Selected Research and Policy Analysis Notes

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CHANGES IN THE PROPORTION OF FIRST-TIME HOME BUYERS AMONG YOUNG FAMILIES ACCORDING TO LEVEL OF INCOME DURING THE YEARS 2007–17[1]

- The proportion of first-time home buyers among employees aged 25–35 at all levels of income rose between 2007 and 2016.
- The connection between household income and the probability of a young family buying their first home was stronger in 2015–16 than in 2007–08, which was prior to the major increase in housing prices.

Introduction

Between 2007 and 2016, home prices in Israel rose by more than 100 percent, while disposable household income grew at a lower rate. Against this background, the question arises as to how the increase in home prices—and the potentially lower financing costs resulting from the declining interest rates during the same period—were manifested in the buying patterns of households. This analysis focuses on young households, which is the main population of first-time home buyers[2] and is the group most exposed to increases in home prices.[3] In particular, has the proportion of young first-time home buyers changed and how have various household characteristics affected the probability of buying a home over the years? The focus of the analysis is household income and in particular the question of how differences in the probability of buying a new home among young households in the various income groups have changed. It is important to note that an increase in the probability of buying a home that is identified in the data does not necessarily reflect a reduction in the economic burden on young households, as it was made possible by, among other things, the lengthening of the mortgage repayment period and it is possible that the homes purchased were more modest in terms of various characteristics.

The increase in home prices and its influence on young households in Israel have been a focus of attention among the public during the past decade. This was manifested in, among other things, the Social Protest in 2011, in the recommendations of the Trajtenberg Committee which was established as a result of the Social Protest, and in the new housing programs that the government has proposed in recent years—Zero VAT (which ultimately was not implemented), "Target Price" and "Buyer's Price". Housing is a basic product, which accounts for a high proportion of household expenditure. It also requires, in most cases, that a large loan be taken out to finance the purchase of the asset. As the ability of households to quickly adapt their residence in reaction to changes in prices is limited, home prices have a major effect on households and on the economy. Benita and Naor (2013), for example, examined the changes in the manner of financing of home purchases (the loan to value ratio and the size of the mortgage) and found that during the years 2008–12 the proportion of mortgage payments within household income rose, together with an increase in the proportion of mortgages with high repayment to income rates. Using data from Expenditures Surveys

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1 Thanks to Yoav Friedmann for professional advice and helpful comments during the research. Also thanks to Ariel Mantzura for professional advice in building the statistical model and to Hila Alalouf for assistance in understanding the database and its construction.

2 During the period 2007–16, the proportion of first-time home buyers aged 25–35 among all first-time home buyers was about 60 percent.

3 Second-time (and onward) home owners are protected from price increases, if only partially, since they already own an asset whose prices increases. This is not the case for first-time home buyers.

for the period 2004–12, Friedmann and Ribon (2014) estimated that the proportion of mortgage repayment within income had not increased despite the rise in the size of the mortgage, due to the significant lengthening of the repayment period, a decline in the interest rate and some increase in real household income. Tzur-Ilan (2017), focusing on the restrictions imposed by the Banking Supervision Department on mortgages, examined the changes generated by Banking Supervision Department's Directive limiting the loan to value (LTV) ratio in household decisions in the housing market. She found that the Directive did not bring about any major change in the number of home purchases, but did affect the characteristics of the purchased homes. Thus, cheaper homes were purchased that are also further from the Center and tend to be located in neighborhoods with lower socioeconomic levels. However, she related to changes in home purchases during a short window of time (in the vicinity of the issuing of the Directive) and within specific price ranges. The current analysis looks at longer time spans and broader price ranges.

Other studies have examined how price increases influenced the composition of buyers and the patterns of home purchases. Ben Naim (2012) examined how the characteristics of first-time home buyers changed during the period 2004–11 and found that a sharp increase in prices in 2009 was accompanied by a shortening of the time between getting married and the purchase of a home. Similarly, she found that in 2009, during which there was an increase in housing prices and in the number of monthly salaries needed to purchase a home, young couples coming into the market were less well-off than in previous years. Another study (Bank of Israel, 2014[4]) focused on young couples—the vast majority of first-time home buyers—during the period 2002–12. It was found that the share of home ownership among 25–40 year olds had declined, together with an increase in the median age of first-time home buyers and an increase in the proportion of homes purchased in the periphery. Ben Tovim (2016) expanded the analysis of buying patterns among purchasers of a single home and estimated the price elasticity of demand for housing during the period 2008–14. She found that this elasticity was lower on average than that found by studies in other countries. In other words, the behavioral response of the buyer of a single home to changes in price is relatively limited (in the price range corresponding to the first level of the purchase tax).

Although home buyers in each year are only a small part of total home owners,[5] over a long period changes in the characteristics of home buyers will also be reflected in those of home owners. The focus on first-time home buyers in the aforementioned studies, and also in the current analysis, derives from the fact that an increase in home prices primarily affects the population that does not own a home. While home owners are relatively protected from the price increases because they already own an asset that provides housing services over time, the population that does not own a home is exposed.[6] It is therefore worthwhile examining how the rise in home prices has affected different income groups, the liquidity constraints they are under and their ability to obtain equity that is sufficient for the purchase of a home. Despite the widespread interest in the subject and the many studies that have been done, the changes over time in the proportion of first-time home buyers by income has so far not been examined.

This analysis looks at the characteristics of first-time home buyers among young households and the

4 Bank of Israel (2014), "First-time home buyers: Changes in buying patterns between 2002 and 2012, according to income level."

5 Thus, for example, the proportion of first-time home buyers within total home owners stood at about 2 percent in 2016.

6 See Bank of Israel (2014), "Housing Affordability: Home Prices and Rents Across Districts in Israel, 2004–12."

changes in those characteristics over time, from 2007[7]—prior to the sharp rise in home prices—to 2016. In contrast to previous studies, which looked at a relatively short time period and only the population of home buyers, the current analysis looks at the characteristics of first-time home buyers relative to all young households that do not own a home over the course of a decade. By looking at all young households, it is possible to determine how the proportion of first-time home buyers among households with various characteristics has changed and primarily according to income group. We find that the probability of a first-time home purchase among the young population has increased, and within that population it has increased more among households in the fourth and fifth income quintiles than among lower quintiles.[8]

The data

The data file used in the analysis was created by merging two other data files:

1. Carmen Real Estate Prices Directory—This database covers all real estate transactions during the period 1998–2016. Prior to 2000, the coverage is thin and up to 2006 it is only partial (50 to 60 percent). For each transaction, there appears, among other things, the year of the transaction and the type of buyer.[9]

2. Employee files—A random sample of 10 percent of employees in Israel and their spouses. These files are in panel form and they include demographic information and detailed data on salaries during the period 2000–16.[10] They also give the salaries of the spouse if they were employees in that year.

These two sources of data, i.e. the Real Estate Prices Directory and the employee files, were obtained from the Israel Tax Authority and were used to characterize home buyers at a high level of detail. The merger is made possible by an identifying number that is given to every individual in the two files, so that for every individual in the employees files it is possible to know whether the person or spouse carried out a real estate transaction (sale/purchase). The merger process is carried out in four stages: merger according to individuals between the employee sample and the home buyers; the employee sample with the home sellers; a spouse of the individual in the employees file with home buyers; and the spouse of the individual in the employees file with home sellers.[11]

7 In the years prior to 2007, the data include only partial converge of real estate transactions and therefore the analysis cannot be carried out for earlier years.

8 Quintiles of net labor income among the young population (details appear in the Methodology section).

9 The Carmen files include information on the type of home buyer – first-time: someone who purchased more than 25 percent of a home and up to the time of the purchase did not own an additional asset; home owner: someone who purchased a home and at the time of the purchase did not own a home, but he did own one in the past (in other words, he owned one home but this was not his first purchase). A local investor: someone who purchased a home and at the time of the purchase owned an additional home.

10 The sample of employees does not include information on households that are not employees (self-employed or non-employed) or on additional income (such as capital income and pensions), but the main part of the income of households buying a home is from salaries.

11 The main drawback of the employees files is the lack of records for individuals in a particular year (for example, in years in which the individual was not an employee) and details for those years were added in order to improve the merger and the identification of home buyers.

The research population

The analysis encompasses all of the employees in the sample and their spouses (even if they were not employees in one of the years during the period 2000–16[12]) and the age of the older spouse is between 25 and 35.[13] Only sales transactions of owned residential homes in Jewish or mixed cities[14] during the period 2007–16 were included. For home buyers, we included only households that belong to the category of first-time home buyers[15] and as potential first-time home buyers we included all households that were not home owners until the relevant year. Finally, we omitted households with outlying incomes relative to the sample[16] and households in Arab localities.

Home owners were identified by tracking the transaction history of the individuals in the household. If a purchase transaction was identified, the household to which the individual belongs would be considered not to have the potential to become a first-time home buyer starting from the subsequent year. If a home purchase was not identified but a home sale was, we concluded that the household had owned a home and therefore that household was not included as having the potential to become a first-time home buyer, even in the years that preceded the sale. If an individual is identified as an investor during one of the sample years and a first-time home purchase was not identified for that individual, we omit the household that the individual belongs to from being a potential first-time home buyer. To illustrate: if a young couple bought a first home in 2010, they will appear in the datafile as being potential first-time home buyers from 2007 to 2010 and starting from 2011 they will be removed from the sample (since they now own a home) and therefore will no longer be regarded as a potential first-time home buyer.[17]

Table 1 presents the main characteristics of first-time home buyers relative to the research population. The table and Figure 1 show an increase in first-time home purchases—according to both the number of homes bought and the share of households that purchased a home out of the entire research population. Between 2007 and 2015–16, the share of first-time home buyers within all young households by 1.9–2.1 percentage points (a growth rate of about 100 percent).[18] Although Brender and Strawczynski (2014) point to an increase in the proportion of young couples with children that rent a home up until 2012 and similarly it is clear that the number of years of income needed to purchase a home increased significantly (Bank of

12 Households that entered/exited the labor market in one of the years were kept in the sample during all of the sample period, such that in the years in which they didn't work they appear as having no income. The goal is to create a balanced situation, such that if in certain years a household had the potential to buy a home, they will remain potential buyers even if they left the labor market and vice versa.

13 The ages were chosen according to the distribution of primary ages of first-time home buyers. The distribution was generated from a data file produced as a result of the merger, before the omission of individuals who are not part of the research (according to age, sector, etc.).

14 Since there were only a limited number of transactions reported for Arab towns, we only included transactions in Jewish/mixed cities (and omitted transactions in East Jerusalem). In parallel, we also omitted observations of residents of Arab towns, the lion's share of whom tended to continue living in the same town (Bank of Israel Report 2016).

15 Some of the individuals who were defined as first-time home buyers according to the original definition were identified by us as home owners by means of tracking their buying history. Therefore, we defined them as investors/home owners and they were sifted from the sample.

16 Households whose income was above the 99th percentile or below the 1st percentile were omitted.

17 Since the details of transactions exist only from 1998 onward and in some of the years the details are only partial, it may be that some of the households that are classified here as having the potential to be first-time home buyers are already home owners. Since the sample includes a young population, we believe that the size of the error in identifying the population of households with the potential to be first-time home buyers is limited. In order to verify that the results are not affected by the definition of the potential to be first-time home buyers we carried out a robustness test in which all households where the older spouse is aged 25 to 35 are potential first-time home buyers.

18 This conclusion is consistent with the raw data according to which the number of first-time home buyers has increased significantly in recent years (see, for example, Figure 9.2 in the 2017 Bank of Israel Report).

Table 1

Research population*, first home buyers and their income (2016 prices), selected years

	Number of households		Average income**		Average age		Average years married		Percentage of married couples*** (percent)		Average number of children	
	First home buyers	Total sample	First home buyers	Total sample	First home buyers	Total sample	First home buyers	Total sample	First home buyers	Total sample	First home buyers	Total sample
2007	1047	52989	11,321	7,115	30.21	29.60	3.46	4.41	85.48	52.08	0.68	0.55
2008	1049	54783	11,366	7,155	30.32	29.58	3.49	4.51	84.94	50.38	0.66	0.53
2015	2570	63801	12,884	7,805	30.28	29.65	3.72	4.37	85.41	53.35	0.67	0.53
2016	2473	63473	13,065	8,061	30.21	29.62	3.82	4.52	84.67	50.97	0.66	0.51

* The research population is taken from an original sample including 10 percent of employed people, and includes households in which the older individual is between 25 and 35 years old, excluding households living in Arab localities. The sample includes only households with the potential to purchase a first home.

