Accounting for Equity in Transport Planning

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OECD Round Table
Broadening the Scope of Transport Appraisal
to Capture the Full Impact of Investments

הטכניון | **Technion**
מכון טכנולוגי | **Israel Institute**
לישראל | **of Technology**

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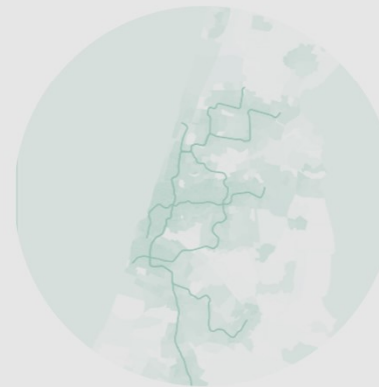| Introduction | Equity consideration in transport appraisal | Analytical framework | Israeli case studies |

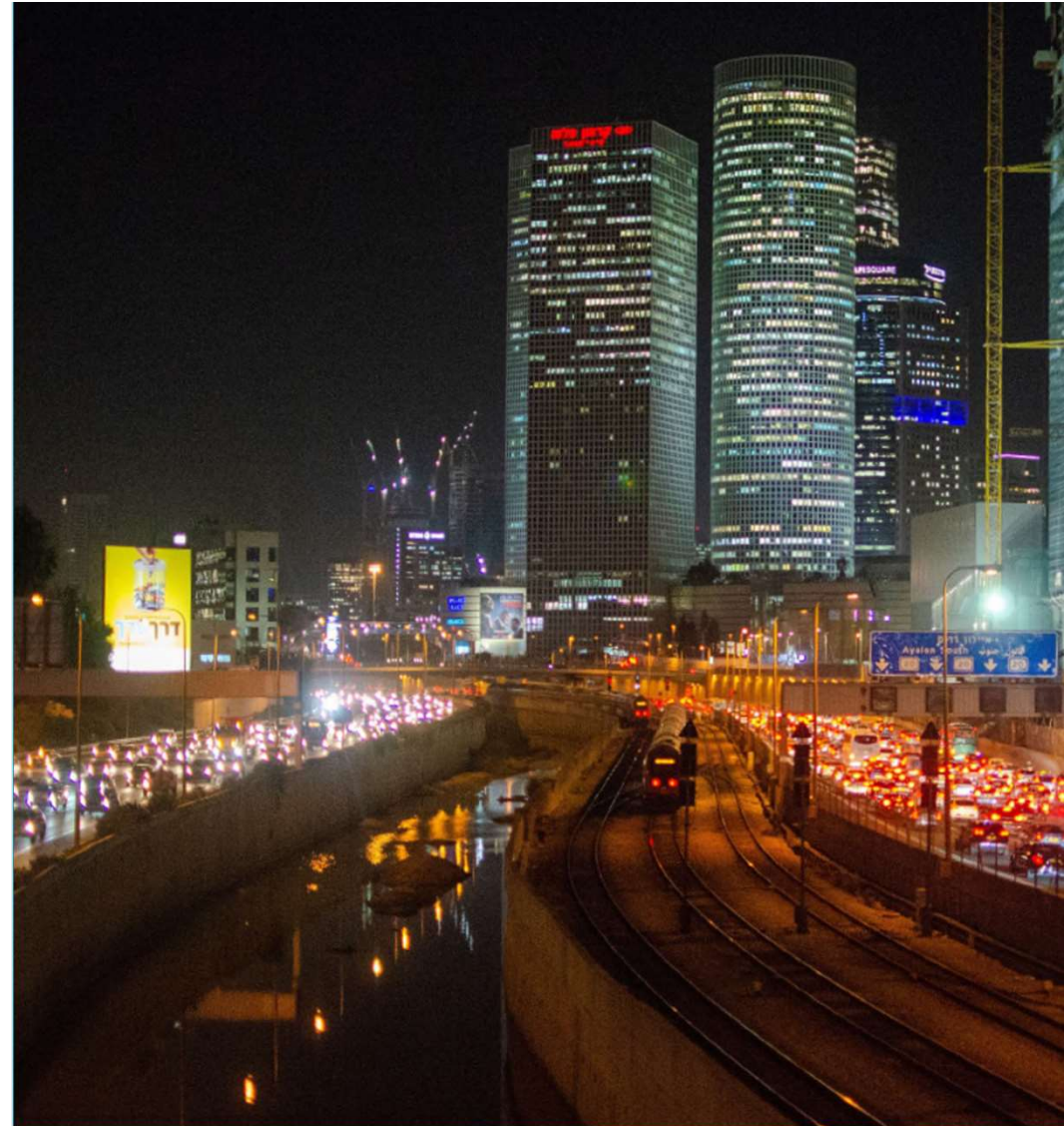| Introduction | Equity consideration in transport appraisal | The analytical framework | The Israeli case studies |

Introduction

- Three dimensions of equity:
  - Distribution (the 'goods' and 'bads' that people receive) – Our focus in Transport
  - Recognition (the way people are being addressed)
  - Representation (the ability of persons to impact decisions)
- Three core questions in relation to distributional equity:
  - Which goods and bads are the focus of the analysis?
  - Which population groups should be distinguished?
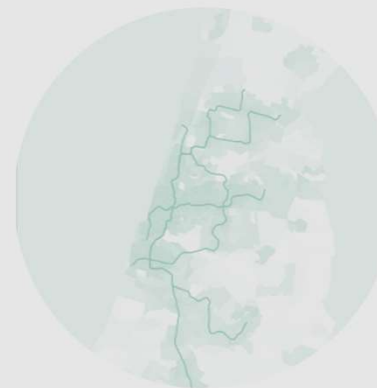 - What constitutes a 'morally proper distribution'

