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Overcoming Jevons Paradox: Improving The Sustainability of Israel's Transportation Policies

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Abstract

The relative contribution of transportation to the global carbon footprint is expected to increase due to expansion of the world's automotive fleets, notwithstanding increasing electrification of vehicles and the introduction of cleaner fuels for electricity. Israel is no exception. Despite the global improvement in automotive fuel efficiency, local regulatory interventions and innovative tax incentives that make cars emissions per vehicle-km traveled lower than ever, transportation's contribution to the country's greenhouse gas profile is rising. Economists describe such situations as Jevons Paradox, where an increase in efficiency due to a new technology that was assumed to lead to reduced consumption of resource, actually increases it. The article assesses the impact of Israel's transportation policies and the measures required to improve the transport sector's environmental performance. Israel's growing emissions from the transport sector can be linked to a lack of reasonable public transportation alternatives for most commuters; inadequate economic incentives, such as congestion pricing to reduce use of private vehicles; widespread employee compensation for driving private vehicles to work and reliance on company-owned cars; and the growing distance of workers' homes from urban employment centers. A narrow focus on technologies that control vehicle emissions is not enough to make the required progress in reducing greenhouse gases. A significant commitment to demand management that revolutionizes transportation patterns and the growing dependency on automotive travel is also imperative.

Keywords: Transportation; Climate change; Greenhouse gases; Demand management; Jevons Paradox; Israel

Introduction

The environmental ramifications of inadequate transport systems are well documented. Climate change is an area where the impact is particularly conspicuous [1]. Transportation is responsible for 23% of global greenhouse gas emissions [2]. Transport's contribution to global warming is quickly increasing, with travel soon expected to produce half the planet's anthropogenic carbon footprint [3]. Private automobile tailpipes will drive this phenomenon for the foreseeable future, as the number of active vehicles on earth is projected to grow from 700 million in 2000 to 2 billion by 2040 [4].

Even after widespread removal of lead from fuels, the health and environmental impacts caused by transportation are enormous: Air pollution associated with transport is responsible for 3.7 million deaths each year [5] and far greater morbidity, including epidemic levels of asthma and heart disease in many urban areas [6]. In Europe, tens of thousands of deaths each year are caused by transportation-related air pollution, roughly equal to those attributable to traffic fatalities [7]. Such figures do not consider direct and indirect health effects from global warming caused in part by automotive emissions [8]. Modern automotive culture also poses economic costs. In the U.S., a 2014 study reported that 6.9 billion hours of lost time and 12 billion liters of gasoline (valued at 16 billion dollars) are wasted due to inefficient transportation systems [9].

These global dynamics are observed in Israel as well. In 2009, for the first time the country commissioned a comprehensive evaluation of its greenhouse gas portfolio from international consultants, the McKinsey group [10]. Transportation then was the second largest source or emissions after electricity, contributing 26% of CO_2 released by local sources. But the report predicted that transportation's carbon footprint would steadily increase. It has. Following discoveries of major Mediterranean Sea natural gas deposits, the country is shifting its electrical production from reliance on coal to natural gas. The government has also committed to increasing energy derived from renewable sources [11]. With non-transport sources dropping, absent any significant interventions, the relative magnitude of transportation within Israel's greenhouse gas inventory is expected to increase accordingly, and could soon become the greatest single source of carbon emissions [12].

In its National Climate Change Program ("INDC"), prepared for the 2015 Paris Climate Conference, Israel promised to cut greenhouse gas emissions by 24. 5-million-tons; the drop in emissions from transportation required to reach this goal was set at 12% (3 million tons of CO_2) [13]. Yet, little indicates that transportation will become a meaningful part of the country's climate change strategy any time soon. Rather, like the global trends, it appears that transport will increasingly be at the heart of Israel's environmental and climate crisis.

This cannot be attributed to lack of proven automotive technologies and traffic management strategies. Since Pacala and Socolow [14] introduced the concept of carbon wedges in 2004 and began quantifying pathways to mitigate emissions at the macro level, experts distinguish between two fundamental approaches for reducing transportation's carbon footprint: improved fuel efficiency and reduced vehicle usage. Israel ostensibly has taken steps to move forward in both areas, with formidable regulatory interventions monitoring tailpipe emissions and green taxes leading to expansion of fuel efficient and low emission

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vehicles in the local fleet. On the vehicle-usage side, a 2015 government decision set a goal of 20% reduction in vehicle travel by 2030, with modest increases in public transportation infrastructure investment [15]. Current performance indicators, however, suggest that actual results will be disappointing.

To some extent Israel's traffic predicament can be attributed to relentless population growth which steadily expands the local vehicle fleet, pushing infrastructure beyond its intended capacity. That only explains part of the failure. It can be argued that the country's technological sophistication and reputation for innovative savvy created conditions where Israelis are driving more, and emitting more pollutants than ever before. For some 150 years, technologies designed to reduce demands for a resource have been recognized as having the potential to actually cause increased consumption. The phenomenon is called *Jevons Paradox,* after British economist, William Stanley Jevons who first documented it [16]. Such unintended consequences need not be destiny and can be prevented through thoughtfully designed strategies. Current Israeli transportation policies, however, remain myopic and environmentally harmful, creating a pernicious path of least resistance.

Israelis are not in denial about the of the grim reality of climate change. Signs of global warming are so far along that there is little room for skeptics or skepticism in national discourse: Average temperatures in the country rose an average of one a half degree per decade for forty years [17]; Rainfall, especially in the critical Jordan River region, has plummeted [18]; Sea levels are projected to rise annually in the Mediterranean Sea by 0.5 cm, with most projections now anticipating an increase of more than 100 cm by 2100 [19]; Marine temperatures in the Mediterranean are expected to rise by 0.5°C every ten years [20]; Climate-exacerbated water scarcity is far more acute just across Israel's borders, in countries like Jordan [21]. Food security concerns are growing for the entire region, following the implosion of Syrian agriculture (contributing to civil war) in the face of prolonged drought [22].

