a given origin town is determined by sampling and weighting in the Social Survey, assuming this to be a typical distribution.

[4] Travel times are reported by survey respondents by categories, with the following ranges specified in the questionnaire: Up to 15 minutes, from 15 to 30 minutes, from 30 to 45 minutes, from 45 to 60 minutes, from 60 to 90 minutes, longer than 90 minutes and "unspecified time". In order to use continuous times, we take multiple samples of travel times, assuming uniform distribution across the reported interval, and then use the averages.

fe_i, fe_j	–	fixed effects of home and job localities; in an alternative version, we assign for these the corresponding peripherality index r_i, r_j (according to the CBS), which are continuous metrics;
ε_{ij}	–	random remainder.

We estimate the gravity equation (2) by transport mode[5], to allow for different decay parameters for travel by public transport and by car.[6]

Travel flows M_{ij} i from locality i to locality j by car / by public transport are calculated as the sum of weights of survey respondents who reported traveling to work between these towns by car / by public transport. These travel flows are normalized for the product of populations in the home and job localities, and constitute a dependent variable (in logarithmic terms) for estimating the gravity equation (2).

The decay parameter obtained by this aggregate method probably results in under-estimation of accessibility gaps, because it does not account for variance in travel time within the localities.[7] Moreover, the heterogeneity in town sizes results, in our analysis, in under-representation of smaller home localities in the distribution of travel destinations and, consequently, in limited reliability of the indices calculated for such localities. We try to mitigate this issue by locating travel directions based on survey data over 3 years (2014–16), rather than based on a single year, as well as by grouping localities by choice patterns, as described below.

Relative accessibility to places of work in a town, G_i, is calculated as the ratio of accessibility by public transport $A_i^{(PT)}$ to accessibility by car $A_i^{(car)}$:

$$G_i = A_i^{(PT)} / A_i^{(car)} \qquad (3)$$

[5] This symbol is omitted in (2) for the sake of simplicity.

[6] In research of transport systems in Sao Paolo (Vieri & Haddad, 2012). The decay parameter is not statistically estimated, but is set to a uniform value for travel by car and by public transport as $\alpha = -0..01154$, by calibration which ensures a weighting of 1 for travel time of 0 minutes and a weighting of 0.25 for travel time of 2 hours.

[7] According to Professor Shlomo Bekhor (Technion), gravity models are not applicable to planning of transportation systems in Israel, see:
Cambridge Systematics: Tel Aviv Activity Schedule Travel Demand System: A Tour-based Approach (2008), prepared for Israel Ministry of Transport.

We should note that the index does not focus on the question of the time it takes to get to a particular workplace by public transportation relative to the time it takes to get to it by private car. Rather, it allows for higher relative accessibility to be expressed when the public transportation makes it possible to reach many workplaces, even if these differ from the workplaces customarily reached by private car.

The lower the index value, the more it reflects a situation where the number of work opportunities reachable by public transport is lower than the number of work opportunities reachable by car. Using a relative index, rather than an absolute one, allows us to control for the town location: Residents of a more distant town are more likely to have fewer employment opportunities, but this relative view is focused on ways to reach places of employment by public transport, given the geographical location.

3.2. Data

This analysis is based on Social Survey data for 2014, 2015, and 2016, which included a specific question about how the employee reached their place of work (by: car, bus, train, transportation provided by employer, bicycle, walking, no single mode of transport or working from home). Surveyed samples in these years included 4,701, 4,569 and 4,429 employees (respectively) who reported their travel to a workplace rather than working from home; based on the survey weightings and after eliminating under-sampled towns (see below), these represent 92 percent of all employees represented in the CBS Labor Force Survey.

Table 4

The distribution of localities by frequency of their appearance in surveys and range of representative employment size

In how many surveys sampled in 2014–16	Number of localities	Ranges of employees represented	
		Minimum	Maximum
Every year	129	782.3	240429.0
Two out of three	73	523.4	9868.5
One out of three	261	220.1	10298.8
Total localities	**463**		

SOURCE: Based on the Social Survey conducted by the Central Bureau of Statistics for 2014–16.

In these years, 463 localities were surveyed, of which only 129 were represented in all three years. The other localities were only represented in one or two of these three surveys. Table 4 shows details of locality distribution by frequency of their appearance in the surveys and the employment size.

In order to avoid—at least in part—reaching conclusions based on small numbers of respondents reporting public transport use, in our geographical analysis we only refer to home localities where at least five residents were sampled who travel to work by car, public transport or by employer-provided transport. This leaves us with 350 towns out of 1,215 towns in Israel for geographical analysis, but as noted above, these account for 92 percent of overall employment.

Based on the population of these localities, we analyze 780 unique pairs of "home locality – job locality" generated for employees reporting public transport use (bus / train), of which 699 routes are outside the home locality, and 2,760 pairs of "home locality—job locality" generated for employees reporting private car use, of which 2,498 routes are outside the home locality.[8] Between 3.5 percent and 4.2 percent of the employed persons in these years did not report the locality of their employment.

In order to address this issue, we performed our processing in two versions: First – by eliminating observations with missing code of the destination locality; Second—by using a Multiple Imputation[9] for missing destinations. This procedure enables statistical inference of categorical values based on known values of home locality, type of destination locality and reported travel time. Comparing results of these two versions shows that imputation prevents the creation of outliers in accessibility indices calculated at the level of the locality, resulting in a more cohesive geographical distribution. Analysis of locality clusters found no significant differences between the two calculation versions.

Both in the geographical analysis and in analysis of individual factors, we use travel time, rather than travel distance, to characterize the alternatives available for employees to choose. The reason for this is that unobserved travel attributes impact the travel time. For example, the travel distances

[8] Only 3.5 percent to 4.2 percent of employees who responded in these years did not explicitly report their town of work.

[9] See FCS method, which allows missing observations to be attributed for a category-based variable: van Buuren, S., Brand, J. P. L., Groothuis-Oudshoorn, C. G. M., and Rubin, D. B. (2006), "Fully Conditional Specification in Multiple Imputation," *Journal of Statistical Computation and Simulation*, 76, 1049–1064.

available to us are distances between town centers (based on Google Maps data). Hence the variance of travel time and distance within the town, as part of a route that also includes travel between towns, is not accounted for. This is a disadvantage, because intra-town variance[10] in travel time is significant. There may also be differences in travel time due to unobserved elements, such as time to reach the public transport station / car parking location, waiting time for the bus or train, hour of leaving for work and time lost to traffic jams.

Even for the 350 preselected localities, an issue of under-represented small localities remains and may lead to unreliable individual accessibility indices. Therefore, further in our study, we move from discussion of individual specific localities to discussion of clusters of localities, in which the number of observations is far greater.[11]

3.3 Estimation results and prominent patterns

Table 5 reports the estimation results of the gravity equation (2) in two versions: "gravity(1)" with fixed effects for home and job localities, and "gravity(2)" with two continuous explanatory variables: the peripherality index of the home and the job locality. This version was estimated as an alternative version, due to concerns about over-parametrization and convergence issues for "gravity(1)".

[10] For example, it may be the case that individuals choose to work in a neighboring town because they reside close to the border between that town and their town of residence.

[11] Calculations for clusters are based on all observations therein, rather than on the average values for specific localities.

Table 5

Results of the estimation* of gravity equation (2) in two versions: gravity(1)–with fixed effects and gravity(2)–with a peripherality index******

Parameters	Private vehicle		Public transportation	
	Gravity(1)	**Gravity(2)**	**Gravity(1)**	**Gravity(2)**
c	-5.6204 ***	-2.1771 ***	-3.354 ***	-0.8659 ***
		[-15.143]	[-6.813]	[3.933]
α	-0.0162 ***	-0.0171 ***	-0.0176 ***	-0.0187 ***
	[-10.074]	[-5.012]		[-4.584]
fe(o), fe(d)	... ***		... ***	
r(o)	***	-0.5992 ***	***	-0.5123 ***
		[-9.704]		[-7.643]
r(d)	***	-0.6487 ***	***	-0.3613 ***
		[-10.274]		[--4.817]
R^2 -adj	0.5345	0.3422	0.4879	0.4203
N obs.	1159	1159	300	300

*Square brackets under the parameter values are the t-stat values; *** represents a significance level of Pr(>|t|)<0.001.

**The gravity(1) specification builds on fixed effects of the origin locality *fe(o)*

****The gravity(2) specification builds on peripherality indices of the origin

SOURCE: Based on the Social Survey conducted by the Central Bureau of Statistics for 2016 and locality statistics of the Central Bureau of Statistics.

The parameters were estimated based on survey data for 2016; observations with no locality code reported were eliminated for the purpose of this estimation; the number of observations on the bottom row of this table is the number of unique pairs of "home locality—destination locality" found, based on the survey, for each mode of transport.

In terms of quality of the explanatory variables, the disadvantage of "gravity(2)" is that the peripherality indices—based on CBS data—are not available for some of the localities in the sample; for these towns, we attributed a value based on peripherality indices of nearby localities validated also with sub-district averages.

Based on model fit statistics, we chose "gravity(1)" to set the decay parameters on which we base the accessibility calculation, in conformity with formula (1): $\alpha = -0.0176$ for public transport and $\alpha = -0.0162$ for private car.