Introduction

Equity consideration in transport appraisal

The analytical framework
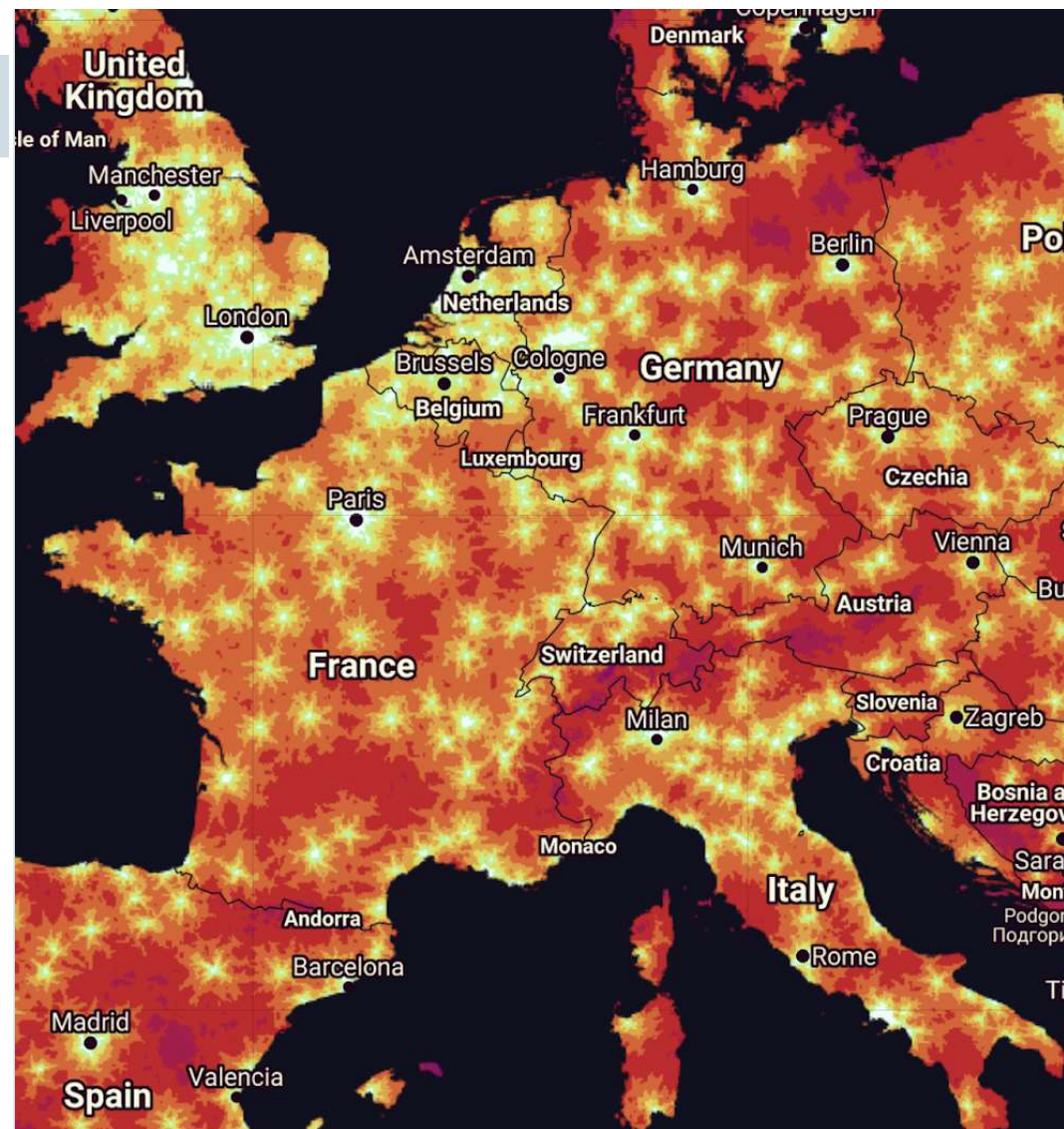
The Israeli case studies

The purpose of Transport Planning

1. **Effective and efficient movement (traditional)**
2. **Adequate accessibility for all**
3. **Other policy objectives**

The appraisal method is contingent on the purpose of transportation planning:

- CBA
- MCA
- Others/variations

CBA

- Maximize welfare -> CBA

- An aggregate measure - does not distinguish between certain groups or people

- Based on willingness to pay/Value of Time

- More trips -> more benefits

- Travel time saving as the main benefit

Equity consideration in transport appraisal

Equity in CBA

- The common approach:
  - Use of Equity values, mostly equity value of travel time or "Reverse" values
  - **There is no right answer**
- Still equity is not the objective function – more equitable projects might not be selected

Max social welfare (Efficiency) ←→ **Equity**

Aggregate   Distribution
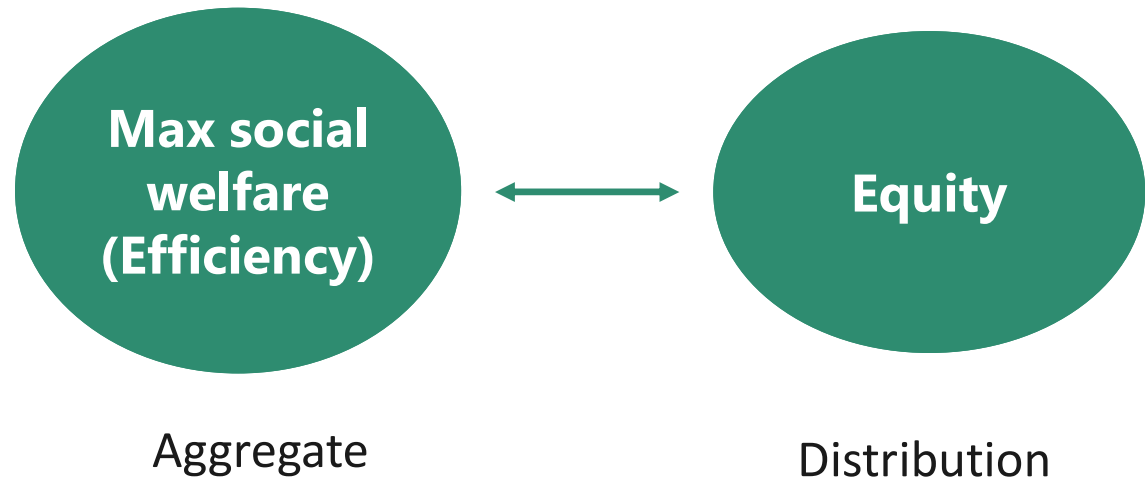
MCA

- The common approach that can address distribution
- Methods
  - Matrix of impacts
  - Creating and overall score based on weights
  - Stakeholder-specific weighting, resulting in multiple parallel outcomes
- Can account for various equity indicators (i.e., Gini)
- Also does not guarantee that (more) equitable projects score better then projects that are clearly less equitable

Adequate accessibility for all

- CBA and MCA do not guarantee the most equitable project selected because it is not the underlined objective
- Equity as a key goal of government policies
- Similar to other domains like education, housing, and health
- The purpose of transport systems is to provide adequate accessibility to all
- Equity in distribution of externalities/other impacts are of secondary importance
- Transport planning can then be redefined as "the field of governance that seeks to guarantee adequate accessibility for all through the regulation, operation, maintenance, and improvement of the transport system" (see Martens 2019).
- Accordingly, Equity should be the main objective from the initial stages of transport planning.