** Net household income from salaried labor, in 2016 prices.

*** Married couples or couples living together and managing a shared houseold.

Figure 1
The Increase in Income, Increase in Home Prices Index and Share of First Home Buyers, Young People Aged 25–35, 2007–16

Figure 1b
Share of first home buyers out of total potential first home buyers

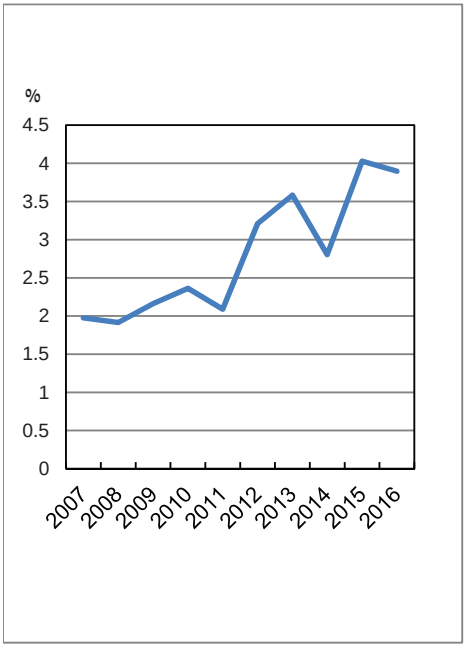
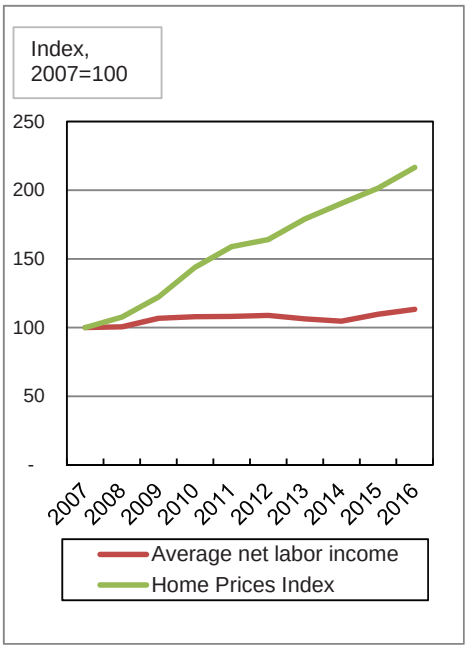


Figure 1a
Growth of net real income from labor and in the Home Prices Index



SOURCE: Based on Israel Tax Authority.

Israel, 2014 and 2015), it should be noted that the current analysis does not relate to the quality of the home purchased, its location or the long-term financing burden that the purchase has imposed on the buyers.

Similarly, a decline can be seen in the proportion of transactions by young households in the years 2011 and 2014 and a relatively sharp increase in the years 2012 and 2015. This is related to the Social Protest of 2011 and the expectation created by the Zero VAT program in 2014. Thus, households that intended to purchase a home in those years and waited because they expected prices to go down, as a result of both the Social Protest and the declaration of the Zero VAT, returned to the market immediately after it became clear that there was no expectation of price declines or special discounts for young buyers. Moreover, it is possible that the increase in transactions in 2012, which brought their proportion to a new and higher level, is an indicator that home buyers had internalized the low interest rate following the reduction in that year and perhaps also the view in those years that no effective government assistance for young home buyers can be expected.[19] It can also be seen that the proportion of married couples[20] among first-time home buyers is high relative to singles.

19 Appendix 1 presents the path of the interest rate during the period 2007–2016. The largest reduction in the interest rate occurred in 2009 following the economic crisis in 2008 and a second reduction occurred in 2012, followed by the stabilization of the interest rate at a low level for an extended period of time.

20 A married couple is defined as one that resides together and maintains a shared household, even if they are not married. Years of marriage are counted starting from the year in which the couple was officially married. The idea is that the household will be considered as a single unit (rather than two separate households), since the decision to purchase a home is made by both spouses even if they are not yet married.

Methodology

The goal of the model is to estimate the probability of a household buying a first home in a particular year. The estimation is carried out by means of a logit regression for each of the years 2007 to 2016. The following equation was estimated:

$$y_i = \beta_0 + \beta_1 Q_i + \beta_2 age_i + \beta_3 age^2{}_i + \beta_4 years\_married_i + \beta_5 years\_married^2{}_i + \beta_5 kids_i + \beta_6 status_i + \beta_7 District_i + \epsilon_i$$

where:

y_i – a dummy variable for the purchase of a first home (1 – if household i purchased a home in that year and 0 otherwise).

Q_i – a dummy variable for the income quintile to which household i belongs in that year.[21] The division into quintiles is according to net annual household labor income at each age: since among the young population salaries increase significantly with age we classify the young households into quintiles according to the household's salary ranking in the cohort it belongs to.[22] Appendix 3 presents the average income for the years 2007–16 by quintiles.

age_i - age of the older spouse in household i.

$kids_i$ – dummy for number of children category (no children, one or two children, three or more children).[23]

$status_i$ – dummy for family status (married, single or divorced).

$District_i$ – dummy variable for household i's district of residence (at the time of purchase).

ε_i – random error

The logit regression allows us to test the effect of various household characteristics on the probability of buying a first home and how they change over time, where the variable of interest is Q_{it}. In particular, is there a statistically significant gap between the income quintiles in the probability of buying a first home and has that gap changed over time?

21 Since this is a young sample, a test was done for the stability of the quintiles: calculation of the proportion of households that remained in their income quintile after five years (as in the calculation done by Brender, 2010). Appendix 2 presents the results of this calculation, once for households aged 25–27 and once for households aged 28–30. It can be seen that a significant portion of the households remained in the same income quintile after five years, and only a small proportion moved more than one quintile.

22 The analysis was also carried for a breakdown into quintiles according to net average household labor income during the past three years. However, among young employees, salaries change significantly with age and therefore we preferred to look at income in the relevant year as representative of the household level of income. Similar results were obtained for both methods of dividing into quintiles.

23 The determination of categories was carried out according to the distribution of number of children in the sample. Since this is a young sample, most of the households do not have children, some have one child and only a few have three children or more.

Results

Table 2 presents the main estimation results.[24] The estimates in the table present the odds ratio, i.e., the probability of one group buying a first home relative to the probability for another group (for example, the probability for the upper quintile to that for the lower quintile)[25], rather than the effect of absolute size of the probability, which will be presented below. A coefficient of greater than one implies that a high value of the variable is correlated with an increase in the probability of buying a home and vice versa. Table 2 can show the direction of the connection between the characteristics examined in the model and the purchase of a home and how, if at all, the strength of the connection varies over time. Thus, for example, the probability of young married couples buying a first home is higher than that for singles of a similar age (the estimated coefficient of the married coefficient is more than one and statistically significant). Although the size of the estimated coefficient declines for a number of years, in 2016 it returns to a level similar to that in 2007. Age and years of marriage were also found to have a positive and statistically significant effect on the purchase of a home, although the relationship was not linear.[26] As in the case of family status, it appears that the estimates for age and years of marriage do not change significantly during the sample period and in general the dynamics of the control variables at the end of the period are similar to those at the beginning of the period.

Income was found to have a strong effect. In other words, there is a significant relationship between a household belonging to a particular quintile (among young households) and the probability of buying a home. In particular, the odds ratio for buying a first home between the third, fourth and fifth quintiles on the one hand and the first quintile on the other is significant throughout the sample period (and between the second quintile and the first in some of the years). It can also be seen that in each year the estimate for the fifth quintile is particularly high (relative to the estimated coefficients of the other variables). Furthermore, the estimated coefficient for the fifth quintile for most of the period is higher than at the beginning of the period. As such, the connection of the income quintile to which a household belongs and the probability of buying a home increases in strength over the years and in particular the odds ratio for buying a first home between the upper income quintile and the lower quintile rose during 2009 and subsequent years relative to 2007–08, the years prior to the sharp rise in home prices.[27]

24 The full estimation results appear in Appendix 4.

25 $$exp[\beta] = \frac{\left[\frac{p(y=1|x=1)}{p(y=0|x=1)}\right]}{\left[\frac{p(y=1|x=0)}{p(y=0|x=0)}\right]} = odds\ ratio$$

26 As age increases, its effect decreases and the same for years of marriage. To illustrate: if we look at a household in 2016, in which the older of the two spouses is 27 years old, the addition to the odds ratio as a result of age increasing by one year (with the other variables unchanged) is higher than for a household where the older spouse is 30 years old.

27 In order to test whether the increase in the gap is statistically significant, we carried out a significance analysis on the difference in the gaps between the first and fifth quintiles by means of a test for each possible pair of years after running a consolidated regression for all the years (with an interaction variable between year and all the variables in the model). Appendix 5 presents the difference in the estimates presented in Table 2 between each possible pair of years and shows that in comparison to 2007 (and for some of the variables also 2008), the increase in the gap between the quintiles is statistically significant, though the gap between later years is not.

Table 2

Results of the estimated regression equation—main variables, 2007–16

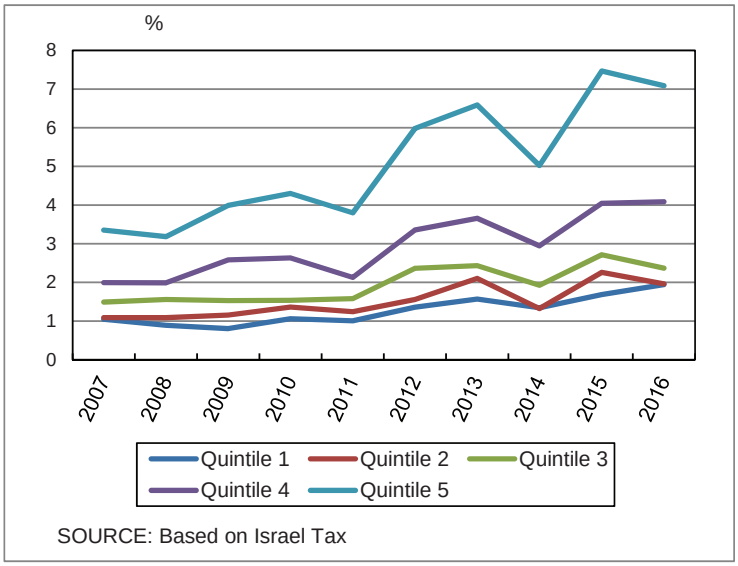
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Quintile 2	1.043	1.224	1.441**	1.294*	1.240	1.151	1.352***	0.983	1.353***	1.008
	(0.160)	(0.192)	(0.216)	(0.174)	(0.170)	(0.140)	(0.148)	(0.125)	(0.143)	(0.103)
Quintile 3	1.437**	1.769***	1.922***	1.461***	1.584***	1.772***	1.572***	1.444***	1.639***	1.226**
	(0.202)	(0.255)	(0.272)	(0.189)	(0.204)	(0.195)	(0.164)	(0.167)	(0.164)	(0.119)
Quintile 4	1.938***	2.275***	3.300***	2.551***	2.153***	2.556***	2.408***	2.245***	2.493***	2.173***
	(0.255)	(0.311)	(0.439)	(0.305)	(0.263)	(0.267)	(0.234)	(0.239)	(0.233)	(0.189)
Quintile 5	3.334***	3.720***	5.215***	4.277***	3.948***	4.761***	4.546***	3.954***	4.862***	3.952***
	(0.417)	(0.487)	(0.680)	(0.495)	(0.462)	(0.479)	(0.425)	(0.405)	(0.436)	(0.328)
Married (vs. single)	3.001***	2.981***	1.323**	1.559***	1.558***	1.676***	1.994***	3.162***	2.246***	2.483***
	(0.349)	(0.357)	(0.152)	(0.169)	(0.177)	(0.155)	(0.168)	(0.294)	(0.176)	(0.199)
Age	2.179***	2.824***	2.576***	2.899***	1.494*	2.443***	2.045***	2.384***	2.534***	2.099***
	(0.516)	(0.680)	(0.561)	(0.602)	(0.310)	(0.425)	(0.332)	(0.436)	(0.387)	(0.321)
Age^2	0.988***	0.984***	0.985***	0.984***	0.994*	0.986***	0.989***	0.986***	0.985***	0.988***
	(0.00388)	(0.00393)	(0.00356)	(0.00337)	(0.00342)	(0.00284)	(0.00267)	(0.00300)	(0.00250)	(0.00251)
Years of marriage	1.220***	1.274***	1.549***	1.519***	1.609***	1.559***	1.451***	1.221***	1.346***	1.320***
	(0.0523)	(0.0580)	(0.0582)	(0.0530)	(0.0613)	(0.0494)	(0.0431)	(0.0409)	(0.0391)	(0.0396)
Years of marriage^2	0.970***	0.965***	0.957***	0.960***	0.954***	0.955***	0.963***	0.975***	0.967***	0.969***
	(0.00413)	(0.00441)	(0.00353)	(0.00326)	(0.00364)	(0.00304)	(0.00280)	(0.00315)	(0.00274)	(0.00278)
One or two children (vs. no children)	1.352***	1.214**	1.129	1.008	1.013	1.073	0.988	0.971	1.026	0.999
	(0.118)	(0.105)	(0.0964)	(0.0805)	(0.0841)	(0.0717)	(0.0617)	(0.0663)	(0.0594)	(0.0584)

* Standard deviations in parentheses.

* Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level.

Figure 2 shows the direct effect of the income variable on the probability of buying a first home, i.e., the marginal effect of the income quintile.[28] The calculation of the marginal effect makes it possible to derive the probability of a household buying a first home given their income quintile, where the rest of the variables are held constant (Average Marginal Effect – AME).[29] The graph shows that the general marginal effect is increasing, but the increase is primarily the result of the increased marginal effect on the upper quintile, such that the gap between the quintiles in the probability of buying a first home grew. Furthermore, Table 3 shows the marginal addition to the probability of buying a first home given that the household belongs to the fifth quintile (relative to the first quintile), where the other variables are held constant. Here again, the expansion of the gap between the upper and lower quintiles relative to the early sample years is evident and this expansion was found to be statistically significant.

Figure 2
The Average Marginal Effect (AME) of Income Quintile on Probability of Buying a Home, 2007-16



SOURCE: Based on Israel Tax

The main finding from the estimation results and the above analysis is that overall, during the sample period, there was an increase in the probability of young couples buying a first home, as can be seen in Table 1. This increase appears in all of the quintiles but most of it is concentrated in the upper quintiles. It

28 In the logit regression, the marginal effect of variable k is calculated as follows:

$$\mathrm{MFX}(x_k) = \frac{\partial p}{\partial x_k} = \beta_k p(1-p) = \frac{\exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)}{[\exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)]^2}\beta_k$$

29 Average Marginal Effect (AME): the AME is calculated when the rest of the variables are kept constant except for one. Thus, in order to calculate the marginal effect of the income quintile variable: the entire sample remains unchanged except for the quintile variable. In the first stage, the whole sample is categorized in the first quintile; in the second stage, it is categorized in the second quintile; and so on, where the other variables are identical. It should be mentioned that the marginal effect can be derived in other ways that are accepted in the literature. For example, by substituting the average values for the variables except for the income quintile variable. The two methods lead to similar results and identical trends. It should also be recalled that the analysis of the probability differs from the analysis of the estimates received from estimating the equation, since the transition from the odds ratio to probabilities is not linear. In order to test the quality of the results obtained from the analysis of the marginal effect, we estimated the equation by OLS, in which the estimates obtained represent the direct effect of the income quintile variable on the size of the probability. The estimates obtained from this estimation are similar in level to the marginal effect obtained from the aforementioned analysis and the trend is identical, i.e. the widening gap in the probability of buying a first home between the upper and lower quintiles during the sample period.

may be that the decline in financing costs as a result of the low interest rates in the market, together with the fear that prices would continue to rise, motivated young couples to buy homes and that the upper quintiles have greater access to the mortgage market and have more equity in order to buy a home.[30] Therefore, they were more able to realize the desire to buy a home.[31]

Table 3

The marginal addition derived from belonging to Quintile 5 vis-à-vis belonging to Quintile 1 in the probability to buy a first home, 2007–16

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Quintile 5 vis-à-vis Quintile 1 (addition in percentage points)	2.31	2.29	3.19	3.24	2.79	4.63	5.02	3.68	5.78	5.14
Significance vs. 2007	_	_	**	**	_	***	***	***	***	***
Significance vs. 2008	_	_	**	**	_	***	***	***	***	***

Significance checked by a Wald test in each year vs. 2007 and 2008 (separately).

* Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level.

The following analysis makes use of the estimation results in order to test whether the income quintile variable affects the cumulative probability[32] of a household where the older spouse is 25 years old (at the beginning of the period) to buy a home over a period of ten years. In the first stage, we estimated for every age the annual probability of buying a first home according to the "typical" household characteristics, i.e., an individual living in the Center who married at the age of 29 and became a parent of one child on reaching the age of 32.[33] The calculation was carried out for each of the income quintiles and by using the estimates for the different years. Finally, we summed the annual probability over 11 years from age 25 to age 35. This calculation finds the expected probability of a household that had not bought a home up to the age of 25, owning a home by the age of 35.

First, the above results show that the cumulative probability of buying a first home rose during the decade and relative to the period prior to the sharp increase in home prices (Figure 3). Thus, according to the estimates for 2007, the household consisting of a single individual aged 25 belonging to the lower labor income quintile for young families will have a cumulative probability of buying a first home by the age of 35 (and after having married at the age of 29) of about 17 percent. The same probability calculated for a household with identical characteristics according to the estimates for 2016 is about 28 percent, a difference of about 11 percentage points. Also in the third and fifth quintiles, an increase in this probability is observed. Clearly evident in the graph is primarily the increased gap between the quintiles in the cumulative probability of buying a home. Thus, according to the estimates for 2007, the gap between the lower and upper quintiles was

30 As mentioned, the database does not provide access to data on household equity. Nonetheless, belonging to a labor income quintile is correlated with the accumulation of equity and therefore it can be assumed that households in the upper quintile have more equity than those in the lower quintile.

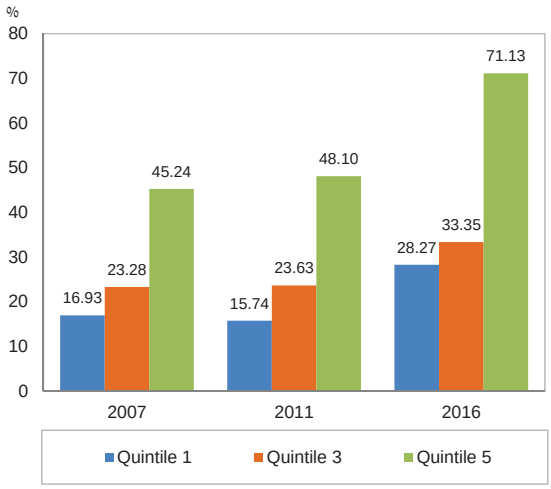
31 It was found that at the beginning of the upward trend in housing prices, young households that did not own a home increased their labor income more than similar households who did own a home (Bank of Israel Report 2015, Chapter V), apparently in order to increase their equity and their repayment ability and thus to finance a home purchase. Nonetheless, the addition to income that was identified is about 15 percent, much less than the gap in average income between the quintiles in this study (Table in Appendix 3).

32 The cumulative probability is obtained by summing the probabilities of a household buying a home at each age (starting from 25) during the ten-year period. This is in contrast to the general probability of buying a first home in a particular year or at a particular age, given particular characteristics.

33 We characterized the household according to the distribution of the variables by age. Since the household age is chosen according to the older of the two spouses, the household's age of marriage and the age of having a first child is larger than the average for the population.

28 percentage points, while according to the estimates for 2016, the gap had grown to 43 percentage points (an increase of 15 percentage points). As indicated by the results presented so far, there was an increase over the years in the probability of a young household buying a home and in the gap in this probability between the income quintiles.

Figure 3
The Cumulative Probability of a Typical Household Buying a First Home During the 10 Years Between Ages 25 and 35 at Various Periods and by Income Quintiles, 2007, 2013, and 2016



* For every age, we calculated the probability of buying a first home given the criteria of a typical household in the sample, for each income quintile. We accumulated the probabilty over 10 years, each time repeating the calculation using the various years' estimates.

SOURCE: Based on Israel Tax Authority.

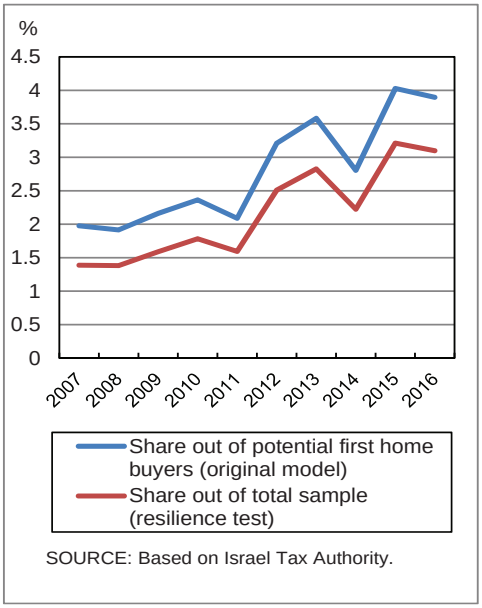
Robustness checks

Since there is data for transactions starting from 1998 and in some of the years it is only partial, it is possible that some of the households categorized in the study as having the potential to buy a first home are already home owners. Since the sample includes a young population we believe that the magnitude of the error in identifying the households with a potential to buy a first home is limited. Furthermore, it is reasonable to assume that most of the households that bought a first home before 2007 replaced it during the decade and therefore it was possible to identify such a household as a home owner (and to sift it from the potential home buyers).[34] In order to verify that the results are not affected by the definition of potential home buyers, we carried out an identical analysis except for the definition of the research population. In this analysis, the population with a potential to buy a first home in each year was defined as the total households in which there is at least one employee and the older of the two spouses is between 25 and 35 years old, whether or not they have a transaction history. We omitted households that had bought an investment home or were second-time (or later) buyers. First-time buyers were defined as households that belong to the category of first-time buyers (as in the first analysis). Since the chance of identification error is higher during the earlier sample years, the goal is to determine whether the proportion of transactions in the sample in both analyses presents a similar dynamic over the sample period. The main idea is that if the trend in the proportion of transactions over the years is similar, it can be assumed that there was no bias in identification in favor of certain years.

Figure 4 presents the proportion of first-time home buyers within the total population defined in two ways: the total population (as defined in the robustness check) and the potential first-time home buyers (as defined in the main model). The trends appear to be identical except for a lower proportion of first-time home buyers in the second model, which is not surprising given the expansion of the reference population. It can be concluded that there is a low rate of error in identification of households as being potential first-time buyers (households who own a home but were not identified as such), due to the aforementioned reasons. Furthermore, the findings are similar with respect to the increase in the general probability of buying a first home, together with the increased gap between the upper and lower quintiles during the decade (Figure 5).

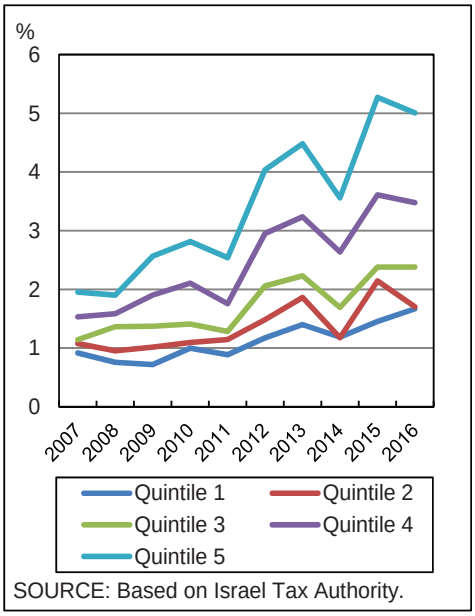
34 In order to test this assumption, we looked at the proportion of young couples that moved/sold apartments during the sample period. It was found that among home buyers aged 25–35 in 2007–8, 60 percent bought or sold a home during the period 2009–16.