The difference in these parameters means that increasing travel time by public transport and by private car, say by 30 minutes, has greater (negative) effect on the probability of travel by public transport than on the probability of travel by car.[12]

As soon as the decay parameter α for travel flows by car and by public transport is evaluated, we can incorporate in formula (1) travel times between all pairs of home and destination localities relevant for public transport and private car mode, as well as the scope of employment in destinations, and calculate the accessibility values by each transport mode. We can then calculate—based on formula (3)—the relative accessibility for each of the 350 home localities in our sample.

Table 6

Share of employees by the relative accessibility values

Relative acessibility	Number of localities	Share of employed persons (%)
0.00-0.10	55	5.5
0.10-0.20	20	4.4
0.20-0.30	31	8.4
0.30-0.40	25	15.1
0.40-0.50	25	21.3
0.50-0.60	25	19.1
0.60-0.80	23	9.8
0.80-1.00	7	1.4
>1	18	3.0
Only private vehicle	120	5.6
Not estimated	866	8.2

As previously stated, we calculated the index only on the basis of home localities from which at least five residents were sampled who travel to work by public transportation or by private car (excluding on foot or by bicycle). As a result of this filtering, and also because many localities were not sampled in the survey, our assessments include only 350 out of 1,215 localities in Israel, but these represent approximately 92 percent of the entire population.

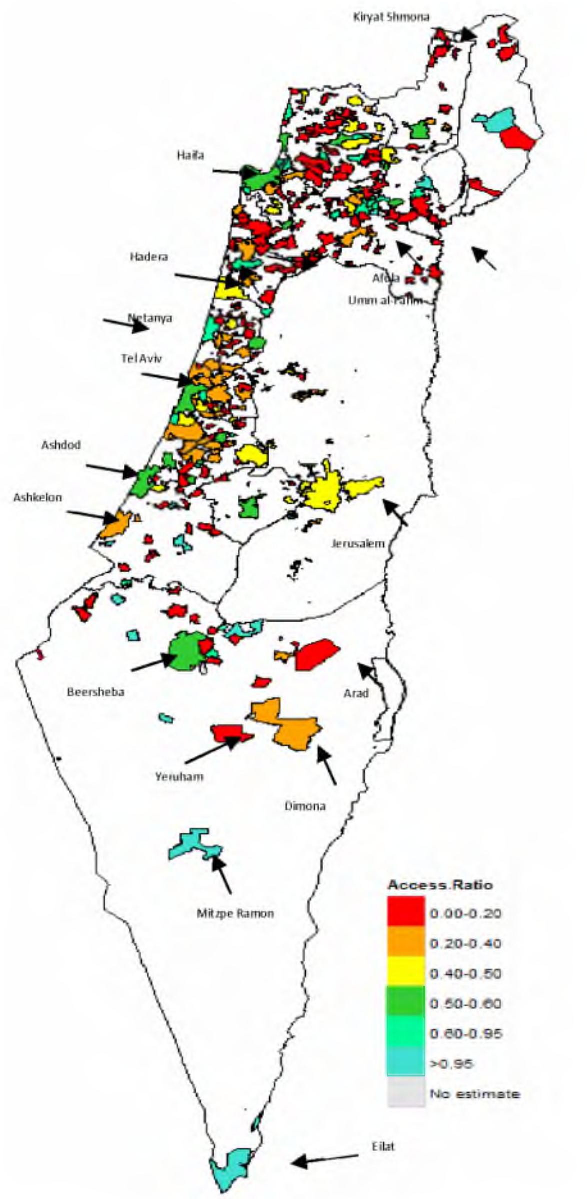
SOURCE: Based on the Social Survey conducted by the Central Bureau of Statistics for 2014–16.

[12] It is not possible to deduce the statistical significance of the difference between these two parameters by a simple test, because these were estimated using two distinct equations for distinct populations; it is possible to deduce the sensitivity of town mapping results to this parameter, and in particular – to the move to a uniform decay parameter for travel by public transport and car.

For illustrative purposes, if the relative accessibility in town i is 0.1, then the (weighted) number of places of work reached by its residents by public transport is one-tenth the number of places they can reach by car; if the relative accessibility is 1, the number of such places is equal.

Figure 1

Geographical Distribution of the Relative Accessibility Index



SOURCE: The Social Survey conducted by the Central Bureau of Statistics for 2014–16.

Table 6 shows the distribution of employees in Israel by ranges of relative accessibility, and reflects significant variance between the localities. Figure 1 shows the geographical distribution on a map, highlighting the fact that localities with lower accessibility are found mostly in peripheral areas and on the outskirts of Gush Dan (the greater Tel Aviv area). By this calculation, the relative accessibility of public transport does not exceed 0.5 for 60.4 percent of employees in Israel (including those in localities with only private car use reported), and is even lower than 0.2 for 15.5 percent of employees. We note that according to the findings in literature, the scale of accessibility indices is apparently sensitive to how detailed the data is; accessibility differences increase the higher the geographic resolution and travel characteristics taken into account (such as: travel durations in peak hours, connections and transfers between the types of public transport; see Benenson, et al., 2010).

An important attribute of public transport we have yet to refer to is the service frequency. The question arises as to what extent is the service frequency (of buses, for this matter) correlated with accessibility indices we have calculated above? According to research by Mavoa, et al. (2012) based on data for New Zealand, correlation was found between these two attributes for urban areas during peak hours; otherwise, these two attributes are not correlated, but rather complement each other.

In order to conduct a similar test, based on data for Israel, we used a database from the Ministry of Transport, containing details of bus travel during peak hours for all pairs of "home locality—destination locality" we have used to calculate the accessibility indices. Based on detailed data in this database, we created variables that characterize the travel frequency in either direction during peak hours (6am to 9am and 3pm to 6pm), on weekdays, for all service providers[13], and the travel density during peak hours (number of passengers departing from home locality during peak hours, by profile of trip (inside/outside the locality), relative to the number of bus stops in the home locality).

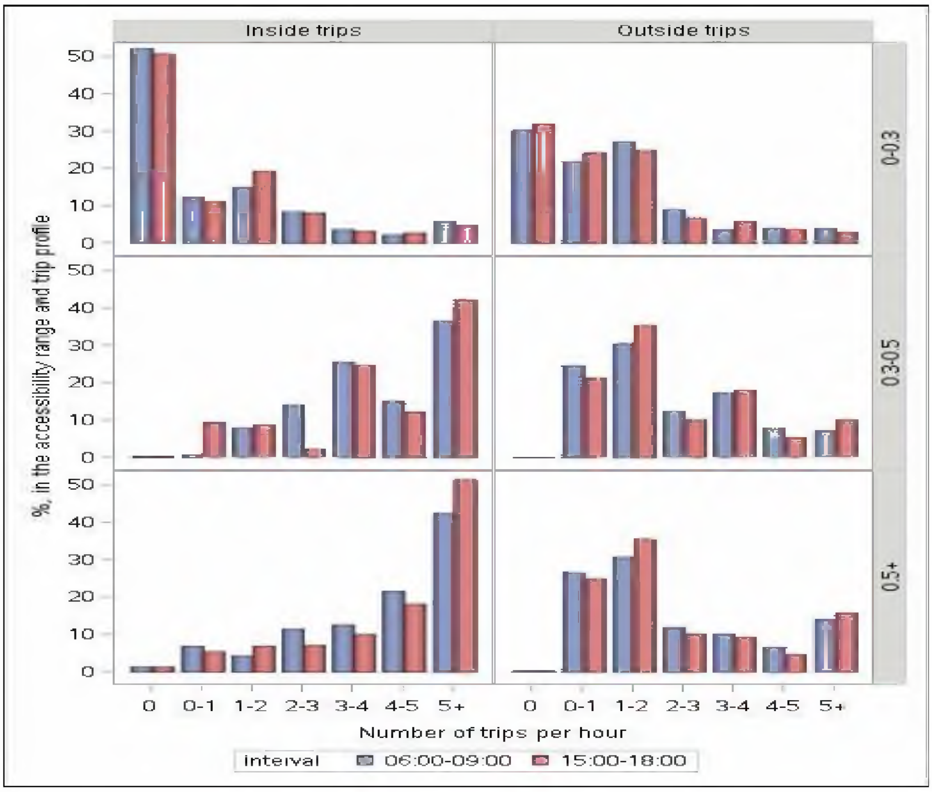
Figure 2 shows histograms of service frequency (buses), calculated in terms of number of buses per hour, grouped as follows: "0" shows no buses for the given hourly range; "0–1" shows intervals of 1 hour or longer of bus availability; "1–2" shows intervals of 30–60 minutes (1–2 buses per hour); "3–4" – intervals of 15–20 minutes; "4-5" – intervals of

[13] For most directions, there are one or two primary service providers.

12–15 minutes; "5+" – intervals shorter than 12 minutes (at least 5 buses per hour). The incidence of service frequencies shown in this figure are calculated for ranges of accessibility indices of the towns[14] (Y axis, right-hand side) and are weighted by travel volume per bus stop in each town. This figure offers more detail with regard to grouping of trips from each origin town, by in-town and out-of-town trips (right and left columns of this figure).

Figure 2

Histogram of Frequency of Service (Buses, Number of Trips per Hour) During Peak Periods (Morning and Evening) by Range of Relative Accessibility of the Locality and Trips Profile (intra-locality and inter-locality)



SOURCE: Based on the Social Survey (Central Bureau of Statistics) and data on line/supplier from the Ministry of Transport and Road Safety.

[14] The average service frequencies are calculated for all localities connected to the home locality by bus routes—as opposed to calculation of accessibility indices, which is based on distribution of destinations relevant to the home locality in terms of only work-purposed trips, and weighted by employment size in the destinations.