Nonetheless, there is a curious complacency regarding Israel's transport sector. At present, transportation is set to undermine Israel's international commitment to reduce per capita greenhouse gas emissions by 26 percent over the next thirteen years. Moreover, uninspired transportation policies threaten to doom the country to a future of gridlock and traffic jams, with past progress in individual mobility replaced by pollution, congestion, economic stagnation and human frustration. It has been convincingly argued by leading experts that the criterion of *accessibility* as opposed to *mobility* is preferable for assessing the sustainability of a transport system [23]. Here too, Israel's increasingly sprawled, urban reality gives little grounds for optimism about the future.

By contrast, in many areas Israeli innovation in technology and policy offer the world new models of sustainability. Israeli breakthroughs in dry land forestry, wastewater reuse, desalination and irrigation are worthy of emulation. But as the world considers pathways to improve its collective carbon footprint, instead of offering a groundbreaking, efficacious approach, Israel's transport system constitutes a cautionary tale and case study of what should be avoided if the planet is to attain a climatically stable future. Present failures make an evaluation of Israel's contemporary transportation system of particular interest to sustainability advocates and experts.

This article offers a brief review of the orientation that led Israel into today's crisis and the associated policies promoted by Israel's government. It opens with a presentation of the country's transportation dynamics. It then assesses key obstacles to environmental progress in the transportation sector. Making environmental progress, in spite of Jevons Paradox dynamics, however, is possible. The article argues that a more ambitious shift away from investment in automotive infrastructure is required. Financial incentives for workers and drivers need to change. Moreover, as Israel increases its housing stock by 40% over the coming twenty years, adding 1 million new housing units, it is missing an enormous opportunity to reduce dependency on private vehicles. If it is to meaningfully address its transportation predicament, meet climate change mitigation objectives and reduce mobile source emissions, Israel must embrace a new policy strategy.

Carbon and Congestion: Israel's Transportation Pathology

Israel's cars, trucks and buses increasingly are the source of the country's greenhouse gases. Mobile source emissions are also the primary cause of urban air pollution and among Israel's most egregious health hazards, [24] associated with a high incidence of asthma and cancer [25]. On account of its proximity to Arabian and African deserts and sandstorms, Israel experiences naturally elevated background levels of particulates, reaching concentrations of 20 mcg/m^3. Nonetheless, it is in Israeli car-congested cities where fine particles ($PM_{2.5}$) are highest, frequently exceeding recommended standards and affecting children's health [26].

Israel's Ministry of Environmental Protection offers a candid admission of the severity of the transportation/air contamination nexus on its Hebrew website: "The state of air pollution among population centers in Israel is not good enough and damages public health. The primary air pollution problem in these urban areas originates in emissions from transportation. Every year air monitoring stations of the Ministry of Environmental Protection measure exceedances from air quality standards. In 2014, the meaning of these exceedances in population centers, according to the estimates of the OECD was 2500 annual excess deaths in Israel" [27].

Part of the reason why Israeli cars contribute so much to the country's air pollution burden is that they move slowly [28]. It is hard to imagine an area of societal infrastructure and services where the gap between public and government perceptions is as great as transportation. In April, 2017 Israel's Prime Minister Benyamin Netanyahu took the press to task on the issue, claiming: "In places where they see traffic jams, I see overpasses, trains and bridges." But objective mobility measurements show Israel's traffic steadily slowing down as roads fill up beyond capacity. The annual economic costs of delays were measured in 2010 at 5 billion dollars [29]. Since that time, over a million new cars joined the fleet.

Like so much of Israel's national infrastructure, transportation is idiosyncratic. Israel may lead the world in areas like per-capita start-up companies, newspapers, book publishers, theater subscriptions and Nobel Prize winners. The fact that Israeli roads are among the most crowded in the world is a more dubious superlative, especially when considering the air quality ramifications [30].

Israel's diminutive dimensions have much to do with its traffic jams: the country is only 22,000 km^2, almost seven times smaller than Norway but with 40% more people – 8.6 million. Little wonder that streets quickly become clogged. A study prepared by the parliamentary research center at Israel's Knesset reports 2,700 cars per km of road versus 773 on average in the OECD [31]. Four of five vehicles on Israel's highways are private cars. With 1250 kms of railway track, the country's rail system ranks a very modest 83rd place worldwide [32].

Israel's Ministry of Transportation is quick to point out that vehicle ownership rates in Israel are actually lower than in many Western countries (Table 1).

Presently, there are roughly 370 cars per 1000 people in Israel, roughly half the motorization rates in countries like America or New Zealand [33]. Yet, relatively low car ownership is counteracted by comparatively extensive usage and Israel's tiny size. Notwithstanding the diminutive dimensions of the country, average Israeli cars drive 17,000 km/year, a distance exceeded only by the United States [34]. The steady upward spiral shown in Figure 1 is a trend which is unlikely to change any time soon, given present policies. Some 300,000 new cars are sold each year. In 2015, there were 3,092,000 motor vehicles in Israel, 83.5% of which were private vehicles, with only 20,000 kms of road to contain them [35].

The resulting congestion highlights the non-linear nature of damage functions associated with population pressures. Steady deterioration may continue for some time before a threshold is passed, and systems suddenly exhibit dramatic collapse. Anyone driving on a highway after a major sporting event lets out knows what 20% additional utilization does to an infrastructure whose capacity is already maxed out.