The purpose of Transport Planning and Policy - Summary

- **Effective and efficient movement as the purpose of transport planning**
  - Focus on the transport network and its separate links
  - Lead to projects that aim to enhance the functioning of the transport system
- **Adequate accessibility for all as the purpose of transport planning**
  - Focus on population groups
  - Lead to projects that aim to reduce the number of people experiencing inadequate accessibility

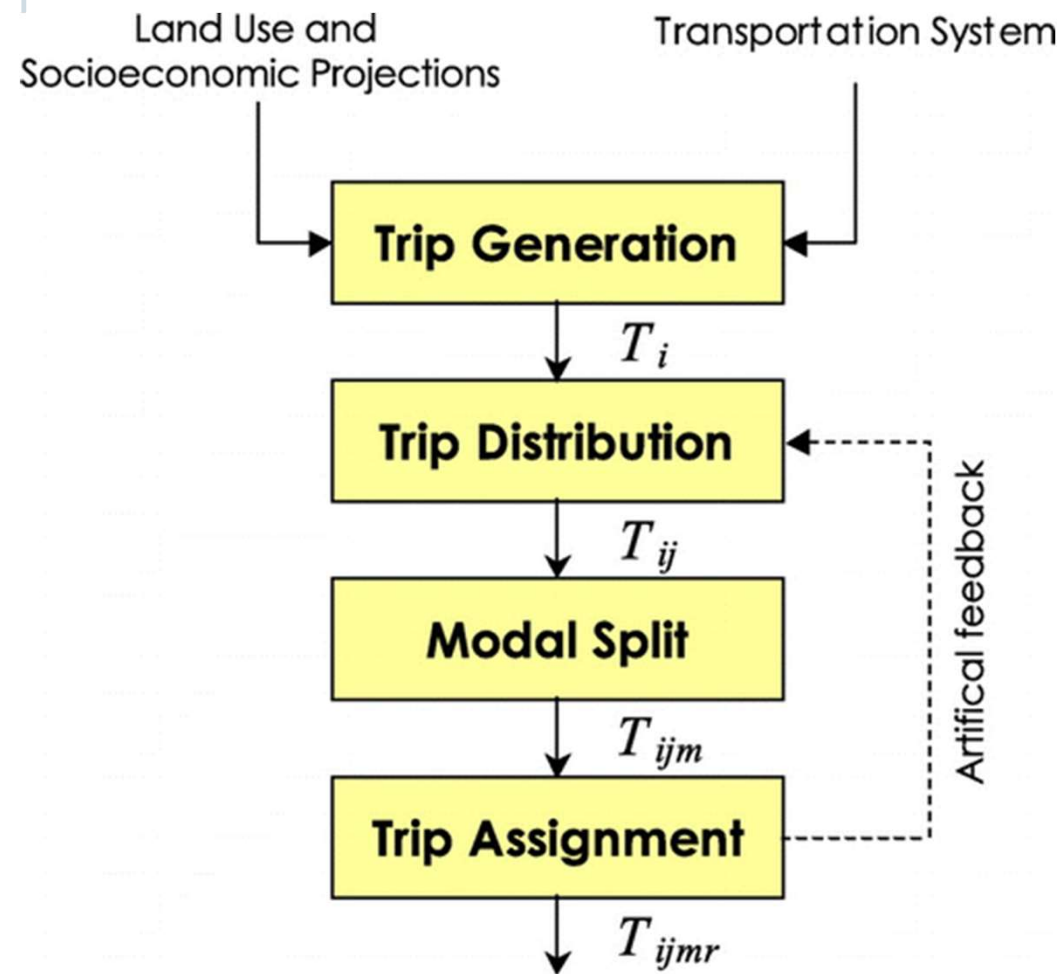| Introduction | Equity consideration in transport appraisal | The analytical framework | The Israeli case studies |

Traditional transport demand models

- The Four-Step model
  - From the 50s
  - Focus on the interstate highway
- Data
  - Travel habit survey
  - What people actually do/travel
  - Complementary data about network performance (speed, volumes)
  - No potential mobility data
- Aggregate
  - TAZ level
  - No distinction between populations group within TAZ
- The assumption of fixed demand
  - Over-estimate benefits to car users
  - Bias toward road projects
- The rule of a half

Land Use and Socioeconomic Projections   Transportation System

Trip Generation
T_i

Trip Distribution
T_{ij}

Modal Split
T_{ijm}

Trip Assignment
T_{ijmr}

Artifical feedback

Activity based models

- Disaggregate
  - Can analyze benefits by any group of population of interest
  - Can provide good equity measures for MCA
- Activity Based Accessibility Measure
  - Emphasis on accessibility rather than actual travel
  - Based on individual characteristic and preferences
  - Logsum based consumer surplus measure (De-Jong et. al., 2005)
  - Thus can be used in CBA
- Complicated and with limited practical application
  - Even metropolitan areas that use such models, do not yet use its full potential
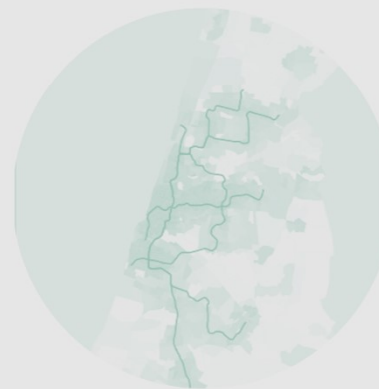
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Case Studies Content

The national appraisal framework

The Tel Aviv strategic public transport plan

Rail to the periphery

Case Studies

The national appraisal framework

The Tel Aviv strategic public transport plan

Rail to the periphery

The national appraisal framework

- The national appraisal framework for transport projects in Israel is based on cost benefit analysis (CBA).

- However, the national guidance documents requires presenting decision makers also with the main impacts separately in an MCA style.

- These impacts include accessibility, safety, environmental impacts, and various equity concerns.

- we present two distinct cases in which equity played an important role.

Case Studies

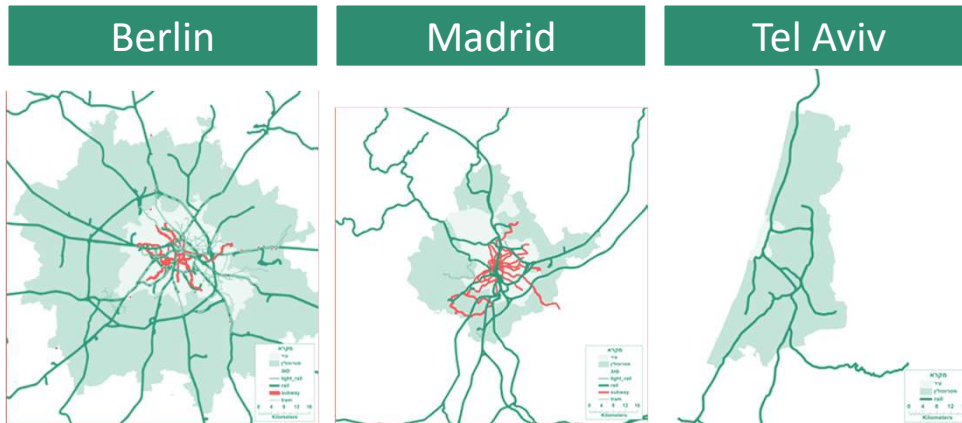The national appraisal framework

The Tel Aviv strategic public transport plan

Rail to the periphery

Tel Aviv Metropolis

- The metropolitan area of Tel Aviv is the largest metropolis in Israel with a population of over 4 millions