This figure shows a correlation between service frequencies and relative accessibility for an inside profile of trips (right-hand panel of the charts): For a low accessibility range (up to 0.3 on the relative accessibility index[15], top-most chart), in-city buses are likely to arrive in peak times once an hour, if that, with a probability greater than 50 percent; for medium/high accessibility ranges (right-hand panel, two bottom charts), buses are 40–50 percent likely to arrive at a frequency of 5 buses per hour, which means that intervals during peak hours are of 10–15 minutes. As for outside trips (left-hand panel in Figure 2), the top-most chart (low accessibility range) shows a 30-percent probability of no buses and 20-percent probability of 1 bus per hour. In the higher accessibility ranges in the left-hand panel (outside trips) there is no indication of improved service frequency, other than the probability of no buses at all is lower. However, the mass of likelihood is concentrated around intervals of a bus once every 30 minutes or longer. This finding is consistent with patterns of transport use, as we define in our analysis below in this paper. As this analysis shows, high accessibility ranges with no intensive use of employer-provided shuttles is typical of large cities, with mostly inside trips.

The comparative analysis we presented up to this point does not take account of shuttles provided by employers, but in some localities, these are used more than public transport. In order to account for both and to identify notable patterns of transport use, we divided the employee population into three equal parts (weighted by population size), corresponding to the intervals of relative accessibility (0–0.29, 0.30–0.51 and over 0.51) and shares of shuttle users in the locality (0–2 percent, 2–7 percent, and over 7 percent).

Consequently, five patterns are discerned (in brackets: the percentage of employees belonging to each group):

None (19.7 percent) – localities with a relative accessibility below 0.296 and the share of shuttle users below 2 percent. In this group, work-purposed trips are mainly conducted by car outside the home locality;

[15] Threshold values for the relative accessibility were determined as the percentiles, while the employee population is divided into three equal groups.

Shuttle (11.2 percent) – localities with a relative accessibility below 0.296 and the share of shuttle users above 7 percent. This pattern indicates the possibility that employers who provide the organized transportation replace inefficient public transport;

Public Transportation (PT) (9.2 percent) – localities with a relative accessibility above 0.509 and the share of shuttle users of 2 percent or less

Both (12 percent) – localities with a relative accessibility above 0.509 and the share of shuttle users above 7 percent. This pattern indicates the presence of public-transport alternatives for employer-provided transportation;

Non-clustered (48 percent) – all other towns.

Figure 3 shows these five patterns by region. As is apparent, the *Shuttle* pattern is strongly represented in Arab localities (mostly in the North region) and the *None* pattern is more prevalent in smaller Jewish (non-Orthodox) settlements. Table 7 shows these phenomena quantitatively.

Table 7 presents additional indicators, all of which are calculated for all residents in localities belonging to the patterns defined above, with the exception of the travel profile (the question of whether the employees work in their locality or outside of it).

These indicators characterize localities in terms of supply of transport services (ratio of number of bus stops to area, access to bus and train, satisfaction with public transport[16]), standard of living and economic conditions (percentage of households with income higher than NIS 4,000 per person and satisfaction with area of residence).

Table 7 shows that in the *None* and *Shuttle* clusters, many travel out of town (77 percent and 66 percent, respectively) and the level of public transport services is relatively low (according to the number of bus stops per area unit, bus and train access and the efficiency index).

However, these groups differ by their socioeconomic characteristics. The *None* group mostly consists of small Jewish (non-ultra-Orthodox) localities with a high socioeconomic

[16] Survey respondents were asked to rate the degree to which they agree with the statement "It is indeed possible to travel by public transport within a reasonable time from my place of residence to my destination", on a scale from 1 to 4. We checked what percentage of respondents gave the highest rating.

rating[17] (according to the satisfaction with the area and the percentage of households with per-capita income of more than NIS 4,000), and the low use, as well as the low availability of public transport may reflect consumer preferences. In contrast, the low accessibility indices for the *Shuttle* group apparently reflect limited public transport. Therefore, it is reasonable to assume that employer-organized transport replaces public transport, meaning that employers assume the responsibility for providing transport to their employees.

The localities in the *PT* group typically have above-average socioeconomic rating and public transport supply. Table 7 shows a higher percentage of employees working inside these localities. In the *Both* group, the socioeconomic ratings are lower and Orthodox employees are over-represented (10.5 percent, with the average being 7.5 percent – these figures are not shown in the table).

Table 7

Patterns of transport use for work-purposed trips, by travel profile, socioeconomic level, and the public transport service in the localities

Patterns of transport use[3]	Share of employed people among those surveyed in the age group 25-65 (%)	Percentage of employyes working in their home locality	Satisfaction[2] from: (% of all respondents in the locality)				Percentage of households[2] with income per capita above NIS 4,000	Number of bus stops (normalized in the areas of the locality)[4]
			Efficiency of public transportation in locality	Residential area	Proximity to a train station	Proximity to bua s stop		
None (19.7)	80.1	22.9	2.3	90.1	6.7	7.9	44.8	6.1
PT (9.2)	82.9	57.4	10.2	91.2	10.8	30.0	47.8	25.5
Shuttle (11.2)	63.9	33.8	7.4	78.2	3.8	13.3	20.1	8.5
Both (12)	70.4	53.7	7.7	77.5	7.1	21.1	22.7	11.2
Non-clustered (48)	78.7	39.7	9.4	84.6	9.0	24.0	38.7	11.1
Total	75.9	41.0	8.9	83.7	8.0	21.2	29.9	11.4

1 The official Socioeconomic Index of the Central Bureau of Statistics is not available for some of the localities surveyed, and therefore we use the share of households with income per

2 Satisfaction with the efficiency of transport in the locality and with proximity to where they live relates to all the interviewees (not only employees), and is calculated on the basis of the share indicating the highest level out of 4.

3 In parentheses—the percentage of employees living in localities with this pattern.

4 Calculated on the basis of data provided by the Ministry of Transport on buses in the locality.

SOURCE: Based on the Social Survey conducted by the Central Bureau of Statistics for 2015 and Ministry of Transport and Road Safety data for 2017.

17 Table 5 provides more detail, showing that this group also includes Arab towns (14.4 percent of the population of towns in this group). These towns typically have a low socioeconomic rating, with 12 of these towns located in the North region.

Table 8 presents geographical distribution of defined patterns. Panels A and B show that the relative accessibility in metropolitan core cities (0.4-0.8) is higher than in satellite cities[18] (0.3-0.5), a phenomenon that is well known in research in transport geography. It is also notable that satellite cities of Haifa and Jerusalem typically have higher use of shuttles (11.1 percent and 7.4 percent, respectively).

In the periphery, relative accessibility is low. Thus, for example, in the North district it is 0.26 on average. Around half of the localities in the North district are Arab (61 of 128) and their relative accessibility is only 0.23 on average. Conversely, the use of employer-provided transportation in this area is very high: 16.7 percent on average and 18.2 percent for Arab towns. In the Haifa district, localities in Wadi Ara are notable: They have very low relative accessibility, along with intensive use of shuttle transportation to work places. In the Negev district, as well, the *Shuttle* pattern is also particularly common.

Panel C in Table 8 shows that the relative accessibility in Arab localities is low (0.25 on average) with half of them (48.8 percent) having employer-provided transportation as dominant. Figures 1 and 2 highlight the fact that Arab localities tend to have very low relative accessibility across all districts.

Panel C shows very low accessibility indices (0.21 on average) for small Jewish (non-ultra-Orthodox) localities characterized by the *None* pattern (the prevalent pattern in localities populated by 67 percent of the residents in localities such as these). As shown in Table 7, these localities are mostly characterized by a high standard of living and great satisfaction with the area of residence, hence we may assume that the little use of public transport may stem from consumer preferences, rather than from lack of infrastructure. In other words, given the size of these localities and their location, the service level that may be provided to them at a reasonable cost is far lower than the level that would cause residents with high income make use of such service to a considerable extent.

[18] Based on CBS definitions.