Figure 4
Share of First Home Buyers out of the Total Sample and out of Potential First Home Buyers, 2007–16



SOURCE: Based on Israel Tax Authority.

Figure 5
The Average Marginal Effect (AME) for Each Income Quintile—Resilience Test, 2007–16



SOURCE: Based on Israel Tax Authority.

Conclusion

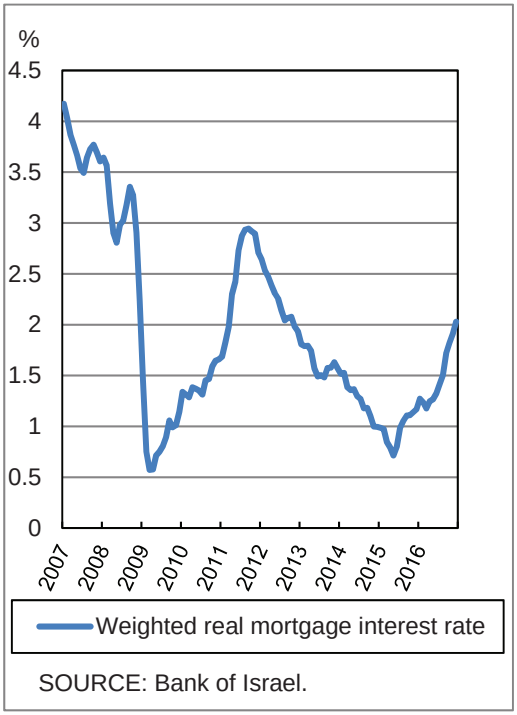
Home prices have climbed rapidly during the past decade and to a greater extent than household disposable income. This study made use of individual data provided by the Israel Tax Authority to examine changes in the proportion of young households that bought a first home, and particularly in their income characteristics, during the period 2007–16. The method of the analysis made it possible to quantitatively estimate the share of young households that bought a first home according to their characteristics and how the effect of each of these characteristics changed over the years. The results show an increase in the proportion of households that bought a first home within the total young population, and particularly among households in the fourth and fifth labor income quintiles for the young. An examination of the proportion of first-time home buyers as a function of the income distribution among young employees shows that the probability of households in the upper income quintile grew, relative to the years 2007–08, more than that of households in the lower quintile. It is reasonable to assume that the main reason for this is the fact that households in the upper quintile possess greater equity[35] on average and have greater mortgage repayment ability (ratio of repayment to household income) and therefore they are more able to implement a decision to buy a first home.

Although the findings show an increase in the proportion of first-time home buyers among young households, this does not necessarily reflect a drop in the economic burden on young households, since it was made possible partly by the lengthening of the mortgage repayment period and was possibly accompanied by a downgrade of home characteristics, such as location, size, etc., which may not have been out of choice.

35 It is reasonable to assume that there are households that use equity from their parents to finance a home. The parents'-equity component is not found in employee data, but it may be assumed that there is a link between parents' wages and ability to build up equity (and use it to assist their children with purchasing a home) and their children's income quintile. For a further discussion on intergenerational mobility, see Aloni and Karil (2017) and Zussman and Frish (2009).

Appendix

Appendix 1
Weighted Real Mortgage Interest Rate, 2007–16



SOURCE: Bank of Israel.

Appendix 2
Households' movement between income quintiles after 5 years, by age

Income quintile at ages 25–27						Income quintile at ages 28–30					
Income quintile 5 years later	**1**	**2**	**3**	**4**	**5**	**Income quintile 5 years later**	**1**	**2**	**3**	**4**	**5**
1	0.30	0.23	0.14	0.07	0.03	**1**	0.37	0.22	0.09	0.04	0.02
2	0.19	0.24	0.25	0.15	0.06	**2**	0.20	0.32	0.22	0.09	0.04
3	0.13	0.16	0.21	0.25	0.14	**3**	0.10	0.17	0.29	0.24	0.08
4	0.10	0.12	0.15	0.24	0.28	**4**	0.06	0.10	0.19	0.34	0.23
5	0.08	0.11	0.12	0.18	0.40	**5**	0.03	0.05	0.10	0.19	0.55
Share of households that exited the sample	0.21	0.14	0.12	0.10	0.09	**Share of households that exited the sample**	0.24	0.14	0.11	0.10	0.09

* The table presents the distribution of households' income quintiles currently and after 5 years (in the same cohort). For example, out of households that were in the first quintile when they were 25–27 years old, 30 percent remained in the 1st quintile, and 19 percent moved to the 2nd quintile, after 5 years.

Appendix 3

Average income of the sample population by quintiles (in 2016 prices), 2007–16

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Quintile 1	1,243	1,251	1,399	1,462	1,486	1,460	1,420	1,356	1,447	1,548
Quintile 2	3,859	3,877	4,157	4,233	4,261	4,239	4,148	4,067	4,268	4,483
Quintile 3	6,188	6,234	6,684	6,783	6,785	6,805	6,666	6,553	6,872	7,145
Quintile 4	9,105	9,181	9,856	9,965	9,958	10,073	9,840	9,667	10,141	10,451
Quintile 5	15,185	15,238	15,877	15,947	15,985	16,176	15,754	15,576	16,302	16,686
Total	7,115	7,155	7,593	7,677	7,694	7,749	7,564	7,443	7,805	8,061

Appendix 4

Results of the estimated regression equation, 2007–16

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Quintile 2	1.043	1.224	1.441**	1.294*	1.240	1.151	1.352***	0.983	1.353***	1.008
	(0.160)	(0.192)	(0.216)	(0.174)	(0.170)	(0.140)	(0.148)	(0.125)	(0.143)	(0.103)
Quintile 3	1.437**	1.769***	1.922***	1.461***	1.584***	1.772***	1.572***	1.444***	1.639***	1.226**
	(0.202)	(0.255)	(0.272)	(0.189)	(0.204)	(0.195)	(0.164)	(0.167)	(0.164)	(0.119)
Quintile 4	1.938***	2.275***	3.300***	2.551***	2.153***	2.556***	2.408***	2.245***	2.493***	2.173***
	(0.255)	(0.311)	(0.439)	(0.305)	(0.263)	(0.267)	(0.234)	(0.239)	(0.233)	(0.189)
Quintile 5	3.334***	3.720***	5.215***	4.277***	3.948***	4.761***	4.546***	3.954***	4.862***	3.952***
	(0.417)	(0.487)	(0.680)	(0.495)	(0.462)	(0.479)	(0.425)	(0.405)	(0.436)	(0.328)
Married (vs. single)	3.001***	2.981***	1.323**	1.559***	1.558***	1.676***	1.994***	3.162***	2.246***	2.483***
	(0.349)	(0.357)	(0.152)	(0.169)	(0.177)	(0.155)	(0.168)	(0.294)	(0.176)	(0.199)
Divorced (vs. single)	0.460**	0.973	1.278	1.175	1.547	1.032	0.883	1.270	0.983	0.964
	(0.171)	(0.273)	(0.344)	(0.330)	(0.424)	(0.275)	(0.240)	(0.338)	(0.232)	(0.239)
Years married	1.220***	1.274***	1.549***	1.519***	1.609***	1.559***	1.451***	1.221***	1.346***	1.320***
	(0.0523)	(0.0580)	(0.0582)	(0.0530)	(0.0613)	(0.0494)	(0.0431)	(0.0409)	(0.0391)	(0.0396)
Years married*Years married	0.970***	0.965***	0.957***	0.960***	0.954***	0.955***	0.963***	0.975***	0.967***	0.969***
	(0.00413)	(0.00441)	(0.00353)	(0.00326)	(0.00364)	(0.00304)	(0.00280)	(0.00315)	(0.00274)	(0.00278)
Age	2.179***	2.824***	2.576***	2.899***	1.494*	2.443***	2.045***	2.384***	2.534***	2.099***
	(0.516)	(0.680)	(0.561)	(0.602)	(0.310)	(0.425)	(0.332)	(0.436)	(0.387)	(0.321)
Age*Age	0.988***	0.984***	0.985***	0.984***	0.994*	0.986***	0.989***	0.986***	0.985***	0.988***
	(0.00388)	(0.00393)	(0.00356)	(0.00337)	(0.00342)	(0.00284)	(0.00267)	(0.00300)	(0.00250)	(0.00251)
1 or 2 children (vs. 0 children)	1.352***	1.214**	1.129	1.008	1.013	1.073	0.988	0.971	1.026	0.999
	(0.118)	(0.105)	(0.0964)	(0.0805)	(0.0841)	(0.0717)	(0.0617)	(0.0663)	(0.0594)	(0.0584)
3 or more children	1.702***	1.189	1.429*	0.893	1.238	1.394**	1.122	0.967	1.132	0.954
	(0.339)	(0.259)	(0.264)	(0.184)	(0.238)	(0.214)	(0.167)	(0.167)	(0.155)	(0.139)
North	0.857	1.391**	1.134	1.021	1.495***	1.097	1.076	1.180	1.547***	1.045
	(0.147)	(0.222)	(0.169)	(0.148)	(0.223)	(0.131)	(0.109)	(0.142)	(0.163)	(0.108)
Haifa	1.623***	1.820***	1.733***	1.596***	2.103***	1.682***	1.495***	1.691***	2.240***	1.736***
	(0.242)	(0.275)	(0.240)	(0.213)	(0.297)	(0.184)	(0.141)	(0.188)	(0.221)	(0.162)
Central	1.605***	1.845***	1.571***	1.733***	1.840***	1.732***	1.308***	1.448***	1.972***	1.491***
	(0.212)	(0.249)	(0.194)	(0.202)	(0.235)	(0.167)	(0.109)	(0.144)	(0.177)	(0.124)
Tel Aviv	1.389**	1.017	1.101	1.189	1.307*	1.112	0.908	1.162	1.430***	1.263***
	(0.193)	(0.151)	(0.148)	(0.150)	(0.181)	(0.118)	(0.0833)	(0.123)	(0.137)	(0.111)
South	1.327*	1.485***	1.144	1.254*	1.781***	1.509***	1.145	1.381***	1.869***	1.552***
	(0.196)	(0.222)	(0.162)	(0.165)	(0.245)	(0.159)	(0.106)	(0.149)	(0.179)	(0.137)
Judea & Samaria	1.631***	2.265***	1.900***	1.467**	2.184***	1.440***	0.934	1.652***	1.542***	1.275**
	(0.291)	(0.391)	(0.297)	(0.234)	(0.347)	(0.192)	(0.118)	(0.215)	(0.189)	(0.147)
Intercept	1.62e-08***	2.21e-10***	1.21e-09***	1.86e-10***	5.05e-06***	3.50e-09***	8.76e-08***	6.11e-09***	2.50e-09***	6.50e-08***
	(5.73e-08)	(7.95e-10)	(3.96e-09)	(5.81e-10)	(1.56e-05)	(9.12e-09)	(2.12e-07)	(1.67e-08)	(5.72e-09)	(1.48e-07)
Observations	51,818	53,722	56,307	58,112	59,633	60,935	61,258	61,785	62,889	63,301

* Standard deviations in parentheses.

* Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level.

Appendix 5

The differences in estimates of the fifth quintile vis-à-vis the first, between each possible pair of years

	2007	2008	2009	2010	2011	2012	2013	2014	2015
2008	0.11								
2009	0.45**	0.34*							
2010	0.25	0.14	-0.2						
2011	0.17	0.06	-0.28	-0.08					
2012	0.36**	0.25	-0.09	0.11	0.19				
2013	0.31**	0.2	-0.14	0.06	0.14	-0.05			
2014	0.17	0.06	-0.28*	-0.08	0	-0.19	-0.14		
2015	0.38**	0.27*	-0.07	0.13	0.21	0.02	0.07	0.21	
2016	0.17	0.06	-0.28*	-0.08	0	-0.19	-0.14	0	-0.21*

* Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level.