In 2010, the average speed of rush hour traffic entering Tel Aviv each morning was already below 10 km/h [36]. By 2017, speeds had grinded to even more sluggish levels. A 2012 projection by Israel's Ministry of Transportation predicted that within sixteen years, Israelis could expect to spend sixty more minutes each day in their cars [37]. Speaking with uncharacteristic honesty, a deputy director of the Transport Minister acknowledged that Israel's gridlock was destined to become far worse. A general failure of the road system in the greater Tel Aviv region was expected: the length of highways segments suffering from traffic congestion would soon double. Aggregated, these delays represent 850 million lost hours [38]. If they aren't electric vehicles, cars stuck in traffic release far more emissions than those driving at optimal speeds of 90 km/h.

Between 2000 and 2014 annual kms driven by Israeli drivers increased by 44% [39]. Steadily, perhaps imperceptibly, they grew

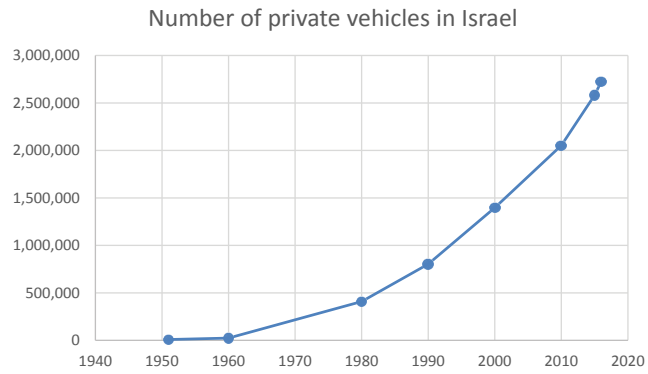

Figure 1: Number of private vehicles in Israel.

	Level of motorization (1)						Motor vehicles (thousands)		
	Thereof: passengers Cars (2)			Motor vehicles - total					
	2015	2014	2013	2015	2014	2013	2015	2014	2013
Israel	***308***	***299***	***290***	***365***	***357***	***350***	***3.092***	***2.966***	***2.851***
Austria	547	546	542	754	751	745	6.466	6.385	6.300
Australia	570	567	562	757	752	743	18.008	17.633	17.181
Italy	614	609	619	854	849	859	51.910	51.585	51.269
Ireland	. .	422	416	. .	546	541	. .	2.515	2.483
United States	. .	411	407	. .	R862	851	. .	274.805	269.294
Belgium	499	496	492	. .	. .	. .	. .	. .	. .
Germany	547	543	539	687	681	677	55.752	55.011	54.480
Denmark	412	405	399	. .	. .	. .	. .	. .	. .
Netherlands	472	471	472	600	R600	603	10.133	R10.097	R10.124
Hungary	324	R315	R307	. .	. .	. .	. .	. .	. .
United Kingdom	479	472	468	577	568	563	37.571	36.715	36.101
Greece	470	468	466	877	866	859	9.518	9.459	9.455
Japan	. .	472	467	. .	715	711	91.316	90.894	90.565
Norway	. .	R500	495	. .	R782	742	. .	R3.995	3.747
New Zealand	617	609	600	765	753	739	3.515	3.398	3.305
Slovenia	527	523	521	676	666	658	1.395	1.373	1.355
Spain	481	474	471	719	710	707	33.413	33.037	33.024
Poland	545	526	503	721	696	667	27.409	26.472	25.684
Finland	595	586	576	809	795	781	4.428	4.334	4.236
Czech Republic	459	450	448	617	605	606	6.499	R6.360	R6.369
France	496	496	496	664	R664	665	42.701	42.476	42.342
Canada	. .	611	605	. .	662	654	. .	23.538	23.006
Sweden	479	475	470	618	614	608	6.021	5.923	5.813
Switzerland	541	539	537	734	729	R727	6.046	5.937	R5.841

Data based on: OECD - IRTAD
(International Road Traffic and Accident Database)
1. Number of vehicles per 1.000 residents
2. Including: private car. taxi and minibus up to 8 seats (in addition to the driver)

Table 1: Relative level of motorization–International comparison.

resigned to the constant delays and frustrations caused by omnipresent traffic jams. Early morning commuters rise earlier to beat traffic; highways are crowded as early as 6:00 a.m. Increasingly, Israelis choose not to venture out of their neighborhoods during holidays as gridlock becomes unbearable, undermining the sense of freedom associated with festive outings [40].

The full price of this environmental and social scourge is rarely comprehended by the Israeli public. A conservative economic estimate by the government reaches 4.3 billion dollars/year of lost productivity. The price tag will surely double as speeds continue to decrease [41].

It is not just the atmosphere that suffers from an automotive, fuel-addicted economy. People suffer as well. The stress associated with lifestyles that face chronic traffic delays is well documented [42]. Commuters in major American cities suffer an average of 52 h of holdups each year. Psychological research there concludes that stress is rooted in the unpredictability of delays and loss of control [43]. Most commuters experience boredom, a sense of isolation and anger due to traffic jams.

Findings from a study of 3,409 regular Canadian commuters confirms widespread perceptions of driving as a stressful experience, in part due to a significant loss of stress-relieving activities, such as hobbies, sleeping and exercise [44]. Women typically complain about gridlock more than men, even though on average their commutes are shorter. A sense of falling behind in uncompleted household chores or work responsibilities often leads to anxiety, impatience and fatigue. Frustrations spill over into family life with abusive behavior more common amongst perpetually agitated commuters [45]. Waking hours are ultimately a zero-sum game so that people who spend significant time before and after work on the road quite literally have less time with their families for meals, communicating and building relationships. Physiologically, long rides to work are also associated with myriad physiological indicators [46]. These include high blood pressure [47], musculoskeletal problems, reduced cognitive performance [48], obesity and hypertension [49].