Figure 3

Relative accessibility patterns and the use of shuttle transportation, by region

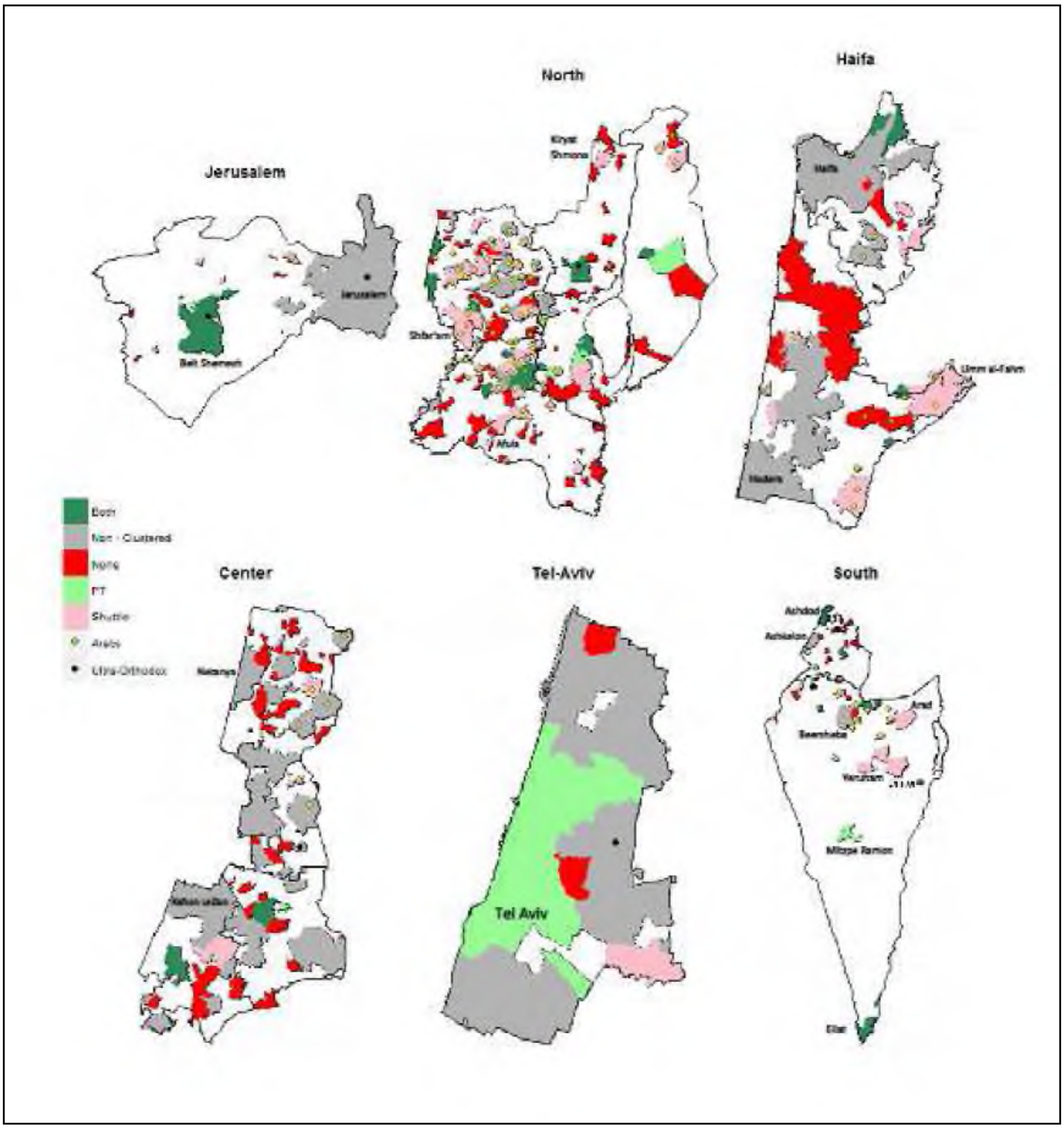


Table 8

Patterns of getting to work according to region

Locality groupings	Average relative accessibility index	Characteristic travel patterns	Representation of travel patterns[1] in the locality grouping
Panel A: Metropolises and large cities			
Jerusalem	0.50		
Haifa	0.59		
Tel Aviv	0.54	*PT*	Average for city
Be'er Sheva	0.50		
Rishon Le'Tzion	0.39		
Petah Tikvah	0.36		
Ashdod	0.59	*Both*	Average for city
Netanya	0.76		
Panel B: Satellite towns[2]			
Tel Aviv region	0.39	*Shuttle*	4.1%
		None	6.7%
Jerusalem area		*Both*	31.6%
	0.28	*None*	22.2%
		Shuttle	9.1%
Haifa area		*Both*	26.9%
	0.49	*Shuttle*	9.0%
		None	4.9%
Panel C: Periphery towns			
Jewish localities in the periphery with 20,000–100,000 residents and ultra-Orthodox share <10%		*Both*	19.90%
	0.36	*Shuttle*	16.20%
		None	2.90%
Arab localities	0.25	*Shuttle*	48.8%
		None	14.0%
		PT	4.5%
		Both	2.6%
	0.21	*None*	66.6%
Small, Jewish, non-ultra-Orthodox localities (up to 20,000 residents and ultra-Orthodox share <10%)		*PT*	8.5%
		Shuttle	7.7%
		Both	2.6%
Panel D: Ultra-Orthodox towns and localities			
Nine towns and localities with ultra-Orthodox share >25%)			
		Both	48.7%
	0.60	*PT*	8.2%
		None	1.2%

[1] The percent of employed people living in localities with the mode of transportation listed in the column on the left out of total employed people living in the locality grouping; the Nonclustered pattern is not represented and totals to 100 percent of the grouping.

[2] According to the Central Bureau of Statistics definition for “satellite towns” under the “Metropolises in Israel” grouping.

SOURCE: The Social Survey conducted by the Central Bureau of Statistics for 2014–16.

4. Individual factors in choosing the transport mode

4.1. Specifications of discrete choice model and description of explanatory variables

We have analyzed above the geographic distribution of localities by relative accessibility of public transport while getting to workplaces. As noted, this distribution reflects the temporary equilibrium between mutually selected places of residence and places of employment, according to the existing level of public transport. Given this endogeneity, the question arises as to the extent to which the choice of transport mode is affected by social and economic demographic characteristics of the employee, such as differences in income / economic status and incentives for using cars, and/or by the proximity and convenience of transport in the area.

For this analysis, we use a Discrete Choice model, which allows us to estimate the probabilities of choosing different transport alternatives for each survey respondent, using the respondent's individual features, recorded in the survey as explanatory variables. This model enables evaluation of these marginal effects by establishing a statistical link between the utility that would be gained from each transport alternative and the individual characteristics of the employee, while controlling on the alternative-specific attribute, i.e., travel time. The utility levels remain undefined in this model: only differences in utilities are relevant for deriving the choice probabilities; thus, one of the transport alternatives (say, use of private car) is assigned to be set as the baseline option.

To describe this model more specifically, let us group the explanatory variables as follows:

- Geodemographic characteristics, such as home locality, job locality, gender, age group, household, belonging to the ultra-Orthodox or Arab communities, marital status (single head of household, with children up to 5 years old);
- Income factors ((higher) education, employment status, wages, housing density);
- Incentives for using cars (ownership of a car and driver's license, car expense benefit or company car benefit);
- Access to public transport (proximity to place of residence and service frequency);

- Fixed effects of home localities, classified into 13 types of localities, in accordance with definitions in the CBS localities file[19];

The utility U_{kl} that employee k gains from choosing alternative l (l = 1,..7), according to the available options predefined in the survey questionnaire (car, bus / shared taxi, train, employer-provided shuttle, bicycle, walking or other) is defined as follows:

$$U_{kl} = c_l + \beta t_{kl} + \gamma_l x_k \qquad (4)$$

Where:

c_l, β, γ_l	–	parameters for estimation;
t_{kl}	–	travel time by l for respondent k; β – generic parameter which refers to travel time as an alternative specific attribute;
x_k	–	vector of individual characteristics of respondent k;
γ_l	–	vector of parameters of individual effects, depending on alternative.

Below we provide more information about these parameters.

The intercept C_l expresses the systematic gaps in choice probabilities when individual effects have been eliminated i

The vector of parameters γ_l refers to marginal effects of individual-specific characteristics, which vary depending on the alternative l;

The parameter β is a generic parameter of the travel-time effect the analysis below shows that travel time is the decisive factor of choice probabilities, but it is mostly captured by the differences between the intercepts c_l.

Based on (4), the model estimates the probability of choosing an alternative $l \;\; (l = 1,..7)$ by deriving maximum utility over other alternatives, while taking into account random disturbances, as follows:

$$P(l) = \Pr(U_l + \varepsilon_l \geq U_m + \varepsilon_m), \quad m \neq l \quad (5)$$

[19] See https://www.cbs.gov.il/en/mediarelease/Pages/2019/Localities-in-Israel-2008-2017.aspx Introduction and definitions).

Where ε_l , ε_m reflects a random disturbance with distribution assumptions that affect the specification; assuming that these disturbances have an *i.i.d.* distribution across the alternatives, the probability $P(l)$ is calculated as follows:

$$P(l) = \frac{\exp(U_l)}{\sum_{s=1}^{7} \exp(U_s)} \qquad (6)$$

The probabilities in (6) sum up to 1, when the utility from choosing the baseline option is set to 0. The probabilities defined by (6) are not sensitive to the baseline option assignment, but the parameters in (4) do depend on it. Generally, we estimate the model by using the option of "other use" (predefined in the questionnaire) as a baseline one, since this obviates the need of matching alternative travel times. However, this setting does not isolate enough the income effect. To obtain sharper contrasts in parameters responsible for income effects, we re-estimate our model by considering "private car" as a baseline option and eliminating the "other use". (Table 10). We show that different specifications of the utility function (4) lead to fairly close fitted choice probabilities.

Let us briefly elaborate on the calculation of the explanatory variables of the utility function in formula (4).

We refer to travel times reported by survey respondents by intervals as a categorical variable using the 7 dummy variables (utility shifters) accordingly. We also show that use of a continuous time variable (in minutes), obtained by repeated draws from the reported time intervals (assuming uniform distribution over the interval) results in similar parameters.

In order to specify the travel time as a generic variable that enables comparison between alternatives, we will need to provide the model with travel times by alternative mode to what was actually chosen and reported by the survey respondent. The following section 4.2 addresses this issue.

The demographic and socioeconomic characteristics of the respondents are categorical variables, the format if which is predefined, in the survey questionnaire. We translate the most into dummy variables, pointing out a feature that may have importance in model estimation, such as: higher education, self-employed, working up to 34 hours per week, parents with children aged 5 or under, single head of household). We also apply dummy variables to encode the access to public transport basing on satisfaction scores (scaled from 4 to 1) reported by survey respondents regarding the proximity of bus stop / train station to the place of residence and the service frequency. Concerning the latter, we encode the negative effect of insufficient frequency by mapping the "relevant" respondents, i.e., jointly reported attempting to use the bus / train (from once or twice per week to irregular use) and low satisfaction with the service frequency.