Each cell in the table represents the difference between the year in the row and the year in the column. For example, the difference in the estimation for the 5th quintile in 2009 and the estimation of this coefficient in 2007 is 0.45.

The significance of the difference of the gaps between quintiles 1 and 5 is measured by an X2 test for each possible pair of years, after running a uniform regression for all the years (with an interaction variable for Year with all the variables in the model.

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THE IMPACT OF YIELDS ABROAD AND THE PUBLIC DEBT ON REAL YIELDS OF ISRAELI GOVERNMENT BONDS: A REEXAMINATION

- Real yields on Israeli government bonds are more closely and more significantly correlated with real yields in the eurozone than with parallel yields in the US. This correlation has intensified since the global financial crisis began, and strengthens with the lengthening of the bond horizon. The correlation is apparently the result of the strong relationship between economic activity in Europe and that in Israel.
- The ratio of the public debt to GDP has a large and statistically significant effect on yields and this effect has grown since the financial crisis. The data that were available in real time explain yields better than the revised data received at a later stage.

1. Introduction

During the last two decades, real yields on Israeli government bonds for short terms and long terms have declined. This trend occurred against the background of a decline in the public debt to GDP ratio, the large and prolonged decline in the Bank of Israel interest rate and the real interest rate derived from it, and the decline in real yields in advanced economies since the global financial crisis.

Brender and Ribon (2014) examined the effect of these factors, i.e. components of fiscal policy, monetary policy and the global environment, on the real yields on Israeli government bonds with 1, 3, 5 and 10-year terms, focusing on the period 2001–13. This analysis uses their analytical framework and expands the sample to June 2017 with the goal of examining two issues: (a) whether yields in Israel are more closely correlated with those in the eurozone[1] than with those in the US[2]; and (b) whether data on the ratio between the public debt and GDP obtained at the time yields are determined in the market, i.e. in real time, explain them better than data revised at a later time.

The motivation for examining the first issue is related to the fact that when analyzing the Israeli market it is the practice to view the US interest rate, i.e., yields in the US, as an indication of the global interest rate environment, even though the volume of Israeli trade with Europe is significantly larger than that with the US and since 2009 the fluctuations in the Israeli equity market have been more correlated with fluctuations in Europe than with those in the US.[3] In the past, the need to separately examine European yields did not exist due to the high level of correlation between them and yields in the US (see Figure 1). However, since the global financial crisis, the trends in the yields have diverged and therefore it is important and feasible to identify which yields are more closely correlated with those in Israel.

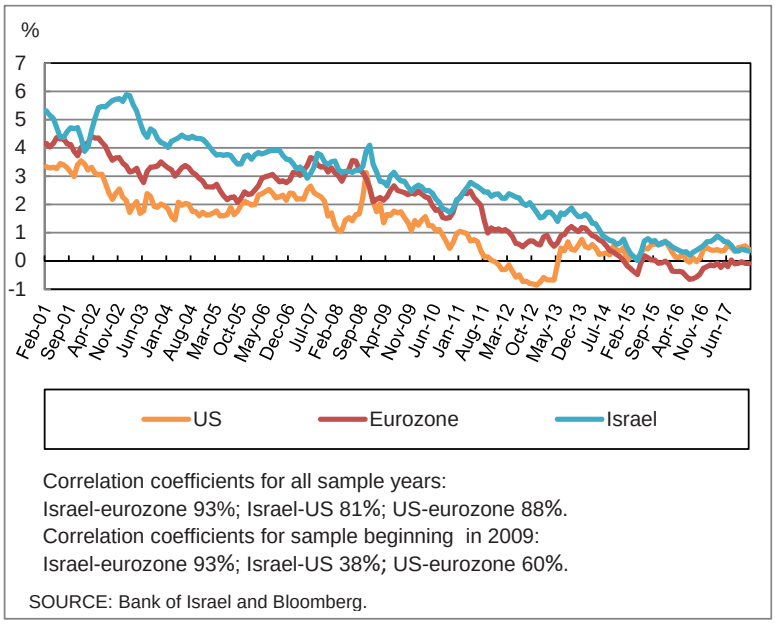
Written by Gilad Shalom.

1 The data on yields in the eurozone were taken from Bloomberg and in that database the yields on German and French bonds represent the risk-free yields in the eurozone countries. The 1-year yield to maturity reflects the nominal yield on French government bonds and the yields for 3, 5 and 10 years reflect the nominal yields on German government bonds. Using only German bonds yields similar results.

2 We have formulated the question in terms of correlation since the analysis does not allow the determining of whether foreign yields directly affected the yields in Israel or reflect economic developments in Europe and other countries that also affected yields in Israel.

3 The correlation between the Tel Aviv 125 Index (in the past the Tel Aviv 100 Index) and the S&P 500 was 85 percent prior to 2009 and remained at that level subsequently. The correlation between the Tel Aviv 125 Index and the NASDAQ index stood at 70 percent prior to 2009 and 81 percent from 2009 to 2017. The correlation between the Tel Aviv 125 Index and the EuroStoxx 50 was 37 percent prior to 2009 and 92 percent between 2009 and 2017.

Figure 1
The Real Yield on 10-Year Government Bonds
February 2001–June 2017

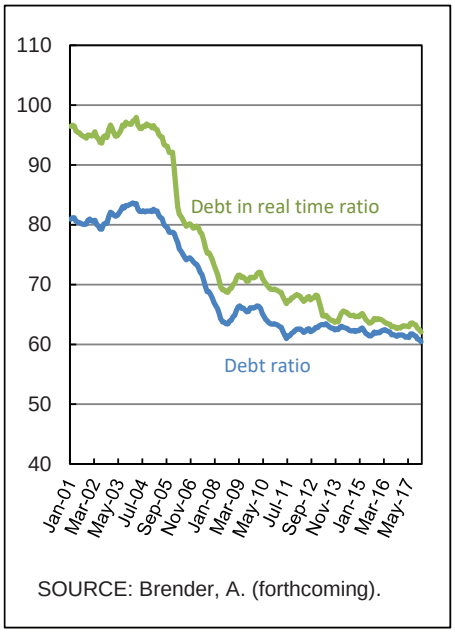


Correlation coefficients for all sample years:
Israel-eurozone 93%; Israel-US 81%; US-eurozone 88%.
Correlation coefficients for sample beginning in 2009:
Israel-eurozone 93%; Israel-US 38%; US-eurozone 60%.

SOURCE: Bank of Israel and Bloomberg.

With regard to the motivation for examining the second issue, Brender and Ribon found that the ratio of (gross) public debt to potential GDP is the best indicator for the effect of fiscal policy on real yields. Several studies have shown that the important variable in this context is not the actual debt ratio but rather the forecasted one. Engen and Hubbard (2004), for example, found that the forecast of the Congressional Budget Office had a statistically significant effect on real 10-year yields, while actual data had none. Therefore, Brender and Ribon focused on the revised data for the debt ratio several periods after the date on which the yields were determined and found that it can serve as an estimate for the debt that investors expected at the time of their determination. However, since the GDP estimates published by the CBS for previous years are revised significantly over the years, the ratio calculated on the basis of the most up-to-date data is not that which investors in the market took into account when the yields were determined. Therefore, we checked the effect of the gross government debt ratio that was known at the time that the yields were determined, i.e., the effect of the debt ratio that was measured in real time. Figure 2 relates to the sample years and presents the trend in the public debt to GDP ratio according to both the data known today and the data reported in real time.

Figure 2
Ratios of Gross Debt and Gross Debt in Real Time to Potential GDP, 2001–17



SOURCE: Brender, A. (forthcoming).

The graph shows that the ratio according to the real time data is higher than the other ratio throughout the sample period, since the estimates of GDP are revised upward in later periods. In this context, it is worth mentioning that the graph also shows that from 2011 until the end of the sample period the debt to potential

GDP ratio dropped from 63 percent to about 60.5 percent, while the debt to nominal GDP dropped to a greater extent, from 69 percent at the beginning of 2011 to about 62 percent in June 2017. This is the result of the output gap (according to the definitions used by Brender and Ribon) that narrowed during this period and the GDP deflator that rose to above the trend.

The rest of the discussion proceeds as follows: Section 2 reviews the theoretical background to the analysis; it describes the channels through which the various variables affect bond yields. Sections 3 and 4 present the data and the methodology, respectively. Section 5 describes the results and Section 6 concludes.

2. The theoretical background

a. The effect of fiscal policy

As noted, Brender and Ribon found that the ratio of debt to potential GDP is the best indicator for the effect of fiscal policy on real yields. This ratio directly affects the level of yields since when the debt grows the government increases the supply of bonds, their price declines and their yields rise. However, in addition, the ratio affects the level of yields indirectly, by way of the expectations of consumers and investors. Thus, when the government debt increases, the risk that the government will not meet its liabilities in the future also increases. This risk is known to investors in the economy and therefore it also leads to an increase in yields. Thus, the estimation will include the ratio of gross government debt to potential GDP[4] (in real time and alternatively according to currently known data).

b. The effect of the global environment

Israel is a small economy that is open to trade and capital flows and therefore is exposed to both real and financial effects of the global environment. The global yields directly and indirectly affect the trends in yields in Israel, for the various terms. There is a direct effect since they constitute an alternative asset and an indirect effect since they impact on monetary policy and are correlated with global economic activity. Therefore, the estimation will include the yields of CPI-indexed US government bonds for various terms and the real yields of German and French bonds for various terms since, as mentioned, they serve as an indicator of the risk-free yields on bonds in the eurozone. We use the interest rate in Germany and France since it is not reasonable to expect that yields in Israel will systematically change in response to changes in the risk premium of other countries in the eurozone. In most cases, the risk premium is unique to each of the other countries and reflects their level of risk relative to that of Germany and France. In addition, the estimation includes an indicator of the level of risk attributed to the global environment in the form of the VIX (Volatility Index). This index estimates the expected volatility of the S&P 500 equity index and is likely to differentially influence yields in a small country like Israel and yields in large developed economies like the US and the eurozone.

4 In order to obtain the growth in potential GDP each year we calculated the average growth in per capita GDP for the main working age population since 1974 and added to it the rate of growth in this population in a particular year. This growth rate is stable for an extended period in Israel and is similar to the growth rate in the OECD countries. In order to adjust the potential GDP data to reflect the information available in real time we took the difference between the nominal GDP and potential GDP (based on revised data), which constituted for us the difference between real time GDP (calculated) and the potential GDP adjusted to real time data.

c. The effect of monetary policy

Monetary policy impacts on bond yields primarily via the interest rate determined by the Bank of Israel.[5] This interest rate is expected to affect the yields for all terms by its influence on short-term yields (which also constitute part of long-term yields). However, to the extent that monetary policy is perceived as permanent, the influence of long-term yields will increase also by way of the yields expected in years to come. To illustrate, Ber, et al. (2004) found that the Bank of Israel interest rate affected long-term yields in the 1990s and the early 2000s and attributed this to the persistent disinflationary policy during that period.

Therefore, the estimation must also include the Bank of Israel interest rate. However, since it is likely to also be influenced by interest rates abroad, its inclusion is liable to conceal part of the influence of interest rates abroad on yields in Israel. In order to deal with this problem, we employ the methodology used by Brender and Ribon. That is, we estimated an equation for the interest rate in Israel and included in it the interest rate abroad and additional exogenous variables that can be assumed to influence the local interest rate. Following that, we included the estimated local interest rate and its residual from the estimation of the yields and thus added the indirect influence of the interest rate abroad to its direct influence, via the interest rate in Israel. Similarly, the estimation of the yields includes inflation expectations[6], since we are examining real yields.