Jevons Paradox: Cleaner Cars – More Emissions

Jevons paradox has long been recognized as a common economic phenomenon with wide implications for environmental economics [50]. The phenomenon was first identified by British economist, William Stanley Jevons in an 1865 book. Jevons observed that while increased efficiency in newly invented equipment should have led to reductions in coal consumption, in fact the drop in operational costs led to greater coal utilization [51]. This helps explain many natural resource phenomena. For instance, in recent years, Israel's per capita water consumption increased after desalination made inexpensive, high quality, water widely available [52]. Israel's transportation crisis is linked to similar dynamics: environmental progress anticipated by reduced prices for fuel efficient and clean vehicles never materialized. Rather the country witnessed a higher rate of fuel consumption as vehicle travel expanded.

When criticized for lack of progress in reducing mobile source emissions, government decision makers in the area become defensive, quick to cite significant progress made in vehicles' environmental performance. Adoption of European emission standards for new cars along with an efficient, privately operated vehicle inspection make a difference. Israeli cars are indeed cleaner than those driven in the past: Between 2000 and 2014, hydrocarbon emissions in Israel dropped by 59%, CO emissions by 67%, particulates by 72% and oxides of nitrogen (NO_x) by 69% [53]. This did not happen by itself. It was the result of tightened EU emission standards, regulatory interventions and better tailpipe control technologies. While Israel was a relative latecomer to environmental taxation, its tariffs on inefficient/high emitting vehicles changed consumer preferences sufficiently to be singled out for praise by the OECD Environmental Directorate.

Israel's green tax program for motor vehicles was enacted in 2009 and has since been updated three times. In 2004, an inter-ministerial committee received a mandate to design a Pigouvian intervention, increasing taxes on new vehicles as environmental performance decreased [54]. (Of course, an ideal Pigouvian tax limits taxes to harmful emissions. Hence, someone who owns a polluting car but uses it sparingly would only pay modest taxes.)

Israel historically had high import taxes on cars, contributing to the perception that private vehicles constitute a privilege and luxury item. Indeed, among OECD countries, only Denmark and Norway tax car owners more. Even so, when the OECD experts calculated total externalities created by Israeli cars, they found that direct and indirect effects cost roughly 6% of GDP. Revenues from taxes from car sales, along with fuel taxes only contributed 3.4% of GDP. This meant that car usage was subsidized by at least 2.4% of GDP [55]. These calculations were understated, ignoring significant governmental outlays devoted to paving highways and roads.

Ultimately, overall taxes on private vehicles were not hiked; rather the structure tilted towards greener cars. To create a revenue-neutral green tax, Israel's Tax Authority replaced the base import tax level of 75% with fifteen different levels of taxes, ranging from 35% to 92% of the vehicle's value. Cars with zero emissions (e.g., electric vehicles) are only taxed at 10% of market value [56]. Among the program's innovative components is a composite criterion adopted for environmental performance based on overall fuel efficiency, quality of pollution control equipment and tailpipe emissions for five different air pollutants: carbon dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, and particulates. Hence, hybrid vehicles, ranked at level 2 (in the 15-tier system) are only taxed at 30% rates [57].

The tax system proved to be highly effective in changing consumer preferences. The OECD is typically parsimonious in bestowing praise. But its report actually called Israel's policy "innovative and creative". Within five years of enactment, some 83% of cars sold in Israel were in the lowest pollution categories, up from 19% in 2009 p [58]. Reductions in average emissions per vehicle for NO_x and particulate matter fell precipitously. The availability of less polluting cars also meant that clean vehicles became less expensive to own, and overall sales skyrocketed [59]. The taxes collected, however, did little to increase the availability of public transportation, rail or cycling infrastructure. Nor did they facilitate policies to create workplaces and entertainment venues contiguous to public transport hubs.

One of the central critiques regarding implementation of green taxes involved the lack of an adaptive management orientation, where tax rates could be ratcheted up to reflect actual shifts in purchasing patterns and aggregate environmental performance. One result of the stimulus created by the green tax system was an increase in total tax revenues. When the government finally did move to adjust, it encountered a hailstorm of criticism for leaving tax rates for polluting vehicles, such as SUVs unchanged, and raising tax rates for clean cars [60].

The other environmental problem associated with Israel's relatively high taxes on new automobiles is that they extend the life of the entire vehicle fleet. When the expense of replacing old cars become

prohibitive, drivers have tremendous incentives to keep their them on the road, notwithstanding mounting bills from mechanics. A fundamental axiom of mobile source air pollution dynamics is that old cars are more polluting than newer vehicles, notwithstanding Israel's conscientious annual inspection program [61].

Another problematic phenomenon involves "moral licensing" among citizens: after "doing something good" people are generally less worried about the consequences of "doing something bad". Psychologists have well-documented examples of such behaviors: Dieters who show restraint all day, feel entitled to binge in the evening; After making modest donations to charity, people indulge themselves by purchasing a luxury item. And drivers of hybrid cars may feel justified driving to the corner market, taking a gratuitous joy ride or foregoing commuter trains because they feel environmentally virtuous in fuel efficient cars and perceive the price of operation to be lower.

Whatever the psychological motivation, a recent 2017 Knesset report confirms that "green taxes" on cars have reduced the number of polluting vehicles [62]. Unfortunately, despite steady reductions in emissions from individual cars, vigorous sales and the overall growth in Israel's fleet produce net increases in emissions from mobile air pollution sources [63]. The transport sector remains responsible for roughly a quarter of Israel's NOx and fine particles ($PM_{2.5}$) emissions. It threatens to undermine Israel's climate change mitigation strategies, taking an increasing toll on the economy, health and quality of life in Israel. It is well, therefore, to evaluate policies alternatives to counter the power of Jevons paradox and reduce Israel's detrimental dependence on motor vehicles.

Improving Transportation Policy in Israel

"Jevons paradox" is a function of people driving cleaner cars more than polluting vehicles were driven in the past. Beyond moral licensing, the reasons behind Israelis' alacrity for driving are not disputed:

- Lack of reasonable public transportation for most commuters, leaving little choice but to opt for automotive-dependent lifestyles;
- Lack of persuasive economic incentives, such as congestion fees or other Pigouvian taxes, to reduce private vehicle usage [64].
- Widespread employee compensation for driving private vehicles and company cars to work; and
- The growing distance of workers' homes from urban employment centers, due to unavailability of nearby affordable housing and transport-insensitive residential development.