As from 2014, travel time by transport modes, as well as geodemographic and socioeconomic characteristics of survey respondents are available from the Social Survey as "core variables"; indicators of public transport infrastructure (station proximity, service frequency and so forth) were surveyed once in the 2015 survey as an "extended topic". This restricts us to using the only cross section of 2015 for estimation.

Let us consider different model specifications that have been estimated.

- A basic model—with no individual effects—attempting to explain choice probabilities exclusively based on differences in travel time, so that the utility function (4) does not include alternative-specific intercepts. This specification helps to test to what extent the time effect is "inflated" compared to more realistic specifications;
- A basic model with alternative-specific intercepts incorporated in the utility function, as well as variables controlling access to bus stop / train station, service frequencies, car availability and benefits from use of a car.
- An extended Multinomial (conditional) Logit model (hereinafter: "MNL"), which controls all individual characteristics described above, as well as fixed effects of types of home locality (based on the CBS categorization).

These three models assume Independence of Irrelevant Alternatives ("IIA"), meaning the relative probability of someone choosing between two alternatives is independent of any additional alternatives in the choice set or, in other words, independence of shocks ε_l , ε_m . $l \neq m$ which precludes a hierarchical choice. This assumption may be too strong, and it is commonly recommended to be tested for a Discrete Choice specification. Having studied some examples of nests proposed in literature, we suggest the following specification of hierarchical choice (Nested logit) which is supported by our data (the fourth model):

- A Nested model, which divides choices into two groups: shuttles and private car vs. all other alternatives, assuming that the shocks affecting the utilities within the first group are correlated due to varying importance of public transport alternative—a geographic phenomenon described in the first part of this study.
- Finally, we also tested a Mixed logit specification, which allows for randomization of the travel time effect in (4); we tried to assess the extent of its range through simulations while sampling this parameter from a normal distribution.

4.2 Estimated travel time by alternative modes of transport

According to specification (4)-(5), the individual's choice depends on the travel time over all the alternatives in the choice set. However, the alternative times remain unknown, since the survey did not include a question such as: "How long would it have taken had you chosen public transport instead of car, by bus? by train?"

In order to access travel times by modes alternative to the one actually chosen, we first have to acknowledge that not all alternatives in the choice set are available to the survey respondent. Table 9 lists the probabilities of finding alternative transport modes to the one actually chosen—by choice—calculated based on survey data. Thus, for example, row 1 in the table shows that an employee who chose to use a private car could have very likely (95.7 percent) also used a bus, but in only 20.8 percent of cases do they have a train alternative and in 10.4 percent – employer-provided shuttle. For bus users, using the train is likely for less than half the employees (43.6 percent). The bicycle and walking alternatives depend on the percentage of employees who work within their town of residence or nearby; for employees who actually chose to travel to work by car or bus, the walking alternative is only available in 31.7 percent and 41.6 percent of cases, respectively, and the bicycle alternative – in 19.4 percent and 38.7 percent, respectively.

Table 9

Shares of employees (in %) who have an alternative way of getting to work to the one actually chosen, by transport modes (based on the number of surveyed people in the Social Survey for 2015)

Actual transport mode	Number of people surveyed	Adjustment rate (%), by alternative means of arrival					
		Private vehicle	Bus	Train	Employer shuttle	Bicycle	Walking
Private vehicle	2661		95.7	20.8	10.4	19.4	31.7
Bus	718	98.9		43.6	17.1	38.7	41.6
Train	78	98.9	98.9		21.6	5.7	4.4
Employer shuttle	397	85.6	80.3	14.6		6.9	23.1
Bicycle	80	78.1	70.3	41.4	26.8		84.2
Walking	389	88.3	62.3	28.7	24.3	40.2	

SOURCE: Based on the Social Survey conducted by the Central Bureau of Statistics for 2016, Google Maps.

The availability of alternative transport modes was compiled using several data sources. First, for each respondent reporting the use of some transport mode for getting to work from the home to the job locality, we pick from the Social Survey data for 2014–16 another one reporting another transport mode between these localities. The 2015 survey was the preferred source, since it enables to enhance the similarity by providing additional data about proximity of the employee's residence to bus/train station.

We found additional data using Google Maps and Moovit[20] travel times by bus and train between some pairs of "home locality–job locality" reported to be covered with a car. Similarly, for employees reporting the use of bus, train or any other mode, corresponding travel times by car have been retrieved for given pairs of localities. Note that we could rely on Google Maps and Moovit only for respondents reporting the travel outside their home locality; then, the time of travel between the town centers was taken. In a case of travel to work within the home locality, this source of data does not help, since the survey does not provide details on the residential and work address.

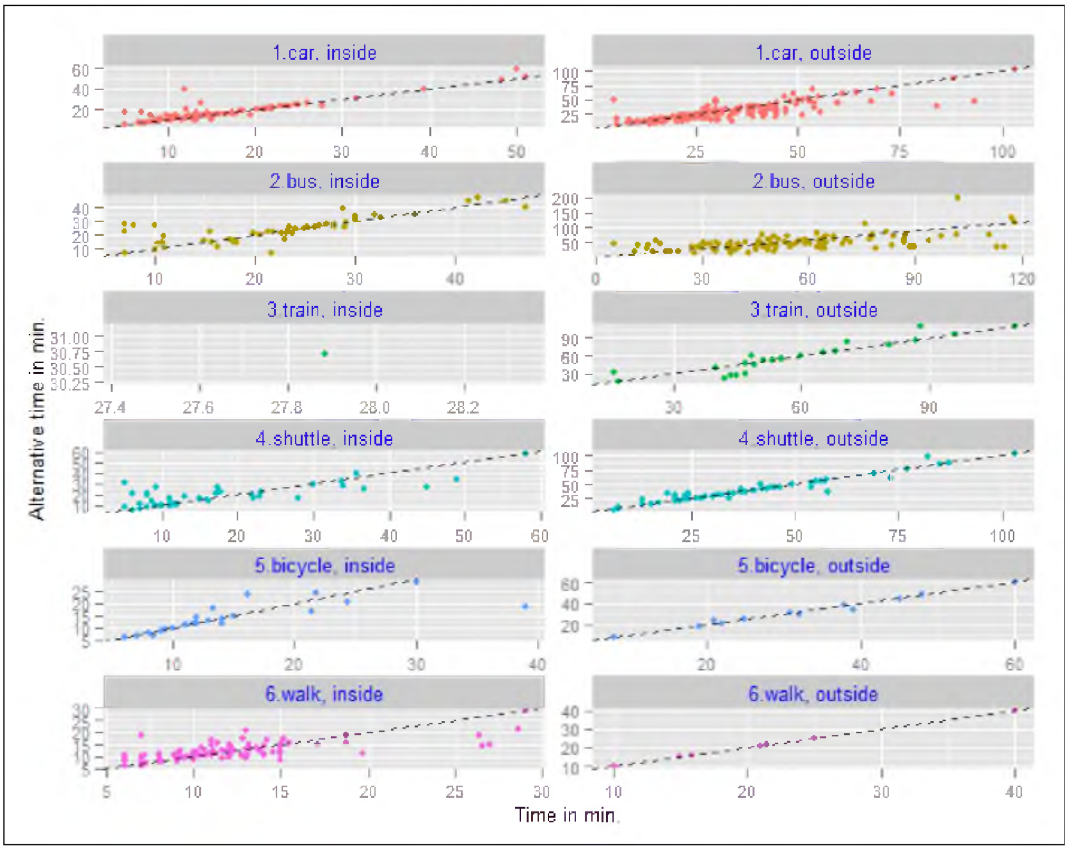
Figure 4 shows how close travel times retrieved from our matching procedure are to those that have been actually reported by transport mode and travel profile (inside/outside the home locality). It scatters between the (average) travel time evaluated for the specific

[20] An app used to plan travel from one location to another by various modes of transport, including combinations thereof.

"home locality–job locality" pair while using the same transport mode as actually reported (X axis) and as alternative one (Y axis). The closer the points are to a 45-degree line, the better the match with the alternatives.

Figure 4

Scatter diagram of actual travel times and travel times retrieved from matched alternatives, by transport modes and travel profile (actual/evaluated travel times for each "home locality–job locality" pair are shown as weighted averages)



4.3.Estimation results

Table 10 lists the (log) values of the likelihood function and the elasticity parameter of the travel time for specifications with continuous travel times (in minutes). Controlling for the individual characteristics significantly improves the likelihood, while as shown in our further analysis the variance in the choice probabilities is mostly explained by alternative-specific constants, as well as car ownership/benefits, access to public transport and service frequency. Note some deterioration in the likelihood statistics when going from the MNL to the Nested and Mixed logit specification due to exclusion of fixed effects of home locality, causing convergence issues. However, the correlation coefficient of remainders within the alternative grouping is 0.19, and is significant at 5 percent—a finding that does not support the IIR assumption and provides indication of hierarchical choice.

The narrow range of the elasticity obtained in the Mixed model does not indicate great importance of random (individual-specific) factors on the choice probabilities.