In order to examine the effect of the interest rate abroad on the Bank of Israel interest rate, we used the monetary interest rate in the US and alternatively the monetary interest rate in the eurozone. The estimation results indicate that the effect of the interest rate in the US was statistically significant while the effect of the eurozone interest rate was not (see Appendices 2 and 3). Therefore, we used the US interest rate in order to estimate the Bank of Israel interest rate.

d. The effect of domestic economic activity and the security situation

The domestic environment is not at the core of the analysis but since it has an effect on yield levels we added two variables to capture the effect: (1) the rate of change in the level of domestic economic activity, measured by the GDP growth rate and which affects yields through the demand for investment, which tends to raise the interest rate and thus is included in the estimation; (2) the security situation which is likely to affect yield levels since it affects the level of risk implicit in investment in the economy. In order to capture the effect of the security situation we include the extent to which the number of incoming tourists deviates from its long-term trend, as in previous analyses.

3. The data

The data were taken from the databases of the Bank of Israel, the OECD and Bloomberg.

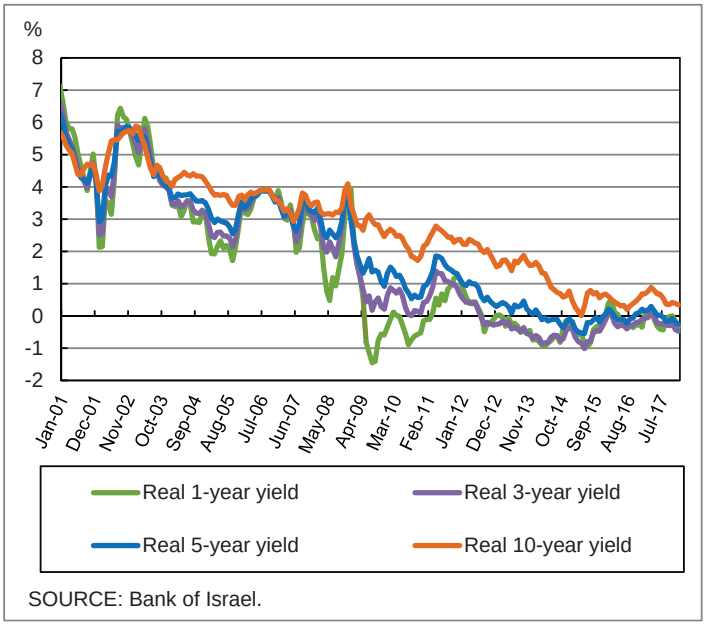
Figure 3 relates to the years 2001–17 and presents the real yields on government bonds in Israel for various terms. The graph shows that, as expected, fluctuations in yield decline as the term lengthens. Similarly, for

5 In this analysis, we do not try to estimate the effect of other monetary tools that have been used in recent years, such as foreign exchange market intervention and forward guidance. Nonetheless, the estimation equations include dummy variables for the period in which the Bank of Israel purchased government bonds in the open market.

6 For one year; derived from capital market.

all horizons, the yields show a prolonged downward trend and as of the end of 2017 all of them were at their lowest level in the last two decades. It can also be seen that up to 2009, the year in which the global financial crisis began, yields for the various terms are very similar and from that point onward, the rates of decline diverge and later converge to near-zero levels.

Figure 3
Real Government Bond Yields in Israel, 2001–17



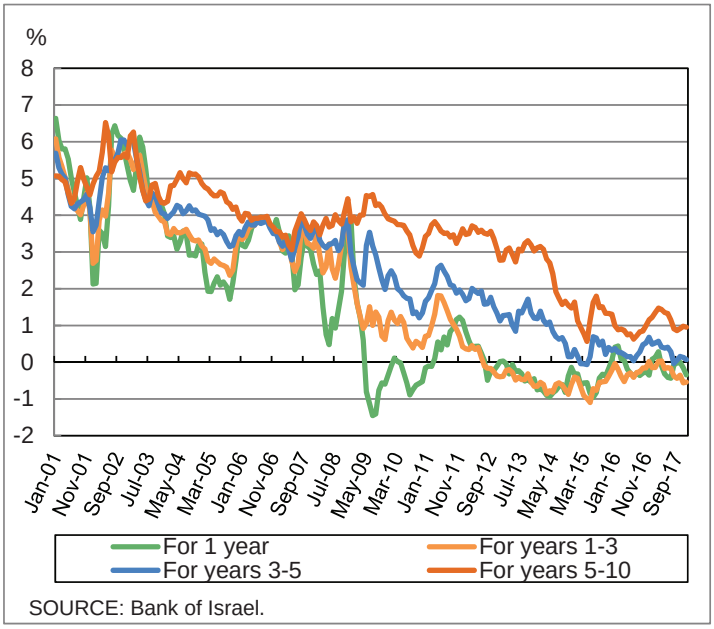
SOURCE: Bank of Israel.

In order to test whether foreign yields and the debt ratio affect long-term yields in Israel only by means of short-term yields or also directly, we looked at forward yields. Figure 4 shows the forward rates calculated according to expectations theory. The graph includes the one-year yield and the forward yields for 1–3 years, 3–5 years and 5–10 years. It can be seen that the forward yields present similar trends to those presented by real yields for the whole period, but real yields fell rapidly starting from 2008 while forward yields, and particularly for longer terms, responded more gradually.

With regard to short-term yields (one and three years) in the US and yields for all terms (1, 3, 5 and 10 years) in the eurozone, there were only nominal data available. In order to calculate the real yields, we deducted from the nominal yields for each term the change in the core index of the CPI for the relevant period, since it serves as an estimate for expected inflation in coming years.[7] However, this calculation does not ensure that the results are identical to the real yields that investors viewed when the yields were determined and therefore we will relate to this issue in the robustness checks.

7 We calculated the real yields for the various periods as follows: from the nominal 1-year yield we deducted the change in the core CPI index in the year preceding the month in which the yield was measured; from the nominal 3-year yield we deducted the change in the core index for the three years that preceded the month in which the yield was measured; and from the nominal 5- and 10-year yields we deducted the change in the core index during the five years that preceded the month in which the yield was measured.

Figure 4
Forward yields in Israel, 2001–17



SOURCE: Bank of Israel.

4. Methodology

We carried out the linear estimation of the real yields for four terms: 1, 3, 5 and 10 years, within a Seemingly Unrelated Regression (SUR) framework. This is a generalization of linear regression model that takes into account the possibility that the residuals of the system's equations are correlated.[8] The sample period ranges from the beginning of 2001 to June 2017 due to data constraints.[9]

In order to test whether the strength of the variables' effects has changed over the years, the following interactions were included in the estimation: between (1) the yields on US bonds; (2) the yields on bonds in the eurozone; and (3) the ratio of debt to potential GDP and a dummy variable that takes a value of 1 starting from 2009. We chose 2009 because we found that it is statistically significant during the sample years[10] and because it is close to the onset of the financial crisis, an event that led to significant and prolonged shocks in the financial markets, both in Israel and globally, including the divergence of yield trends in the eurozone from those in the US.[11]

8 In all the specifications, the Pagan-Breusch test for correlation between residuals is significant at a level of 0.000 percent and therefore the hypothesis that the residuals of the equations are not correlated is rejected.

9 Potential GDP (according to the calculation method we used) is an annual series and therefore we were able to calculate it only up to 2017. The public debt to GDP ratio is calculated on the basis of potential GDP; in the estimation, it is represented by the deviation of the average during the six subsequent months from the average for the last 20 years and therefore the data only go up to June 2017.

10 The year 2006 is also significant, which can also be seen from the rolling regression results in Figure 6.

11 See Figure 1.

The estimation equation

We chose the explanatory variables on the basis of the considerations presented in the Theoretical Background section and estimated the real yields on government bonds in Israel by means of the following equation:

$$y_{r,t} = \alpha + \beta F_t + \gamma W_{r,t} + \delta E_t + \theta M_t + \pi VIX_t + \mu dumh_t + \epsilon_{r,t}$$

where:

r=1,3,5,10 – years to maturity of the bond.

t=1,...,198 – number of months in the sample period (January 2001 to June 2017). This is the month in which the yield on each bond was measured.

y – the dependent variable: the real yields on government bonds in Israel for various terms.

F – the deviation of the average ratio of gross public debt to potential GDP in real time during the subsequent six months from the long-term average.[12] In addition, we also included a variable for the interaction between the debt ratio and the dummy variable for the year 2009 and subsequently.

W – a vector of global environment variables. It includes the real yields on US bonds[13], the calculated real yield on eurozone bonds and variables for the interactions between them and a dummy variable for the year 2009 and subsequently.

E – a vector of domestic economic activity variables. It includes the change in GDP[14] and the deviation (in logs) of the number of incoming tourists from the long-term trend (which, as mentioned, represents the security situation).

M – a vector of monetary policy variables. It includes the Bank of Israel interest rate which was estimated from an interest rate equation, the residual from the interest rate equation and the expectations of inflation for the coming year derived from the capital market.

VIX – The value of the VIX index (which is, as mentioned, an indicator of the level of risk attributed to the global environment).

dumh – a dummy variable for February to August 2009, during which the Bank of Israel intervened as a purchaser in the bond market.

12 The average for the past 20 years.

13 The original for 5-year and 10-year terms, and the calculated one for terms of 1 year and 3 years.

14 The average change in the past 6 months, with a lag of 1 period.

5. Results

We found that monetary policy and domestic economic activity affect the yields in a manner similar to that found by Brender and Ribon; the coefficient values are presented in Table 1. With respect to fiscal policy, we found that in all the specifications the public debt to potential GDP ratio has a statistically significant effect on yields for all terms and since 2009 the coefficient ranges from 0.08 for a term of one year to 0.1 for a term of 10 years. In other words, when the debt ratio drops by 10 percentage points, the real interest rate on government bonds falls by 0.8-1.0 percentage points.[15] It was also found that the effect of the change in the ratio grew after 2009 for all terms, which is manifested in the interaction between the debt and the dummy variable for 2009 and onward (Table 1). The estimates of the effect of the debt to GDP ratio prior to 2009 are similar to those for other developed countries during the same period (Poghosyan, 2014). For recent years, it is difficult to make such a comparison since the central banks in the developed countries acquired large amounts of government bonds of various terms.

Table 1
The factors impacting on real government bond yields in Israel

Variable	The real yield on government bonds in Israel			
	1 year	3 years	5 years	10 years
US yield for relevant term	0.079**	0.018	-0.003	-0.042
US yield * dummy for 2009 and later	-0.105	0.255***	0.017	-0.265
Eurozone yield for relevant term	0.106**	0.120***	0.147***	0.190***
Eurozone yield * dummy for 2009 and later	-0.135	0.098**	0.101**	0.331***
Debt ratio in real time	0.020***	0.016***	0.020***	0.035***
Debt ratio in real time * dummy for 2009 and later	0.056***	0.057***	0.065***	0.062***
Change in GDP	0.397***	0.474***	0.380***	0.092
Bank of Israel interest rate - estimated	0.590***	0.456***	0.368***	0.170***
Bank of Israel interest rate - residual	0.932***	0.678***	0.547***	0.353***
Inflation expectations for the coming year	-0.637***	-0.321***	-0.166***	0.015
VIX index for the US	0.013***	0.016***	0.014***	0.017***
Intercept	0.802***	1.028***	1.356***	2.076***
Number of observations	198	198	198	198
R-squared	0.990	0.988	0.985	0.978
RMSE	0.216	0.222	0.223	0.228
ADF test for residuals	-6.66***	-6.52***	-6.38***	-5.80***
Breusch-Pagan test	T= 515.046, Pr= 0.000			

[a] The results of a linear regression using SUR. We examined the residuals of each equation in the system using an ADF (Augmented Dickey-Fuller) test, and rejected the null hypothesis, meaning the hypothesis that the residuals are not stationary. Besides the variables listed above, the regressions included two controlled variables - the deviation (in log) of the number of tourist entries from the long-term trend and a dummy variable for BOI intervention in the foreign exchange market.
*** indicate significance at the 1 percent level, ** indicate significance at the 5 percent level, * indicates significance at the 10 percent level.

15 The effect after 2009 is equal to the sum of the coefficients of the government debt ratio and of its interaction with the dummy variable for 2009 and onward.