All of these factors can be changed with policy reform, more sustainable budgetary priorities, and greater political will to confront the country's transportation crisis.

Accessible public transportation

One unique aspect of Israel's transportation policies is that for almost a decade, they have been overseen by a single individual. In an executive branch characterized by constant ministerial turnover, Yisrael Katz has exhibited rare political perseverance, keeping his hand on the steering wheel as Minister of Transportation for more than eight years. Unfortunately, Katz's budgetary priorities at the Ministry of Transportation focus on paving roads, with public transport deemed a second, supplementary measure [65]. The numbers speak for themselves: Between fiscal years 2011-2015, roughly half of the budget for infrastructure at the Ministry went to inter-city highways, with some 62% of the overall budget going to road infrastructure [66]. This comes at the expense of open spaces and habitat [67].

It is not surprising that his evaluation of his ministry's record is highly favorable. Unfortunately, his assessment relies on output rather than outcomes. Proud of the many expanded new highways paved around the country, he argues that just because he supports roads doesn't mean he opposes public transportation. Unfortunately, ministry budgets tend to be a zero-sum game.

The wisdom of a national strategy that tries to pave its way out of gridlock is questionable, especially given the country's rapid and relentless 2% annual demographic growth. This is exacerbated by recent consumer frenzy. After subtracting attrition and the 100,000 junked or damaged vehicles, every year roughly 200,000 new cars are added to the fleet: In 2014, there were 2.8 million cars in Israel. By 2016 the number had surpassed 3.2 million [68]. This is roughly 50% more than the 150,000, new people in the population. In recent years, the number of cars driving on the roads increased in all but two of Israel's major intersections [69]. The only positive outcome of the present gridlock involves reduction in accidents, which can be attributed, in part, to lower traffic speeds. Like it or not, traffic forces the public to drive slower.

Politicians also sit in traffic jams too and embrace the simplistic solution of investing in road infrastructure. On average since 2008, each year over 500 km of road have been either paved or widened. In retrospect, the effort is "too little too late": national investment in transportation infrastructure lags behind other, less congested OECD countries [70]. More importantly, much like the Jevons paradox air quality dynamics, providing more roads is self-defeating, and only seems to encourage more cars.

In short, extending the area and length of the country's highway network to accommodate the steady growth in vehicles is not working. As Professor Einstein wrote: "you don't solve problems with the same thinking that created them in the first place." The paramount priority for Israel's transportation policy needs to involve shifting ridership from private vehicles to public transportation. Typically, public transport brings benefits in the form of reduced air pollution, congestion, and delays [71]. Ministry policy papers claim that public transportation is in fact a priority, and has set a 4% annual increase in ridership as a quantifiable goal. Reality is more complicated. Citing planning and technical obstacles, the transportation ministry often does not utilize funds for many public transport projects that are allocated, redirecting them to completing road projects.

It is true that building rail infrastructure takes time and requires approval from planning commissions. Adding buses to the existing fleet, increasing the number of routes and frequency of trips, subsidizing rides and dedicating bus lanes on major thoroughfares, however, does not. Increasing public transport ridership need not be a long-term venture.

In practice, there were 818,161,884 public transport trips taken in 2016. This translates into 2.2 million trips a day [72]. While this is a substantial number, it actually means that fewer than twenty percent of citizens take public transportation on a daily basis. There are many reasons why Israelis take their cars to work, to amusements or to vacations rather than public transportation. Inadequate *reliability, comfort, speed and frequency* combine to make travel by private vehicles more compelling. All of these factors can be immediately improved with more meaningful budget allocations for public transport needs. When bus passengers must wait for unreliable bus arrivals and then meander

through sprawled communities, travel times become prohibitively long. At the same time, buses that only pick up on main thorough fares are unattractive to riders who enjoy the option of a private vehicle. A 2017 expose showed that it takes Israelis everywhere more than twice as long to get to night life or arrive at other leisure destinations when they took take a bus rather than their cars [73].

Better enforcement of high occupancy and public transport lanes is another inexpensive initiative that can pay for itself via fines levied against violators. Not only will such interventions clear out designated lanes for buses and high occupancy vehicles, they raise the morale of the bus-riding and carpooling community. Otherwise, conscientious citizens who take buses feel like suckers – losing out twice as they wait for buses and then crawl in traffic. Average bus speeds in the greater Tel Aviv area are less than half the 30 km/h speeds which European buses enjoy. It is little wonder that Israeli ridership on buses (fewer than 133 annual trips per person) is less than half the percentage of European cities like Amsterdam, Munich or Rome. European bus ridership is high in addition to their relatively robust cycling levels [74].

Recently, Israel's Transportation Ministry decided to purchase cameras and install them around the greater Tel Aviv area to expedite enforcement of public transportation road lanes [75]. (Anyone who has driven in Israel knows that street signs for many drivers are merely recommendations.) Even so, the country has far too few public transport and designated bike lanes. Mayors prefer to leave existing boulevards open to private vehicles, with pedestrians giving up sidewalk space to make way for bike lanes (and in some cases car parking) instead. Indeed, the Minister of Transportation argues that the unwillingness of mayors to prioritize public transport constitutes a major obstacle to progress in reducing traffic.

Another critical reform involves increasing accessibility to public transportation among Arab-Israeli communities. Minority cities and towns are among the poorest in the country with low vehicle ownership rates. A combination of historical neglect and logistical problems associated with public transport in dispersed and peripheral locations means that few bus lines connect them to major employment centers. A comprehensive study conducted at Tel Aviv University identified poor bus service among Arab-Israeli communities as a major impediment to empowerment of women. For Arab mothers without cars, it simply does not pay to leave behind young children when irregular bus service with frequent stops makes commutes prohibitively long [76].