- Estimated population in 2040: 5.4 million

- Tel Aviv has limited mass transit system

Berlin	Madrid	Tel Aviv

Population **44%**

Work-places **50%**

Gross product **62%**

The Tel Aviv strategic public transport plan

The Tel Aviv strategic public transport plan 2040

- A Multi-Criteria Analysis (MCA) was conducted to assess the plan alternatives according to goals, criteria, and weights set by policy makers in the Mass Transit Committee (MTC).

- The four main criteria considered in the MCA analysis were:

- *Transportation* (40%): Accessibility, transit usage, transit speed, performance, and **social equity.**

- *Economic* (30%): B/C ratio, overall cost per transit user, percentage of operating costs covered by revenue, and agglomeration benefits.

- *Quality of life and the environment* (20%): Population coverage, number of transfers, reliability, land-use coherence, safety, and environment.

- *Feasibility* (10%): Both planning and implementing.
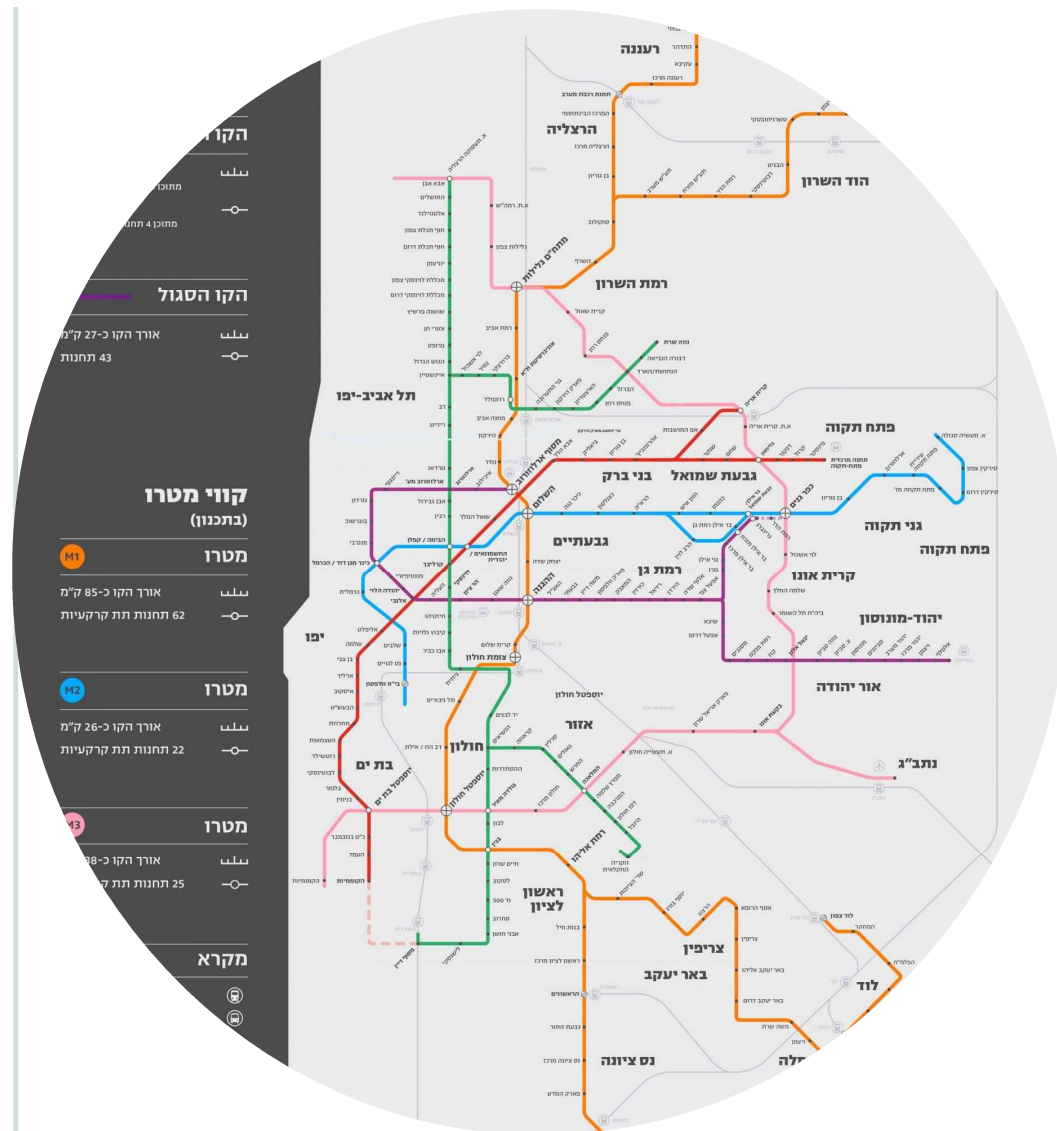
The Tel Aviv strategic public transport plan 2040

- The final plan is set as a radial-web network based on 3 metro lines and 3 light rail lines.