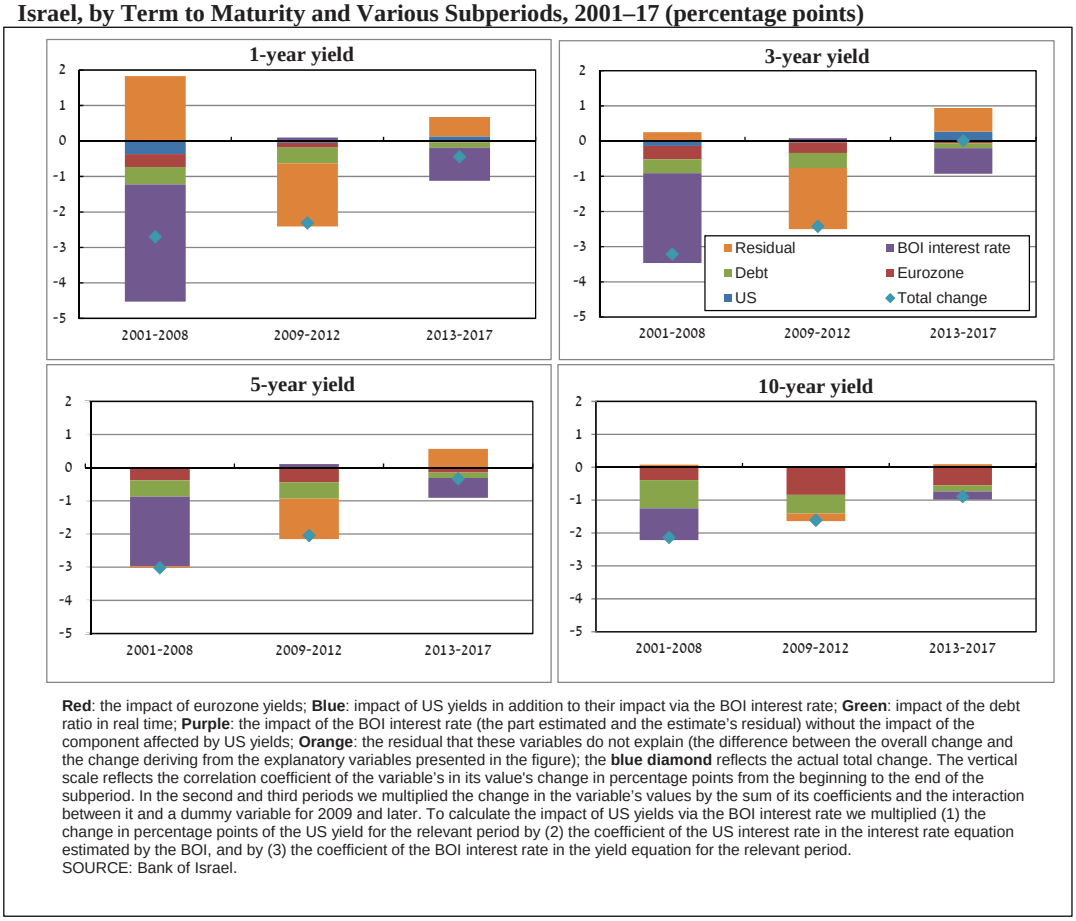
The use of the debt ratio in real time improves the estimation in all ranges and when testing its effect together with the effect of the debt calculated according to revised data, it is found to have better explanatory power for short terms (1, 3 and 5 years). In contrast, in the estimation of 10-year yields, the use of these data does not improve the estimation. Appendix 4 presents the specification in which we replaced the debt ratio in real time with the debt ratio calculated according to currently known data. Since the purchasers of bonds rely on the debt ratio in real time, which is the data available to them at the time of the purchase, it is not clear why it does not improve explanatory power also for the longer term. However, since in all the specifications it explains yields better for short terms than the debt ratio that is known after the fact, it is important to use it when analyzing the long-term trends in the market retrospectively, even if the revised data is more accessible.

With respect to the global environment, foreign yields affect yields in Israel both directly and indirectly (via the Bank of Israel interest rate). The direct effect of US yields prior to 2009 is statistically significant and large only for a term of one year and after 2009 also for a term of 3 years. In contrast, the effect of European yields prior to 2009 is large and statistically significant for all terms; subsequently it is large and statistically significant for all terms except for one year and its intensity increases with the term. To illustrate, for terms of 5 years, the estimate is equal to 0.25 and for 10 years, it is equal to 0.5.[16] Even when we add the indirect effect of the US interest rate to the estimation,[17] we find that the link between yields in the US and yields in Israel is weaker than the link between yields in the eurozone and yields in Israel and that the gap for the longer terms has widened since 2009 (see the relevant interaction variables in Table 1). Therefore, the link between long-term yields in Israel and yields in the eurozone was stronger than that between them and yields in the US even before the crisis and since 2009 it has even intensified. Meanwhile the link to US yields (beyond that which is a result of the correlation between US yields and eurozone yields) remained not statistically significant and the coefficient even became negative. It is possible that the fact that until 2009 there was a high correlation between yields in the eurozone and US yields makes it difficult to isolate the effect of the latter on yields in Israel and therefore this has not been examined until now.

16 As mentioned, the analysis does not make it possible to determine whether foreign yields directly influenced yields in Israel or that they represent economic developments in Europe and the world that influenced yields in Israel as well. We assume that yields in Europe are more correlated with shocks to the European economy, while yields in the US reflect economic developments there.

17 The effect of yields in the US, including the indirect effect by way of the domestic interest rate, stands at 0.15 for a term of 1 year and 0.4 for a term of 3 years. The value of the estimate is obtained from the coefficient for the relevant term (Table 1) plus the product of the coefficient of the US interest rate (Appendix 2) and the coefficient of the domestic interest rate estimated for that term.

Figure 5
The Contribution of Eurozone Yields, US Yields, and the Government Debt to Changes in Yields in Israel, by Term to Maturity and Various Subperiods, 2001–17 (percentage points)



Red: the impact of eurozone yields; **Blue**: impact of US yields in addition to their impact via the BOI interest rate; **Green**: impact of the debt ratio in real time; **Purple**: the impact of the BOI interest rate (the part estimated and the estimate's residual) without the impact of the component affected by US yields; **Orange**: the residual that these variables do not explain (the difference between the overall change and the change deriving from the explanatory variables presented in the figure); the **blue diamond** reflects the actual total change. The vertical scale reflects the correlation coefficient of the variable's in its value's change in percentage points from the beginning to the end of the subperiod. In the second and third periods we multiplied the change in the variable's values by the sum of its coefficients and the interaction between it and a dummy variable for 2009 and later. To calculate the impact of US yields via the BOI interest rate we multiplied (1) the change in percentage points of the US yield for the relevant period by (2) the coefficient of the US interest rate in the interest rate equation estimated by the BOI, and by (3) the coefficient of the BOI interest rate in the yield equation for the relevant period.
SOURCE: Bank of Israel.

Figure 5 presents the contribution of the debt ratio and yields in the US and in the eurozone to changes in yields in Israel during the sample period. We divided the period into three sub-periods: (1) prior to the crisis—2001 to 2008; this period was characterized by a prolonged and large decline of about 25 percentage points in the ratio of debt to potential GDP in real time and high but declining yields—in the eurozone for all terms and in the US primarily for the short terms (one year and 3 years). (2) The crisis—2009 to 2012; in this period, the downward trend that characterized all of the variables in the previous period continued and only the debt ratio rose somewhat at the peak of the crisis. The prolonged decline in yields in the eurozone and the US resulted in all of the yields there becoming negative, apart from yields in the eurozone for a maturity of 10 years. (3) Subsequent to the peak of the crisis—2013 to June 2017; during this period, the debt was at a relatively low level and declining gradually and yields in the US rose for all terms, primarily toward the end of the period, while the yields in the eurozone continued their downward trend although this moderated somewhat towards the end of the period.

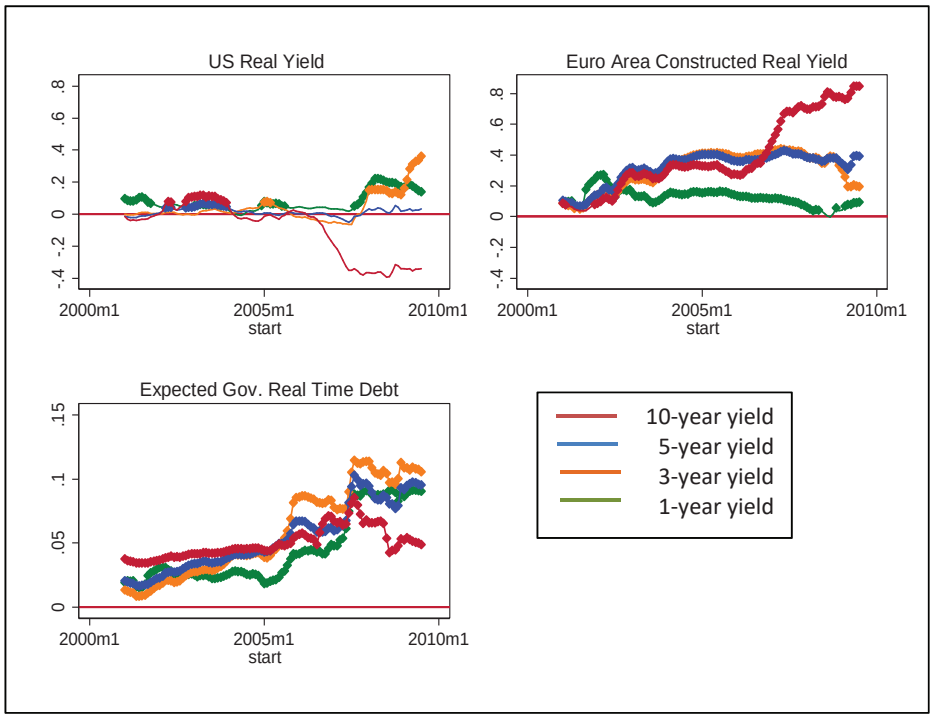
The public debt ratio was characterized by a prolonged downward trend, primarily during the first and second periods, which reduced the level of yields for all terms by about 0.32–0.85 percentage points. The yields in the eurozone were characterized by a downward trend throughout the sample period and they

explain about 0.18–0.8 percentage points of the drop in yields in Israel. The effect increases with the length of the term and after 2009 the effect for longer terms intensified. The yields in the US had a statistically significant effect only for the short terms and therefore their effect is not presented for the long terms. The yields in the US were characterized by a downward trend during the crisis and subsequent to it and they had a negative, though small, effect for the short terms. After the crisis they rose and had a positive effect only for the 3-year yields. The graph illustrates that yields in Israel are quantitatively affected by the real yields in the eurozone to a great extent and the effect is more statistically significant than that of the parallel yields in the US. The gap has grown since the global financial crisis. Apparently, these results can be attributed to the growing integration between the European and Israeli economies. The graph also shows that the longer the term of the bond the greater the explanatory power of foreign yields, the debt to GDP ratio and the Bank of Israel interest rate. This is reflected in the fact that the residual is declining. The large residual in the columns for short and intermediate terms during the period 2009–12 indicates that these variables have trouble explaining the drop in yields during this period.

In order to better characterize the change that occurred over time in the relationship between yields and the various variables, we estimated rolling regressions that include 96 monthly observations (8 years). The results are presented in Figure 6.

It can be seen that the correlation between yields in the eurozone and yields in Israel is positive, large and statistically significant for all terms and during the entire sample period and that the coefficients for 5 and 10 years show an upward trend throughout the period. In contrast, the US yields are correlated to only a limited extent, and the effect is not statistically significant at longer terms, and for the short terms the correlation is positive and is generally significant, beyond their connection by way of the Bank of Israel interest rate. It can also be seen that the ratio between government debt and potential GDP (in real time) has a positive and statistically significant effect for all terms and throughout the entire sample period. The coefficient of the ratio for all terms is characterized by an upward trend until the middle of the period and subsequently there is a slowdown and in the case of 10-year yields they diminish significantly.