Another report by human rights organization "Sikuyee" calculates that bus ridership in Arab communities is only a third of the low levels found in the Jewish sector. With private vehicles the only option, getting in and out of Arab towns during morning and afternoon rush hours is an ordeal. The Ministry of Transportation purports to have expanded bus service dramatically to the periphery in general, especially the rural Jewish sector and Arab towns which in the past had no bus service whatever [77]. As opposed to trends in greater Tel Aviv, ridership of inter-city buses has increased in the geographical periphery among Arab Israelis. This is an important challenge where environmental and social justice objectives coincide.

But at the end of the day, "money talks": in 2015, only 38% of the Ministry's budget went to support rail or bus public transport. This is a higher budget commitment than in years past. But it still remains less than 50% of the investment in roads and highways and a fraction of the subsidies provided for train infrastructure in Europe [78]. A recent report by the Bank of Israel documents consistent delays in completion of public transport infrastructure projects. This means that actual annual investments end up being lower than levels budgeted [79]. The Transportation Ministry's 15.6-billion-shekel budget (~4 billion dollars) is anticipated to increase by 20% by 2018 to 5 billion dollars. If budgetary proportions were to flip – and 62% went to fund rail and bus travel - a 3.1 billion-dollar level of investment, it would make a meaningful difference in upgrading public transport service.

Transportation and tax policy

Taxes levied on private transportation take two forms:

1) Fees charged on vehicle ownership with no relation to actual usage; and

2) Fees charged on the utilization of vehicles;

The green Israeli import taxes on new vehicles as well government licensing fees fall in the first category. Spare parts are also taxed significantly in Israel, making repairs in Israel a far more expensive venture than in Europe or America. As Table 2 suggests, the associated revenues from selling new cars and spare parts have grown steadily. In 2016, total revenues from the taxing of automobiles reached 40 billion shekels [80].

This leads many observers to reach the conclusion that Israel's powerful Finance Ministry has little interest in reducing car sales, given their significant contribution to balancing the national budget. The extraordinary revenues to Israel's treasury from taxation of vehicles, parts and fuel undermines traditional "win-win" dynamics that might occur as a result of the high price of driving. Indeed, Israel even introduced an accelerated retirement program, where it paid citizens 3000 shekels to take old, twenty-year cars off the road, knowing that revenues associated with the new cars purchased would be far greater [81]. Today, 50,000 vehicles are candidates to receive such funding [82]. While the environmental ministry trumpets environmental benefits, the economic justification for the program involves anticipated tax revenues from replacement vehicles.

Once private vehicles become a major source of governmental revenues, fiscal responsibility and balanced governmental budgets become an interest that competes with environmental health and quality of life. Should public transportation become a viable alternative to private car ownership, tax revenues would have to be generated elsewhere or public outlays reduced. Unfortunately, lost revenues to the economy from a country paralyzed in gridlock will soon surpass the windfall gained from taxing new vehicles.

Israel also imposes significant taxes for vehicle *usage*: levies on fuel reach the extraordinary rate of 65%. Add to this a generic 17% Value Added Tax [83]! These tax burdens raise both the fixed and incremental

Motor Vehicles			Replacement Parts			
Year	Import Value	Sales Tax	Import Tax	Sales Tax	Import Tax	Total Tax Revenues
2005	10.478	6.507	321	233	39	21.863
2006	10.962	6.659	227	227	40	23.270
2007	13.348	8.029	267	267	47	26.821
2008	13.841	7.659	277	277	52	27.655
2009	13.064	7.277	270	270	53	28.078
2010	16.110	8.557	291	291	61	32.239
2011	16.590	8.352	303	303	63	33.684
2012	15.552	7.444	370	324	68	33.684

Source: State Revenues Administration Israel

Table 2: Revenues from the taxes on motor vehicles (*in millions of shekels)*.

costs of driving significantly. Belgium, Ireland and the Netherlands have similar approaches. These differ from tax policies in the UK, Italy and Spain, where automotive expenses are kept low. (Sweden and France have modest prices for fixed costs, but impose relatively high incremental costs [84].

As carbon taxes become more common, the incremental expenses for car usage will rise through higher fuel costs, as occurred after legislation in British Columbia [85]. High taxes make driving in Israel expensive; but they still don't seem to send a clear signal to drive less. Congestion fees may deliver such a message more clearly, at the very least urging the public to drive on less congested routes and during less congested times of day. Ever since London's congestion fees showed the remarkable elasticity among rush hour drivers' driving patterns, Pigouvian taxes are considered an effective way to reduce private vehicle usage, especially during peak demand hours [86].

Positive incentives are also important. In Oslo, electric vehicles are not only given priority in high occupancy vehicle lanes, but for parking as well [87]. Israeli government analysts have studied such policy options for some time, [88] but have yet buy in (A private company operates a tolled "fast lane" on the Jerusalem-Tel Aviv highway, but this does not penalize drivers who visit the city during congested hours).

Transport Minister Katz has publicly expresses his theoretical preference for taxing vehicle usage rather than ownership. He argues that in a modern society, owning a car constitutes a basic individual right, which is only ensured if cars are modestly priced. Ideally, revenues now produced from taxing car sales could be generated from charging drivers according to distance and the time-of-day traveled. This presumably creates a more powerful incentive to drive less. Without the option of trains, buses or bicycle lanes, however, congestion fees simply become another tariff on a public that is already highly taxed, according to Katz. People still must travel to get to work, hospitals or family. Without compelling public transport alternatives, Katz argues that congestion fees would not change behavior among Israeli drivers [89].