Table 10

Comparison between the model specifications regarding the elasticity of the travel time (ß) and the likelihood statistics (with travel times defined as a continuous variable)

Model specification	β	t-stat	Values seen, in logs	R^2 McFadden
Basic, without constants	-0.018	(-15.021)***	-3857.3	0.27
Basic, with constants	-0.004	(-6.331)***	-2558.9	0.49
MNL	-0.005	(-5.837)***	-2038.3	0.62
Nested	-0.004	(-2.459)**	-2179.6	0.59
Mixed (median of distribution)	-0.004 (-0.003 – 0.005)		-2184.6	0.59

** and *** represent significance levels of 1 percent and 0.1 percent, respectively.
The Nested model and the Mixed logit model do not include fixed effects of the type of home locality as they are included in the MNL.
The median of the estimated distribution (posterior). In parentheses—the 5th and 95th percentiles of the distribution.
SOURCE: Authors' computations.

Travel times have little effect on the choice of transport, but are statistically significant. The elasticity estimated from the basic equation—without alternative-specific constants—is biased upwards, meaning an increase in choice probability by two percentage points for each 1-minute reduction in travel time. Alternative-specific constants incorporated reduce the magnitude of this parameter more than four times, while keeping its statistical significance.

The elasticity we derived (-0.004 - -0.005) is lower than the parameter of (-0.006) per minute, obtained in a similar model by Hoogendoorn et al. (2015), based on survey data for 2013–15 in the Netherlands. This result should come as no surprise: shorter travel times for unavailable alternatives should not affect the choice. According to this finding, a great portion of choice probabilities variance is set endogenously, based on mutual selection of place of residence and place of work—given the existing level of public transport—and explained by differences between alternative-specific constants.

The weak parameter of travel time elasticity may be somewhat explained by mismatched alternative travel times, since in our matching procedure we have not been able to account for many factors having impact on travel time, such as: departure time, number of connections between modes of public transport and changing from car to bus or train. We may also have been able to obtain more robust time estimates had the survey respondents been asked to list and rate alternative modes of transport (first choice, second choice, third choice), as described in the questionnaire by Liu (2006).

In further testing we have conducted, we found no substantial differences between the likelihood statistics, while evaluating travel time either continuously (in minutes) or through dummy variables (utility shifters), based on intervals predefined in the survey questionnaire. Since the latest parameters do not reveal much difference between the time intervals and remain significant at a 0.1 percent level, they are not listed in Table 10.

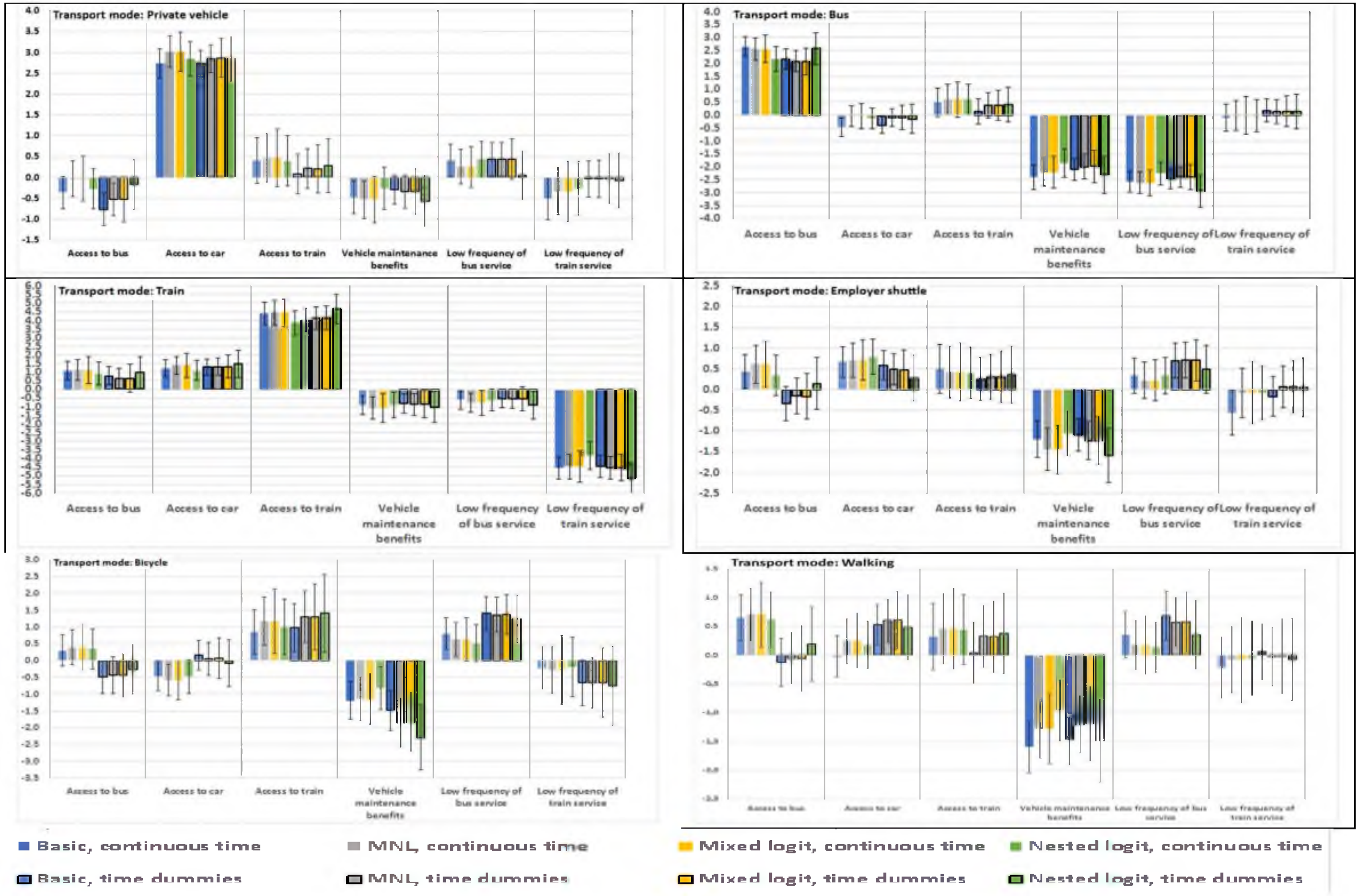
Figure 5 allows a comparison between the main effects, obtained under different specifications of the model described in section 4.1, while the baseline option was set on "Other". The factors to be compared are listed on the X-axis, and the corresponding parameter is expressed by the height of columns.

The standard deviation of each parameter is indicated by a line departing from the column. Each of the 8 specifications is in a separate color (see legend), with specification differences due to use of continuous/categorical travel time indicated using the same color, either framed/unframed. Parameters that are non-significant (higher than 5 percent) are shown in transparent color.

As shown in the figure, the parameters are similar between the specifications in direction, intensity and significance. This finding allows us to focus on one of the specifications—MNL with categorical (interval-based) travel times—to discuss the marginal effects calculated relative to using a car (Table 11).

Figure 5

Parameters of main effects, by transport mode and model specification (listed in the legend)



The top panel in Table 11 shows the significant negative effect of owning a car and having a driver's license on choosing alternatives to a car, and that car expense benefits provide an incentive to using a car over using a bus, organized shuttles and walking. Concerning trains, the low significance of this factor may be interpreted as a mixed effect, since using trains often requires one to use a car to get to the train station, in absence of convenient or frequent bus service.

Proximity of bus/train station to the place of residence (in terms of satisfaction scores) has a significant positive effect on the probability of choosing a bus/train; dissatisfaction with service frequency has a significant negative effect. We also documented a significant positive effect of information service on the probability of choosing a bus.

Table 11 also indicates that women are more likely to use the bus and less likely to use organized shuttles and bicycles. The probability of choosing organized shuttles (relative to using a car) is negatively correlated with being self-employed, working part-time and having higher education, and is positively correlated with belonging to the Arab community—this finding is consistent with our geographic analysis.

The income effect is expressed by significant negative parameters of car ownership and car expense benefits (which are common for high-income respondents) on probabilities of choosing bus or shuttles, as well as these probabilities are found positively correlated with low income and high residential density.

We found no significant effect of being the sole head of the household and/or of having young children.

Table 12 lists several marginal effects due to the major contrasts found.[21] Just owning a car and having a driver's license reflect an 82 percent probability of the employee choosing to use a car to travel to work, whereas for those who do not own a car, this probability drops to as low as 15.5 percent. The probability of employees who do not own a car using a bus is 42 percent, compared to a mere 4 percent for car owners. Car expense benefits increase the incidence of using a car by 33 percentage points (from 53 percent of all employees, to 87 percent), and reduce the incidence of using a bus from 20.5 percent to 2.3 percent, and

[21] Based on Nested specification with category-based travel times.

of using organized transport – from 10 percent to 2 percent. The car expense benefit has no significant marginal effect on the incidence of choosing a train.

Proximity of a bus stop to the place of residence increases the probability of choosing a bus by nearly 30 percentage points and reduces the probability of choosing a car by nearly 40 percentage points; we also found a positive marginal effect of proximity of a train station to the place of residence, which increases the incidence of using a train four-fold. Naturally, these incidences also reflect the employees' choice to reside in places appropriate for their preferences with regard to mode of travel to work.