- The network was complemented with 3 bus rapid transit lines (BRT) forming an outer ring and providing local service on the edges of the urban area.
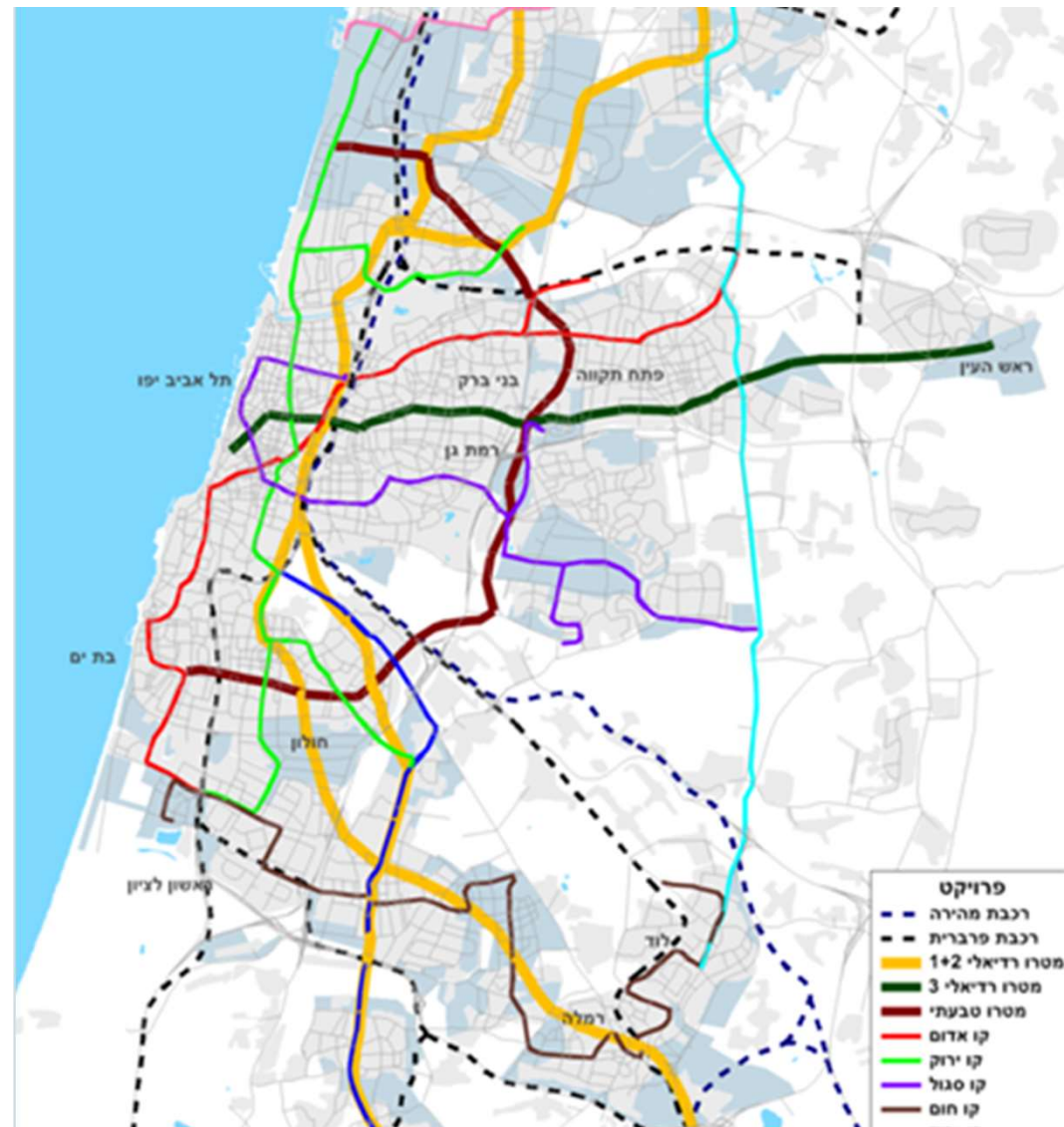
Analysis of areal accessibility

- First, we analyzed the impact of the strategic plan on the metropolitan accessibility by metropolitan zones and super-zones.

- Implementation of the strategic plan increases the average metropolitan accessibility significantly, for all travel time thresholds (30-60 minutes), and for all day periods.

Table 1: Accessibility levels* by public transport, for 2018 and for 2040 after implementation of the strategic plan

	30 min	45 min	60 min
Peak AM			
2018	9%	24%	39%
2040	20%	45%	64%
Off-Peak			
2018	11%	30%	45%
2040	22%	49%	66%
Peak PM			
2018	8%	23%	37%
2040	19%	43%	60%

Source: TATDM forecast, door to door time

*Percent of destinations within X minutes
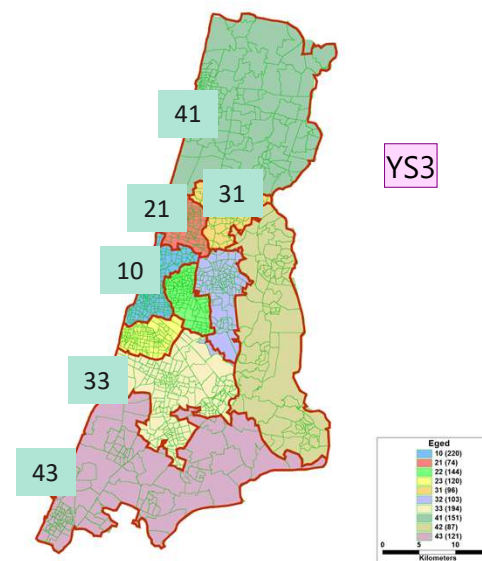
Analysis of areal accessibility

- Major changes occur within zones 10-33, which are areas where the strategic plan lines are deployed.

- The most significant changes are predicted for radial trips to zone 10 (the core of the metropolitan area) and internal trips in zones 10-33.

Table 2: 45 min accessibility by public transport: change* from 2018 to 2040 due to implementation of the strategic plan, peak AM by super-zones

GE_from	10	21	22	23	31	32	33	41	42	43
10	35	38	35	33	7	38	4	4	0	0
21	43	46	12	1	30	13	0	7	0	0
22	45	7	36	25	0	39	0	0	1	0
23	61	0	32	40	0	6	37	0	0	0
31	13	33	2	0	49	5	0	0	8	0
32	42	10	43	8	2	34	0	0	1	0
33	9	0	1	31	0	0	28	0	0	3
41	8	8	4	0	4	0	0	16	1	0
42	8	6	2	0	13	9	0	0	1	0
43	8	0	1	0	0	0	7	0	0	4

* Total change in accessibility percent

between 2018 and 2040 scenarios

Source: TATDM forecast, door to door time

The Tel Aviv strategic public transport plan

YS3   is it possible to show the zone numbers in the map?

Yoram Shiftan, 9/22/2021

Analysis of areal accessibility

- The figure presents the accessibility by public transport within 45 minutes (door to door time) in morning peak hour for each zone.

- The figure shows significant increase in accessibility in zones covered by the strategic plan lines.