While there is logic in this position, it perpetuates a vicious circle of car dependence, skewed budgetary priorities, spawning congestion and pollution. At present investment levels, public transport, will never serve large segments of Israel's population. If Israel's government is serious about addressing the transportation crisis, it should phase in time tables for increased bus service, expand existing "park-and-ride" parking schemes and prioritize cycling infrastructure. Congestion fees should be introduced soon thereafter.

Employee car reimbursement

A considerable portion of salaries in Israel's public and private sector jobs rely on a special payment to remunerate workers for driving to work. Receiving this monthly compensation requires car ownership [90]. This "vehicle reimbursement" salary supplement is grounded in a collective bargaining agreement between labor unions and the State. It is not a trivial sum. Roughly 15 to 20 percent of Israeli workers' salaries is contingent on utilization of a car on a regular basis. The payment is taxed as part of the worker's income, but does not provide a basis for setting pensions. Some 31% of workers in Israel's public agencies, central and local government enjoy this significant perk. In an astonishing 12% of Israeli households, at least one adult enjoys an additional vehicle through their work. Families who do *not* enjoy this benefit, typically have 10% lower motorization rates than those who do [91].

An extra car that can be utilized after work hours is a significant windfall. With taxes already paid, associated maintenance expenses are generally covered by employers, making marginal usage, essentially free. These dynamics constitute a market failure, as many gratuitous trips are made without considering actual costs, economic or environmental [92]. Moreover, workers in the public sector who prefer to cycle or walk to work, who cannot drive or who do not own a car, are essentially penalized for "doing the right thing", regarding their transportation choices.

In the policy literature, situations where governments pay people for activities that contravene the public interest are called: "perverse incentives" [93]. Such absurdities can be found in areas as diverse as agricultural water subsidies which encourage inefficiency to child allowances in countries suffering from overpopulation [94]. In such circumstances, dispassionate commentators usually call for their cancellation. Nonetheless, they often persist for years, due to political influence of vested interests, who often are responsible for getting the *perverse incentives* adopted in the first place.

In the present case, it makes little sense on the one hand to have a government working to reduce vehicle usage and congestion -- and on the other -- pushing workers towards extraneous rides while undermining possibilities of alternative or public transportation for much of the work force. The central explanation for the endurance of this incongruous policy involves the political power of public-sector unions who the government prefers not to provoke. Unions' commitment to this worker benefit seems non-negotiable. But, governments are elected to lead. It is time to place public interests first and initiate a frank discourse with workers' representatives with alternative proposals on the table. A reasonable contract that creates incentives to cycle or take the train to work need not leave workers worse off economically.

Transport-insensitive residential development

Each day, hundreds of thousands of Israelis take the train, with over 5 million rides per month; on many lines ridership consistently rises by 20 percent each year [95]. The positive experience with Israel's train ridership and exponential rise in travel (Figure 2) suggests that when offered a compelling substitute, Israelis happily opt for public transportation.

Unfortunately, the percentage of such lucky citizens is unlikely to grow significantly. Israelis increasingly live far away from where they work in neighborhoods that are not designed to encourage public transport ridership, cycling or walking. Among the characteristics of such development includes:

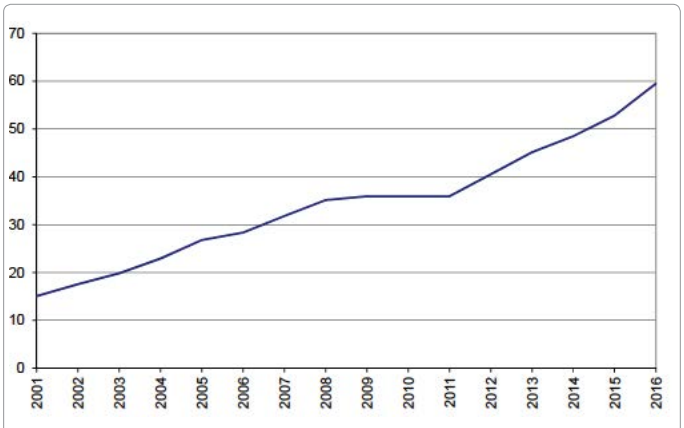

Figure 2: Number of annual passenger trips on Israel's trains (in millions).

- Inaccessible by-pass roads that circumvent residential streets;
- Large distances between intersections;
- Commercial, business and municipal activities that take place outside the city;
- Poor pedestrian accessibility making walking an unrealistic option, especially during hot summer months; and
- Poor public transportation service [96].

Part of the problem can be traced to the sense of emergency created by acute housing shortages which leads to hasty and unwise planning decisions. In 2011, over three hundred thousand Israelis demonstrated against the lack of affordable housing in a spontaneous social protest movement that purportedly engaged one seventh of the entire population [97]. The government responded by establishing an emergency residential housing planning commission (known by its Hebrew acronym the VATMAL) [98]. Dominated by government representatives, the committee has clear marching orders: approve the 60,000 new residential units required each year to meet growing demand.

A representative from the Ministry of Transportation sits on the committee. She is supposed to ensure that new developments are built with effective transportation solutions for residents that do not exacerbate present transportation problems. But as a lone voice among other, myopic agency representatives, her influence appears to be extremely modest. Hundreds of thousands of apartments have been expeditiously approved in new neighborhoods and communities. But the task of delivering the people who will live there to their work, shopping centers, hospitals or recreational outlets is rarely considered seriously. Israel's environmental community warns that the housing boom will cause present catastrophic levels of congestion, to get worse [99].

Just how should these new neighborhoods be built and how should urban renewal recraft existing neighborhoods to expand utilization of public transport, cycling and walking? (A complimentary challenge is how to overcome resistance to densifying redevelopment --and in-fill development in cities and inner-ring suburbs?) Ewing and Cervero [100] evaluated the relative contribution of several neighborhood characteristics to reduced utilization of private vehicles. Most influential among the independent variables was increasing, urban, population density. Ensuring mixed zoning allows for residential, commercial, business, entertainment, essential services and schools, transforming the character of an area from a sterile, suburban feel, which locks people into car dependency. At the same time, it is important to create pleasant walking conditions with shaded sidewalks and wide cross-walks, while giving pedestrians the right-of-way. Living within 500 meters of a bus or train stop turns out to be an essential factor as well. In short, it is far easier to reduce driving in communities if they are designed so that residents do not need a car.