Table 11

Individuals' characteristics (t-stat values in parentheses) from the MNL model, with categorical travel times and Fixed Effects for residential locality type

Independendent variables/means of travel	Bus		Train		Employer shuttle		Bicycle		Walking		Other	
Ownership of private vehicle and vehicle maintenance benefits												
Ownership of private vehicle, has driver's license	-3.065 (-19.862)	***	-1.851 (-4.205)	***	-2.333 (-11.303)	***	-3.623 (-9.173)	***	-2.829 (-16.229)	***	-2.829 (-6.406)	***
Vehicle maintenance	-1.703 (-5.885)	***	-0.996 (-1.775)	*	-0.878 (-3.315)	***	-0.534 (-0.925)		-0.849 (-2.932)	***	0.743 (-1.412)	
Access to public transportation (satisfaction) and frequency of service (dissatisfaction)												
Proximity to bus stop	2.532 (14.26)	***	1.83 (3.591)	***	0.772 (3.283)	***	1.126 (2.557)	**	0.801 (3.81)	***	0.946 (1.756)	*
Proximity to train station	0.08 (0.38)		3.601 (7.337)	***	-0.099 (-0.359)		0.799 (1.383)		0.018 (0.071)		-0.975 (-1.512)	
Frequency of bus service (low)	2.839 (15.807)	***	1.225 (2.783)	***	0.086 (0.377)		-0.08 (-0.209)		0.098 (0.501)		0.478 (0.953)	
Frequency of train service (low)	-0.384 (-1.902)	*	4.01 (7.522)	***	-0.261 (-0.965)		-0.009 (-0.016)		-0.191 (-0.795)		-0.941 (-1.555)	
Information on traffic arrangements	0.783 (4.703)	***	0.691 (1.69)	*	0.459 (2.021)	**	0.745 (1.975)	**	0.518 (2.658)	***	0.486 (0.954)	
Demographic characteristics												
Gender: female	0.273 (1.864)	*	-0.132 (-0.317)		-0.569 (-2.936)	***	-2.125 (-5.363)	***	-0.088 (-0.522)		-1.199 (-2.61)	***
Parents (children up to age 5)	0.144 (0.76)		0.512 (1.066)		0.013 (0.056)		1.367 (2.79)	***	0.385 (1.834)	*	0.395 (0.714)	
Age cohort: 25-34	-0.106 (-0.444)		-0.812 (-1.248)		0.284 (0.908)		0.267 (0.399)		-0.492 (-1.723)	*	1.4 (1.597)	
Age cohort: 35-44	-0.301 (-1.158)		-1.129 (-1.563)		-0.105 (-0.307)		-0.646 (-0.894)		-0.289 (-0.99)		1.014 (1.08)	
Age cohort: 45-64	0.012 (0.051)		-2.109 (-2.743)	***	0.104 (0.34)		0.073 (0.114)		-0.301 (-1.102)		0.185 (0.204)	
Age cohort: 65+	0.305 (0.879)		-1.646 (-1.513)		-0.17 (-0.305)		0.832 (1.081)		-0.508 (-1.231)		1.852 (1.742)	*
Study at academic institution	-0.097 (-0.644)		0.337 (0.809)		-0.785 (-3.763)	***	-0.789 (-2.078)	**	0.236 (1.382)		-0.259 (-0.555)	
Ultra-Orthodix	0.152 (0.54)		0.533 (0.714)		0.094 (0.22)		-0.734 (-0.838)		0.509 (1.763)	*	0.123 (0.135)	
Arab	-0.09 (-0.376)		-0.706 (-0.591)		0.617 (2.287)	**	0.493 (0.54)		-0.158 (-0.634)		0.071 (0.09)	
Individual characteristics: Socioeconomic												
Gross wage: NIS 0-4,000	0.771 (2.835)	***	0.518 (0.546)		-0.086 (-0.214)		-0.158 (-0.26)		0.646 (2.14)	**	0.22 (0.238)	
Gross wage: NIS 4,001-7,500	0.095 (0.386)		0.007 -0.01		0.096 (0.269)		-0.588 (-1.1)		0.192 (0.698)		0.152 (0.2)	
Gross wage: NIS 7,501-14,000	-0.12 (-0.453)		-0.091 (-0.118)		-0.041 (-0.107)		-0.404 (-0.738)		0.097 (0.335)		-0.051 (-0.064)	
Gross wage: NIS 14,001-2,1000	-0.412 (-1.193)		0.897 (1.093)		0.184 (0.419)		-0.572 (-0.879)		-0.627 (-1.642)		-0.689 (-0.775)	
Employment status: Self-employed	-1.419 (-4.135)	***	-0.499 (-0.616)		-4.477 (-3.607)	***	-0.537 (-1.016)		0.546 (2.276)	**	-0.266 (-0.375)	
Part-time work (up to 35 hours per week)	-0.36 (-1.987)	**	-0.475 (-0.769)		-1.236 (-4.383)	***	0.723 (1.583)		0.066 (0.336)		0.115 (0.205)	
Housing density: Medium (1-2 people per room)	0.233 (1.481)		-0.07 (-0.159)		-0.145 (-0.727)		-0.116 (-0.299)		0.258 (1.433)		-0.314 (-0.672)	
Housing density: High (2+ people per room)	0.781 (2.475)	**	-0.163 (-0.147)		1.072 (2.699)	***	-0.503 (-0.579)		-0.226 (-0.614)		-0.615 (-0.622)	

This table presents the parameters that were estimated relative to the "private vehicle" alternative, in order to highlight the significant income effect. For simplification, fixed effects and parameters for dummy variables reflecting travel times are not presented. *, ** and *** represent levels of significance of 5 percent, 1 percent and 0.1 percent, respectively.

The 7 intervals for travel times were taken in accordance with the survey questionnaire, as follows: Up to 15 minutes; 15–30 minutes; 30–45 minutes; 45–60 minutes; 60–90 minutes; more than 90 minutes; inconsistent time. Statistically significant parameters were received for the dummy variables representing the reported travel times for each interval, which are not presented for simplification.

SOURCE: Bank of Israel.

Other findings:

- Bus service frequency found to be insufficient by the survey respondent reduces the probability of choosing a bus from 21.5 percent to 6 percent. Train service frequency found to be insufficient by the survey respondent reduces the probability of choosing a train from 2.4 percent to 0.7 percent.
- Men tend to choose a car more than women do (65.8 percent compared to 54.7 percent), whereas women tend more to choose the bus (23 percent compared to 10 percent).
- Employees from a lower socioeconomic level[22] tend to use a car less (55.8 percent, compared to 80.8 percent for employees from a higher socioeconomic level, tend to use a bus more (18.7 percent compared to 7.7 percent) and tend to use employer-provided shuttles more (10.6 percent compared to 3.2 percent). However, when it comes to using a train, this ratio is reversed: 3 percent for higher socioeconomic background, compared to 1.3 percent for lower socioeconomic background.

Table 13 shows further indication of the high willingness to use the train, even among car owners. This table shows that whereas the nationwide incidence of using the train is 3 percent, among commuters who own a car and who have train stations near their place of residence and in the town where they work, the percentage of those traveling by train to work is as high as 13 percent (for men—17 percent). Concurrently, where there is a train route available, use of a car to travel to work decreases from 82 percent to 68 percent (for men—from 85 percent to 65 percent).

[22] According to our calculations, based on low income, lack of higher education, high residential density, low per capita income in the family and being from the Arab community.

Table 12

Selected marginal effects*, based on forecasted choice probabilities (x1,000)**

Effect/Travel mode		Private vehicle	Bus	Train	Employer shuttle	Bicycle	Walking
Access to bus[1]	No	76.85 [0.62]	5.55 [0.27]	0.94 [0.15]	7.86 [0.41]	1.18 [0.16]	6.52 [0.33]
	Yes	38.02 [0.91]	34.14 [0.87]	2.72 [0.28]	10.87 [0.56]	2.81 [0.30]	12.52 [0.44]
Access to train[2]	No	62.84 [0.70]	15.76 [0.51]	0.7 [0.08]	8.85 [0.38]	1.45 [0.16]	9.18 [0.40]
	Yes	55.03 [1.13]	18.42 [0.85]	4.11 [0.45]	9.79 [0.58]	2.87 [0.37]	8.66 [0.59]
Frequency of bus service[3]	Insufficient	58.6 [0.73]	5.94 [0.61]	1.81 [0.18]	13.83 [0.34]	3.41 [0.14]	14.98 [0.32]
	Sufficient	61.53 [1.05]	21.53 [0.33]	1.62 [0.27]	6.89 [0.75]	1.13 [0.40]	6.22 [0.78]
Frequency of train service[4]	Insufficient	58.71 [0.95]	18.73 [0.74]	0.68 [0.08]	9.18 [0.52]	2.42 [0.29]	9.12 [0.53]
	Sufficient	61.85 [0.77]	15.05 [0.54]	2.36 [0.24]	9.08 [0.44]	1.48 [0.18]	8.97 [0.43]
Access to car[5]	No	15.5 [0.59]	42.05 [1.01]	1.78 [0.26]	16.02 [0.79]	4.24 [0.43]	18.31 [0.64]
	Yes	82.32 [0.47]	4.23 [0.18]	1.64 [0.18]	5.8 [0.30]	0.71 [0.10]	4.56 [0.27]
Vehicle maintenance benefits/company car[6]	No	53.3 [0.69]	20.49 [0.54]	1.74 [0.17]	10.24 [0.41]	2.19 [0.20]	10.9 [0.41]
	Yes	86.83 [0.75]	2.28 [0.26]	1.46 [0.29]	5.1 [0.49]	0.68 [0.19]	2.31 [0.34]
Gender	Men	65.82 [0.78]	10.4 [0.47]	1.64 [0.19]	11.36 [0.52]	2.6 [0.26]	6.74 [0.39]
	Women	54.69 [0.90]	23.44 [0.74]	1.73 [0.22]	6.6 [0.41]	1.03 [0.16]	11.62 [0.55]
Socioeconomic status[7]	Low	55.75 [0.68]	18.68 [0.52]	1.35 [0.14]	10.55 [0.40]	2.02 [0.19]	10.37 [0.40]
	High	80.8 [1.06]	7.73 [0.68]	3.04 [0.47]	3.25 [0.41]	1.19 [0.28]	3.54 [0.49]
Total distributions							
Actual		60.81	16.41	1.78	9.07	1.83	8.89
MNL with fixed effects		60.58	16.53	1.68	9.12	1.86	9.03
Nest without fixed effects		60.46	16.6	1.7	9	1.84	9.15

* In square brackets: standard deviations for average choice rates for each variable.