Figure 4: Public transport accessibility* within 45 minutes by metropolitan zones in 2018 (left) versus 2040 after implementation of the strategic plan (left), for peak AM (door-to-door time).
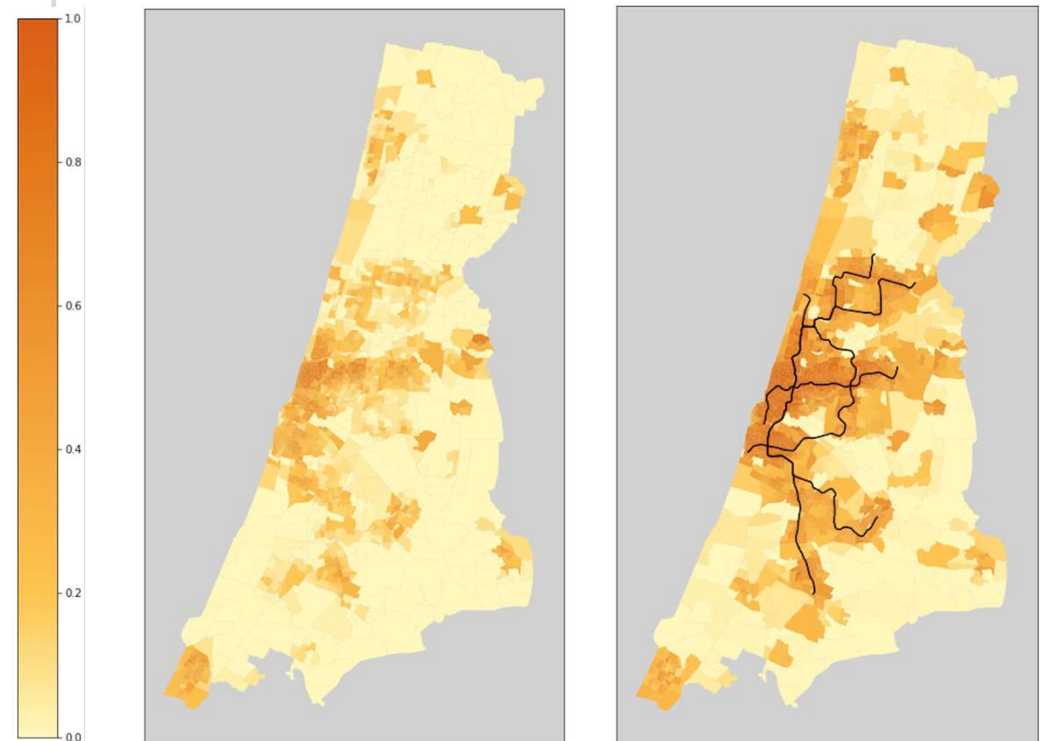

* Percent of destination reachable within 45 minutes from each zone

Accessibility by socio-economic group

- An average calculated for both private cars and public transport.
- The implementation of the strategic plan by 2040 will create a more equitable transport system.
- It will increase accessibility to all socio-economic groups, however, the increase to lower socio-economic groups is higher than the increase to higher socio-economic groups.

Figure 5: Accessibility by socio-economic groups, for 2018 and 2040 after implementation of the strategic plan, for all modes, peak AM.
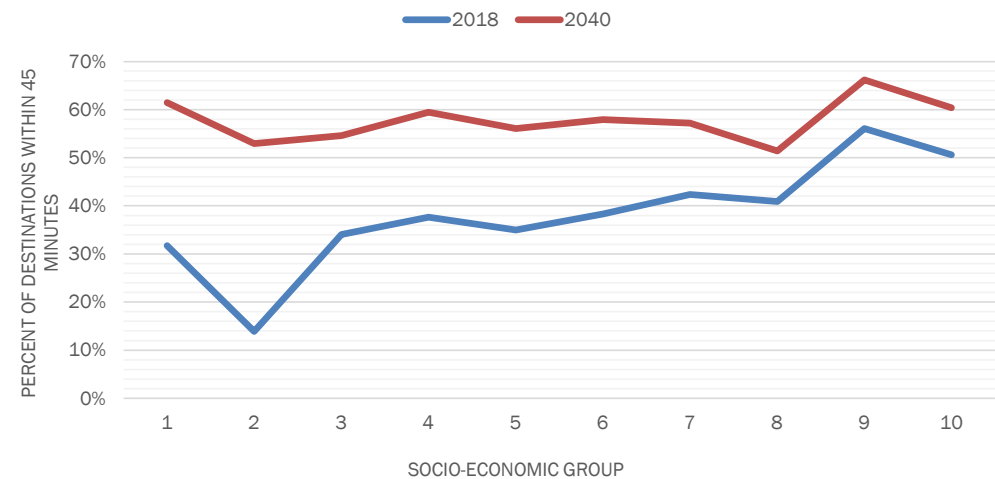
Lorentz curve of accessibility

- Based on the accessibility data, we generated Lorentz curves to further capture the distribution of accessibility across socio-economic groups.

- The graph shows that the distribution of accessibility for the 2040 network lies closer to the equal distribution line than for the 2018 network

Figure 6: Lorentz curve of accessibility in the metropolis within 45 minutes, 2040 with strategic plan and 2018, peak AM

Accesibility Lorentz Curve - 45 minutes
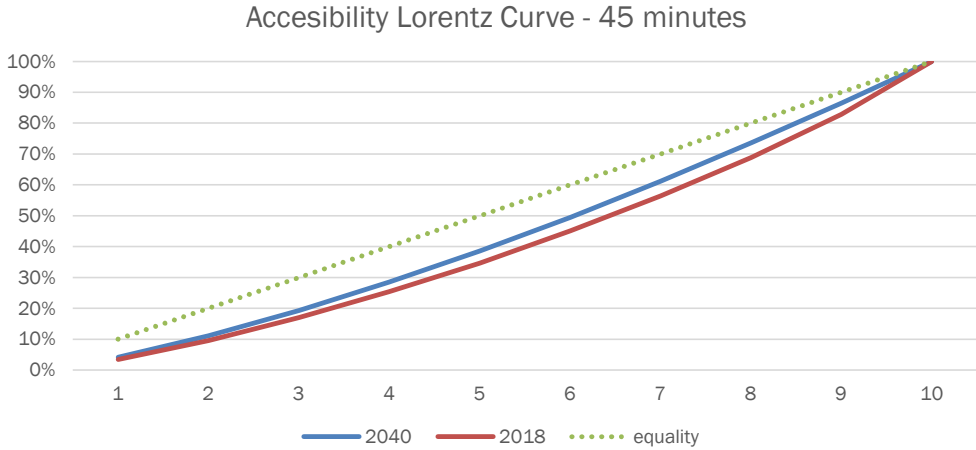
The Gini index

- Gini Index of accessibility (for 30 and 45 minutes) in the metropolitan area for the current transport network (2018) and the future 2040 network after implementation of the strategic public transport plan.