Addressing Population Growth: A Broader Definition of Demand Management

Not only do a higher percentage of Israelis own cars than they did twenty years ago, but there are many more Israelis. Since the country was established in 1948, population has grown 10-fold: from 680,000 to 6.8 million [101]. Present projections anticipate that by 2040, more than 13 million people will live in Israel [102]. In a closed system, the idea of infinite growth is an impossibility. In a very small country, this truism quickly becomes an uncomfortable reality. Demand management requires public policies that not only stabilize the number of automobiles in the local fleet, but the number of people driving on the roads.

Just to keep up with the growth in population, massive investment in public transport infrastructure is vital: according to one estimate from the Ministry of Transport: a minimum of 200 billion shekels is necessary. New rail and subway systems are needed. Bus service needs to be expanded. Cycling lanes need to be created. There is no sign that the infrastructure "wish list" will ever be filled.

The advent of autonomous vehicles in Israel (anticipated to be approved and rolling locally by the year 2022) [103] will only exacerbate present congestion: people who presently cannot drive or afford a private vehicle will suddenly avail themselves of cars. With 2% annual population growth, the number of automobiles on Israeli roads naturally doubles within 35 years. In fact, as car dependency became even more pervasive due to residential sprawl, the 4% rise in automobiles on the roads [104] is twice demographic growth and the rate of road pavement [105]. Even though Israel adds an average of 150 km of paved highway each year, overall congestion only increases. The country is running on a proverbial treadmill, leaving it unable to keep up with relentless demand for more roads, more highways, more asphalt. It is time to get off the treadmill.

Ultimately, investments in automotive infrastructure addresses the symptoms of a far deeper problem. As long as Israel's population continues to grow exponentially, real progress will be elusive. Tel Aviv, has only one Ayalon highway that can take cars through the heart of the country's central metropolitan region. Already, traffic jams there begin in the early morning hours and remain fairly steady until long after sunset. With 5 million more Israelis anticipated over the next 23 years, it will soon more closely resemble a parking lot than a freeway. Israel's train stations, a bright spot in an otherwise inadequate public transport system, will become unbearably crowded during rush hours, as they are in cities like Mumbai and Beijing.

The British naturalist David Attenborough argues that there is no environmental problem that isn't more easily solved with fewer people. Improving a country's greenhouse gas profile along with transportation mobility and accessibility, constitute a case in point.

Conclusion

During the last decade, Israel's automotive fleet has become significantly less polluting due to a combination of conventional "command and control" interventions and innovative green taxation that successfully altered consumer choices in the local car market. In retrospect, this impressive achievement did little to change mobile source emissions' contribution to the country's overall greenhouse gas burden. In fact, the carbon footprint of transport is actually increasing. Whether or not these dynamics are attributed to Jevons Paradox, "moral licensing" or poor planning is of little consequence. A significant commitment to *demand management* that revolutionizes transportation patterns and the growing dependency on automotive travel is imperative. Without it, local climate change mitigation efforts will fall far short of the 60% reduction accepted as critical for stabilizing atmospheric CO_2 levels [106].

This *inconvenient truth* is consistent with the position of sustainable transportation advocates who consistently argue that Israel cannot pave its way out of traffic jams. Temporary relief created by new highways and roads will soon be filled by the new influx of drivers. The need to manage demand is self-evident. Physical constraints simply cannot be

ignored: the number of cars that can drive through a 3.5 m wide lane of traffic in an hour will never exceed 2000 by very much. In contrast, 14,000 bicycles, 19,000 pedestrians and 22,000 people in a light rail system can pass through the same space [107].

Jevons Paradox is an unfortunate phenomenon, but hardly constitutes an immutable destiny. It is defeatist to think that nothing can be done for the many citizens of Israel (and the world) who are not yet lucky enough to live within walking or biking distance of their work or in proximity to a bus stop or train line. There is no single magic bullet, but a range of measures might help. In its recent report, the OECD weighed in on Israel's situation with recommendations for reducing the motivation to drive a private vehicle [108]. These include: Eliminating vehicle-based employee benefits, accelerating investment in land-based public transport and introducing congestion taxes to raise the cost of bringing cars into urban areas during rush hours [109].

For too long, successive governments, regardless of political affiliation, relied on the extraordinarily high taxes collected from sales of new vehicles and automotive parts for revenues [110], making expanded car ownership an unspoken fiscal priority [111]. This is a narrow and myopic way to apprehend a problem that has morphed from a local conundrum to part of a global tragedy of the commons. Transportation budgets must be completely realigned to prioritize public transportation, cycling and pedestrian infrastructures [112]. Policy tools, like congestion tariffs that have worked successfully elsewhere, can help reduce traffic in Tel Aviv, Haifa and Jerusalem.

In considering strategies to address the overwhelming challenge of climate change, many policy makers have confidence in technological innovation. There is an implicit pessimism about democratic governments' ability to change human behavior. While global warming's existence is no longer questioned by most decision makers in the enlightened world, including in Israel, pragmatists assume that engineers will need to extricate humanity from global "overshoot". Transportation is one such area: it is hoped that electric cars, airplanes that fly on hydrogen or even carbon-free jet packs will allow humans to continue "business as usual" in personal mobility habits, without having to fundamentally alter lifestyles. Israel's nascent efforts to reduce its national carbon footprint suggests that such faith is ill-advised. Overcoming Jevons paradox in the transportation realm is certainly possible. But it requires new ways of thinking about mobility and a rejection of a culture and policies dependent on private vehicles [113].

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