** Based on MNL model.

[1] Binary variable assigned the value 1 ("Has access") for respondents who answered "Very satisfied" or "Satisfied" to the survey question "Are you satisfied with proximity of the bus stop to your place of residence?"

[2] Binary variable assigned the value 1 ("Has access") for respondents who answered "Very satisfied" or "Satisfied" to the survey question "Are you generally satisfied with location of the train station? Such as: accessibility, arranged parking spaces".

[3] Binary variable assigned the value 1 ("Insufficient frequency") for respondents who reported infrequent use of a bus (i.e., respondents who, in response to the question: "In the past 12 months, how often did you travel by bus?" gave one of the following answers: "Once or twice a week", "once or twice a month", "less than once a month", "once a month" or "infrequent use") and who expressed their dissatisfaction with the frequency of inter-city buses (i.e., in response to the question: "In general, are you satisfied with the frequency of inter-city buses in your town of residence?" gave one of the following answers: "Not so satisfied" or "Not at all satisfied").

[4] Binary variable assigned the value 1 ("Insufficient frequency") for respondents who reported infrequent use of a train (i.e., respondents who, in response to the question: "In the past 12 months, how often did you travel by train?" gave one of the following answers: "Once or twice a week", "once or twice a month", "three or more times a year", "fewer than three times a year" or "infrequent use") and who expressed their dissatisfaction with the frequency of trains (i.e., in response to the question: "In general, are you satisfied with the frequency of trains you have used?" gave one of the following answers: "Not so satisfied" or "Not at all satisfied").

[5] Binary variable assigned the value 1 ("Has") for respondents who answered "Yes" to the question "Do you have available for your use a private car or a commercial vehicle (up to 4 tons in overall weight)?"

[6] Binary variable assigned the value 1 for respondents who answered "Yes" to one or more of the following two questions: "Do your terms of employment include: Contribution towards car expenses?" and "Do your terms of employment include: A company car provided for your use?"

[7] A survey respondent of low socioeconomic background is one who meets one or more of the following criteria:

Respondent who, in response to the question "Average (gross monthly) income per person in the household, in NIS", gave one of the following answers: "Up to NIS 2,000" or "NIS 2,001-4,000".

Respondent who answered "No" to the question "Have you studied towards an academic degree in educational institution?"

Respondent who gave one of the following answers: "Up to NIS 2,000", "NIS 2,001-3,000", "NIS 3,001-4,000", "NIS 4,001-5,000", "NIS 5,001-6,000", "No income" or who did not answer the question: "In the past month, what was your gross income (before deductions) from all your places of work?"

Source: Bank of Israel.

Table 13

Forecasted probabilities[a] of choosing a train, bus, or private vehicle

Reference group		Train	Bus	Private vehicle
Panel A: Total employed people except those for whom no residential locality is identified				
Own a private vehicle and hold a driver's license	No train station[3]	0.70%	4.30%	85.30%
	Yes train station	4.10%	6.20%	76.50%
Own a private vehicle and hold a driver's license, work outside their residential locality	No train station	0.90%	3.70%	89.20%
	Yes train station	5.50%	5.70%	78.80%
Own a private vehicle and hold a driver's license, identify a train option[2]	No train station	3.50%	6.50%	82.00%
	Yes train station	12.90%	7.40%	68.00%
Panel B: Only men				
Men: Own a private vehicle and hold a driver's license	No train station	0.70%	3.20%	85.10%
	Yes train station	4.00%	4.70%	78.80%
Men: Own a private vehicle and hold a driver's license, work outside their residential locality	No train station	0.90%	3.00%	88.50%
	Yes train station	5.30%	4.70%	76.60%
Men: Own a private vehicle and hold a driver's license, identify a train option[c]	No train station	5.40%	4.10%	84.40%
	Yes train station	17.10%	5.60%	65.40%

[1] Based on the Nested specification, which includes categorical travel times in which the deleted category is "Other".
[2] Identification of the possibility of using a train is based on the origination locality-destination locality combination.
3 Based on identification of access to train, as defined in Table 12.

SOURCE: Bank of Israel.

5. Summary and conclusions

1. This study presents estimates for accessibility to places of work by public transport, calculated relative to accessibility by private car from Israeli localities. These estimates are based on the distribution of work destinations, as represented in the Social Survey of 2014–16. Comparing localities by the relative accessibility index allows the isolation of the geographical factor in the choice of transport mode and the identification of prominent choice patterns.
2. It is important to note that although the 2015 Social Survey (which included an extended transportation topic) is a rich data source for nationwide analysis; its questionnaire should be enhanced. For example, further precision is required with regard to using a car as driver or passenger; options should be provided for reporting

connections such as "car-train" or "car-organized transport"; additional question should be added to describe the time when the trip (forth and back) takes place, as well as the second choice of the transport mode. There should also be consideration of conducting a more comprehensive, special-purpose survey once every few years.

3. For most employees (around 60 percent) the relative accessibility was less than 0.5, meaning that the employment opportunities accessible to them via private vehicle are more than double the number accessible via public transportation. Between-locality variation of the relative accessibility may be under-estimated by our model due to average decay parameters derived from the gravitation model specified for low resolution of GIS data we use (town level only).
4. There is a positive ordinal association between relative accessibility and service frequency (of buses and shared taxis, in terms of number of trips per hour) for inside trips. For outside trips in localities with high relative accessibility, this relationship is not documented, due to the high share of travel to work in-town.
5. As the distance from the metropolis's core increases, the relative accessibility declines; prominent differences have been recorded even between core cities and peripheral cities within the metropolitan area. Thus, for example, the relative accessibility for public transport in Tel Aviv is 0.5, whereas in peripheral cities in the Gush Dan (greater Tel Aviv) metropolitan area it is only 0.39.
6. The need to address the issue of transportation in metropolitan areas is reflected in Government Resolution 3988, dated 2011, which stipulated that public transport authorities would be established—a national one and one for each metropolitan area. This matter was also discussed in reports by the Knesset.[23] This resolution has been partially implemented: The national authority was created, but the legislative memorandum with regard to creating public transport authorities for metropolitan areas has yet to be published. Creating metropolitan authorities may assist efficient planning of public transport infrastructure in metropolitan areas, resulting in increased use thereof.

[23] Knesset Research and Information Center, 2016.

7. In most outlying towns—and even more so in Arab towns—the relative accessibility is low, due to limited supply of transport services. In smaller Jewish outlying towns, accessibility is low but their higher socioeconomic standing may indicate that, considering the level of public transport that may be provided to such towns, the low accessibility is due to the fact that residents prefer to use their car. In cities and in Jewish ultra-Orthodox towns, relative accessibility is high.
8. The findings indicate that in peripheral localities, mostly in the North and South districts, and particularly in Arab ones, there is significant dependence on transport services provided by major employers. Eliminating this dependence, through development of an efficient public transport system in these areas, would enhance, over the medium and long terms, the employment options available to employees in outlying towns and would help reduce their dependence on major employers nearby. However, we should note that employer-provided transport also has the advantage of being efficient in terms of travel distance, travel time and cost for users. Another advantage lies in the fact that authorities may co-operate with employers in order to manage the demand for public transport, as is being done in various metropolitan areas around the world.[24]
9. The finding, whereby in Arab towns there is an extensive system of organized transport, weakens the claim that it is hard to provide them with effective public transport, due to their typical urban planning and topography. It is important for public transport planners to intensively study the features of employer-provided transport systems, and use this information for planning effective public transport in Arab towns, balancing current employment needs and the desire to enhance accessibility to other employment alternatives.
10. Model parameters obtained with regard to individual employee characteristics reveal a significant positive effect of proximity of bus/train station to their place of residence on the choice in favor of these transport modes; this finding highlights the importance of accessibility of places of residence and employment to inter-city public transport,

[24] For example, in Washington State in the US, a law was enacted in 1991 concerning management of demand for transportation, and Section 13 thereof lists various requirements from employers. http://lawfilesext.leg.wa.gov/biennium/1991-92/Pdf/Bills/Session%20Laws/House/1671-S2.SL.pdf?cite=1991%20c%20202%20%C2%A7%2010.

to promote the use of such public transport. We also found that car owners, and those entitled to car expense benefits from their employer, make significantly less use of public transport, and more use of their car, considering such employees' other attributes.

11. Low income and socioeconomic background are correlated with higher use of bus and organized transport—but not of train.
12. Use of train by car owners increased from 3 percent (on average) to 13 percent (17 percent for men) when they had access to use of the train—i.e., when a train connected the employee's home locality to their job locality.

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