- The Gini Index shows that the 2040 network is more equitable than the current 2018 network by 30%.
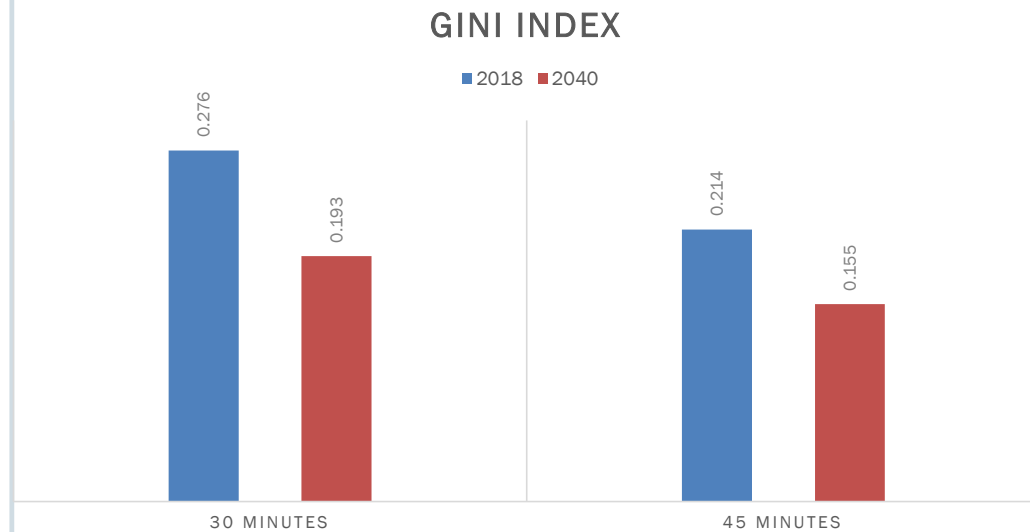
Figure 7: Gini Index of accessibility in the metropolis within 30 and 45 minutes, 2040 with strategic plan and 2018, peak AM

GINI INDEX

■ 2018 ■ 2040

	30 MINUTES	45 MINUTES
2018	0.276	0.214
2040	0.193	0.155

Conclusion

- The strategic public transport plan has major effects on transport equity:

- It increases accessibility for all population groups

- It increases accessibility more for low socio-economic groups

- It ensures a minimum accessibility of 50% to all areas within a daily commute time, for all socio-economic groups

Case Studies

The national appraisal framework

The Tel Aviv strategic public transport plan

Rail to the periphery

The rail to the periphery

- Israel population - 9.3 million people in an area of 22 thousand square km.

- A concern about the link between the Northern and Southern peripheral areas to the center of the country.

- This concern has resulted in a plan to build high-speed rail in an effort to address broadly shared concerns about (the lack of) spatial equity between the center and the periphery.

ISRAEL
Population density
2007

North Periphery

South Periphery

LEGEND
- 3,000+
- 1,000-3,000
- 500-1,000
- 250-500
- 100-250
- 0-100
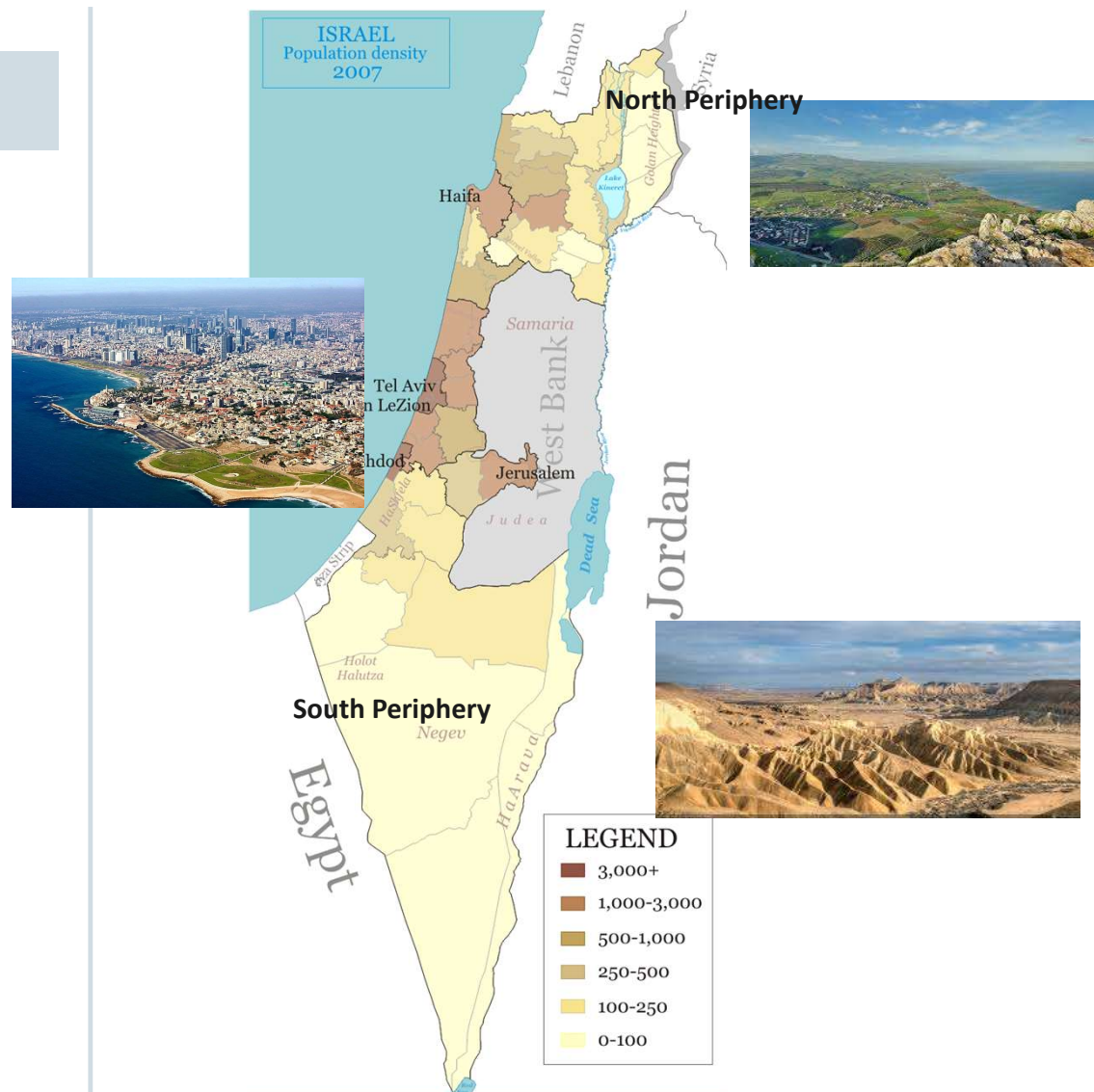
The alternatives

- The objective of this case study is to analyze transport interventions designed from the very start to address spatial equity.

- We compare two alternative services to connect the periphery and the center, based on quantitative measures with an emphasis on equity considerations.
  - The high-speed rail service (Alt. C1)
  - The regional BRT shuttle service (Alt. C2)
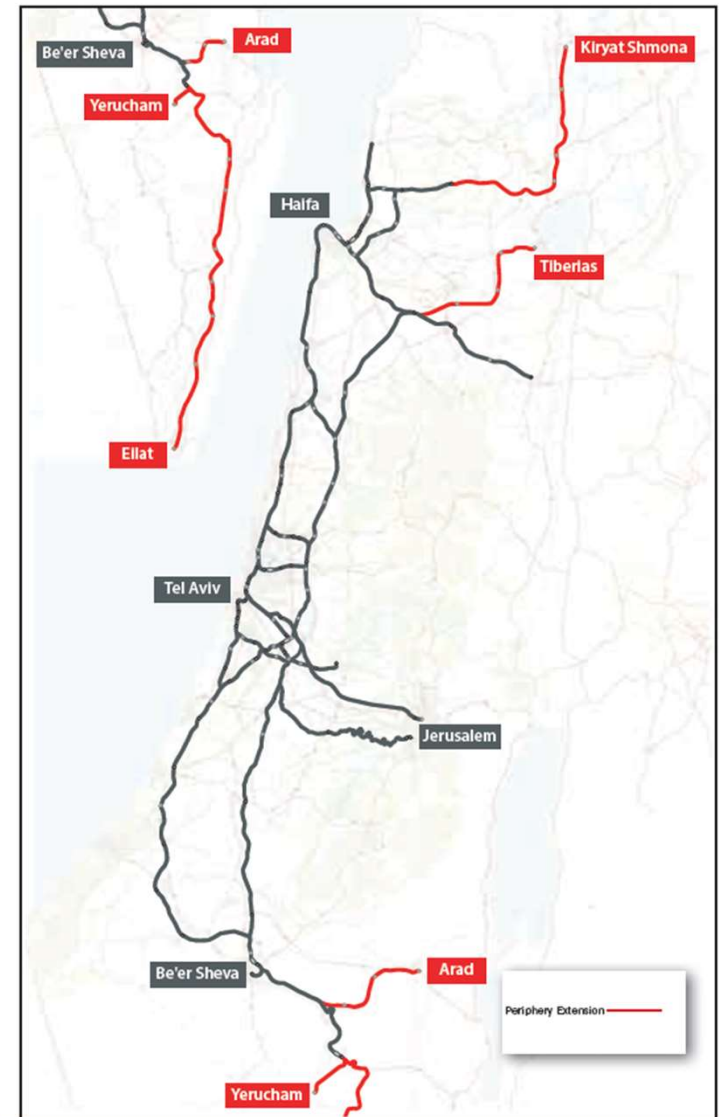
The equity objectives

- Multi-criteria based on 4 groups of indicators
- Both alternatives significantly improve the current situations on all criteria
- Differences between the two alternatives are small, given the analysis is conducted mostly on the national network

Table 3: Measures of the alternative plans to the Northern and Southern periphery, compared to 2016 network

	Measure	2016	2040 C1 HSR	2040 C2 BRT
Transportation	Percent of passenger km on rail network	6%	19%	19%
	Number of rail passengers (million per year)	60	305	306
	Percentage of public transport passengers on main corridors	31%	47%	48%
Equity and Periphery	Inner trips in the periphery (Thousand per hour)	-	13.5	17.5
	Percent of population in the periphery within 90 minutes to Tel Aviv	16%	64%	62%
	Percent of jobs within 90 minutes ride from low- income population	12%	49%	49%
	Percent of population within 45 minutes ride from nearest metropolitan area	36%	69%	72%
Economics	Operating cost recovery ratio	0.45	0.65	0.73
	Benefit/Cost (B/C) ratio at 7%	na	1.0	1.9
	Percentage of peak hour mileage with adequate occupancy (v/c>0.5)	41%	53%	59%
Quality of Life and Environment	Population coverage up to 7 km from rail station	68%	86%	80%
	Reduction in private car usage - (% relative to do nothing scenario)	na	-10%	-12%

The Potential Mobility Index

- Captures the ease with which a person living in a particular area can reach all other areas.
- For one origin-destination pair, the PMI is defined as the quotient of the aerial or Euclidean distance ('as the crow flies') and the travel time on the transport network between that origin and that destination.
- The main advantage of the PMI is that it takes the network structure and network quality into account.
- We found the index suitable as it reflects the ability and ease which persons can get to all the places around them.
- We used the PMI in this paper and calculated potential mobility for each city and town in the periphery to all the other municipalities in the country, and thus obtain a national view of the potential mobility to and from the periphery.

The Potential Mobility Index (PMI) is formally defined as follows (Martens 2016):

$$PMI(i) = \frac{1}{n} \sum_{j=1}^{n} \frac{d(i,j)}{T(i,j)}$$

where,

PMI(i) = average aerial speed for zone i

d(i,j) = aerial distance between zone i and zone j

T(i,j) = travel time on the transit network between zone i and zone j.

The Potential Mobility Index

- The in-vehicle PMI shows a clear advantage to the high-speed rail service to all cities with an average 30% higher speeds.

- The door-to-door calculation of PMI indicates that the actual door-to-door average speeds are lower and that the BRT service achieves higher or equal average speeds for all cities. This result is explained by the higher frequencies and coverage that the BRT service provides and thus reduces access and wait time and the overall door to door time.

Table 4: Potential mobility index (PMI) for selected peripheral cities

City	In-vehicle speed (km/h)			Door-to-door speed (km/h)		
	2016	C1	C2	2016	C1	C2
Periphery - North						
Kiryat Shmona	-	56	41	-	33	34
Rosh Pina	-	53	41	-	29	31
Tiberias	-	47	38	-	26	27
Beit She'an	40	44	44	22	25	25
Periphery - South						
Arad	-	51	45	-	34	34
Yeruham	-	64	59	-	39	46
Ksiefa	-	54	50	-	34	32
Dimona	50	75	74	28	41	41

Discussion

- The high-speed rail service will provide shorter travel time to/from the periphery to the center of the country and may change the experienced time/space in Israel as in the government's vision. On the other hand, BRT service will provide more coverage (more stops) and higher frequency but lower in-vehicle speed than the rail service.

- This case study shows that the regional BRT service is more efficient and provides good service to the periphery with good coverage and frequencies and at a much lower cost.

- The questions of the high cost of providing this service and how many residents in the periphery in Israel will benefit from it and commute to Tel Aviv frequently remains.

Conclusions

- There is no one "right way" to account for equity in transport appraisal

- Advanced modeling and computational can help but doesn't provide the "one right way"

- Equity should be considered in the planning process as part of its objectives

- Transport planning should seek to guarantee adequate accessibility for all through the regulation, operation, maintenance, and improvement of the transport system

- There can be many measures of equity, the more equity implications are shown in the planning and appraisal process, the more likely that projects will be selected that will enhance equity.

Thank for your attention!

Yuval, Karel, Nir, and Yoram