Figure 6
Rolling Regressions on Yields



In order to make the estimation, we defined a fixed window of 96 monthly observations. First we estimated the initial 96 observations, then we move the window 1 observation forwarrd and repeated the process, and so on. The years represent the beginning of the sample. A thick line indicates statistical significance. The vertical scale presents the estimation's value throughout the period.

Forward yields

As mentioned, in order to test whether foreign yields and the debt ratio also affect the long-term component of the intermediate and long-term yields in Israel, we estimate a similar equation for the forward yields, which are presented in Appendix 5. The results are qualitatively consistent with the estimation results for the real yields. We found that the effect of the public debt on yields has a similar impact for all terms and that the coefficients of the yields in the eurozone for 5 to 10-year terms are significantly higher than the coefficients of yields for shorter terms and only for this term does the effect of the yields grow after 2009.

Robustness checks

As mentioned, even if we deduct the core index in France and Germany during the years prior to the date on which the nominal yields were determined, this does not guarantee that we obtain the real yields that investors perceived, and therefore we carried out the following additional checks:

In order to check the quality of the calculation of the eurozone yields, we took the original data for the real US 5- and 10-year yields and replaced them with data calculated using the methodology used to calculate the eurozone yields and then compared the results. The results are presented in Appendix 6 and it appears that they are consistent with the original results, except that the 5-year eurozone yields have no incremental effect after 2009.

In order to test whether the eurozone yields had a stable effect, we carried out an estimation that includes them but does not include the US yields. The results are presented in Appendix 7 and they are qualitatively consistent with the results in Table 1. In other words, the effect of the eurozone yields is statistically significant and the coefficient ranges from 0.13 to 0.18; subsequent to 2009 there is an additional effect for all terms apart from one year and it ranges from 0.1 to 0.2.

Moreover, starting from 2009, there are data for yields on 10-year CPI-indexed bonds in Germany. We found that there is a correlation of about 97 percent between these yields and the yields that we calculated for Germany. We also found a correlation of about 91 percent between the real 10-year yields in the US and the calculated yields for that term.

Two additional robustness checks are not presented here: We tested the effect of only German yields[18] and the effect of CPI-adjusted eurozone yields. These results are also consistent with the results of the specification presented in Table 1. It should be mentioned that Brender and Ribon also calculated real yields in this way.

6. Conclusion and recommendations

We have examined two questions: first, do the real eurozone yields contribute to explaining real yields on government bonds in Israel, such that it is not sufficient to use only US yields; and second, does the debt ratio measured in real time explain yields better than the debt ratio measured after the data have been updated?

The first question can be examined more accurately now than in the past as the paths of European and US yields diverged in 2008–09 following the global financial crisis. Eurozone yields are included in the estimation and it is found that prior to 2009 the correlation with US yields was large and statistically significant only for a term of one year, and that since 2009 it is large and statistically significant only for a term of 3 years. In contrast, the correlation with eurozone yields is large and statistically significant for all terms up to 2009; from 2009 onward, it is statistically significant for terms ranging from 3 to 10 years, the relationship is stronger for longer terms and for 5- and 10-year yields the coefficients also increased markedly. The estimation indicates that since 2009, an increase of 1 percentage point in the yields on eurozone bonds is correlated with an increase of 0.12 percentage points in real yields on 3-year government bonds in Israel, which increase up to 0.5 percentage points for a term of 10 years.

This is an important finding since many analyses of yields in Israel view US yields as an indicator of the global environment. The strong and increasing correlation between yields in Israel and those in Europe require that greater attention be paid to developments in Europe. Nonetheless, there is no room to conclude from the results that the developments in the US economy do not influence the yields in the capital market in Israel, but rather that this effect is already implicit to a large extent in the eurozone yields.

With respect to the second question, when we examine the ratio between debt and potential GDP, it is found that the ratio measured in real time has greater explanatory power than the debt measured using

[18] In order to obtain the real yields in Germany, we carried out a similar calculation to that carried out in order to obtain the real eurozone yields (deduction of the change in the core CPI index from the nominal yield).

revised data (which were not available to investors when the yields were determined) and therefore it can be concluded that there is an advantage in using real-time data, particularly in the estimation of short-term yields.[19] We found that the public debt ratio has a positive, statistically significant and large effect on yields and that the effect has even increased since 2009. When the ratio drops by 1 percentage point, the real yields for various terms drop by 0.08–0.1 percentage points, and the intensity of the effect increases as the term lengthens. We also found that the effect of the debt ratio on 10-year yields started to decline in recent years toward levels measured prior to 2009 (Figure 6), although its effect on shorter-term yields did not.

The prolonged downward trend in the debt ratio and the decline in eurozone yields resulted in a major decrease in the level of yields on government bonds in Israel during the past decade. As can be seen from Figure 5, the decline in the debt ratio reduced it by 0.32–0.85 percentage points, primarily up to 2013, and the drop in the eurozone yields explains 0.18–0.8 percentage points of the decline in yields in Israel, which apparently also reflects the effect of economic activity in Europe on economic activity in Israel.

The use of these variables made it possible to improve the estimation relative to previous ones. The contribution of the data on eurozone yields implies that when examining the trend in yields it is important to look at the changes in Israel's economic relationships and to recognize their growing complexity as a result of globalization. With respect to the data on the public debt to GDP ratio, the results indicate that when retrospectively examining economic developments it is important to give weight to information that investors (and policy makers) viewed in real time, even if it was revised after the fact.

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[19] We found that the real-time debt ratio to potential GDP is statistically significant for short terms according to a t-test also when we add it to the estimation that includes the revised debt ratio.

Appendix

Table A.1
Descriptive statistics, January 2001–June 2017

Variable	Mean	Standard Deviation	Minimum	Maximum
1-year yield in Israel	1.65	2.15	-1.45	6.63
3-year yield in Israel	1.81	2.03	-1.01	6.26
5-year yield in Israel	2.14	1.85	-0.55	6.03
10-year yield in Israel	2.84	1.54	0.02	5.88
GDP rate of chage	0.27	0.59	-1.04	2.38
Bank of Israel interest rate, estimated	3.20	2.58	-0.17	9.46
Bank of Israel interest rate, residual	0.00	0.27	-1.27	1.98
1-year inflation expectation	1.64	0.96	-1.72	4.46
1-year yield in US	-0.35	1.38	-2.08	2.76
3-year yield in US	0.17	1.29	-1.40	2.87
5-year yield in US	0.70	1.27	-1.77	3.28
10-year yield in US	1.32	1.10	-0.86	3.54
1-year yield in eurozone	0.08	1.24	-1.76	3.27
3-year yield in eurozone	0.29	1.45	-1.57	3.34
5-year yield in eurozone	0.61	1.47	-1.67	3.29
10-year yield in eurozone	2.05	1.42	-0.65	4.41
Gross government debt to GDP ratio	69.82	8.40	60.97	83.65
Real time gross government debt to GDP ratio	77.07	13.04	62.68	97.94
VIX index	19.95	8.61	10.51	62.64
Deviation (in log) of the number of tourists from the long-term trend	-0.08	0.27	-1.40	0.27

Table A.2
Equation to estimate the Bank of Israel interest rate with the US interest rate representing the interest rate abroad

Variable	iboi
Output gap, average of 3 months with 1-period lag	-0.026***
Deviation of inflation from the target	0.257***
1-year nominal interest rate in the US - deviation from average	0.0465***
Bank of Israel interest rate, lagged	0.942***
Intercept	0.366***
Number of observations	207
R-squared	0.990

Table A.3
Equation to estimate the Bank of Israel interest rate with the eurozone interest rate representing the interest rate abroad

Variable	iboi
Output gap, average of 3 months with 1-period lag	-0.029***
Deviation of inflation from the target	0.245***
1-year nominal interest rate in the eurozone - deviation from average	0.031
Bank of Israel interest rate, lagged	0.944***
Intercept	0.346***
Number of observations	207
R-squared	0.989

Table A.4
The factors impacting on real government bond yields in Israel when using the updated debt ratio, January 2001–June 2017[a]

Variable	**The real yield on government bonds in Israel**			
	1 year	**3 years**	**5 years**	**10 years**
US yield for relevant term	0.086**	0.023	0.006	-0.053
US yield * dummy for 2009 and later	-0.072	0.281***	0.037	-0.227***
Eurozone yield for relevant term	0.111**	0.123***	0.130***	0.178***
Eurozone yield * dummy for 2009 and later	-0.054	0.151***	0.173***	0.385***
Updated debt ratio	0.035***	0.029***	0.033***	0.057***
Updated debt ratio * dummy for 2009 and later	0.059***	0.070***	0.087***	0.098***
Intercept	0.573***	0.831***	1.169***	1.957***
Number of observations	198	198	198	198
R-squared	0.988	0.988	0.985	0.979
RMSE	0.232	0.224	0.227	0.222
ADF test for residuals	-6.20	-6.35	-6.07	-5.98
Breusch-Pagan test	T=530.331, Pr= 0.000			

[a] The results of a linear regression using SUR. The control variables are identical to the control variables in the standard estimation equation presented in the paper itself. However, in this case the debt for all terms is calculated based on updated data.

Table A.5

Factors impacting on the forward return, January 2001–June 2017[a]

Variable	The forward yield on government bonds in Israel			
	1-year	1-3 years	3-5 years	5-10 years
US yield for relevant term	0.081**	-0.003	0.014	-0.100
US yield * dummy for 2009 and later	-0.012	0.516***	0.034	-0.252
Eurozone yield for relevant term	0.117***	0.111***	0.134***	0.379***
Eurozone yield * dummy for 2009 and later	-0.191	0.070	0.000	0.281***
Real-time debt ratio	0.021***	0.016***	0.028***	0.047***
Real-time debt ratio * dummy for 2009 and later	0.048***	0.074***	0.057***	0.032**
Intercept	0.750***	1.115***	1.594***	1.890***
Number of observations	198	198	198	198
R-squared	0.990	0.980	0.969	0.950
RMSE	0.213	0.281	0.286	0.301
ADF test for residuals	-6.80***	-6.86***	-6.27***	-5.13***
Breusch-Pagan test	T=186.477, Pr= 0.000			

[a] The results of a linear regression using SUR. The dependent variable is the forward yields on government bonds in Israel. The control variables are identical to the control variables in the standard estimation equation presented in the paper itself. However, in this case we adjusted the US and eurozone yields to forward data.

Table A.6

Resilience test of results presented in Table 1: A different definition of the real US interest rate, January 2001–June 2017

Variable	The real yield on government bonds in Israel			
	1 year	3 years	5 years	10 years
US yield for relevant term	0.085**	0.036	0.040	0.023
US yield * dummy for 2009 and later	-0.088	0.307***	0.088*	-0.237
Eurozone yield for relevant term	0.111***	0.111***	0.116***	0.138**
Eurozone yield * dummy for 2009 and later	-0.163	0.036	0.044	0.360***
Real-time debt ratio	0.021***	0.016***	0.021***	0.035***
Real-time debt ratio * dummy for 2009 and later	0.054***	0.056***	0.063***	0.042***
Intercept	0.773***	0.948***	1.215***	1.911***
Number of observations	198	198	198	198
R-squared	0.990	0.988	0.985	0.977
RMSE	0.215	0.221	0.222	0.230
ADF test for residuals	-6.72***	-6.60***	-6.39***	-5.47***
Breusch-Pagan test	T=495.739, Pr= 0.000			

[a] The results of a linear regression using SUR. The control variables are identical to the control variables in the standard estimation equation presented in the paper itself. However, instead of the original data on real 5-year and 10-year yields on government bonds in the US, we included a figure that was calculated via methodology we used to calculate the eurozone yields.

Table A.7

Resilience test of findings presented in Table 1: Estimation without US yields, January 2001–June 2017[a]

Variable	The real yield on government bonds in Israel			
	1 year	3 years	5 years	10 years
Eurozone yield for relevant term	0.179***	0.130***	0.139***	0.129***
Eurozone yield * dummy for 2009 and later	-0.223	0.099**	0.102***	0.229***
Real-time debt ratio	0.022***	0.017***	0.020***	0.034***
Real-time debt ratio * dummy for 2009 and later	0.053***	0.075***	0.067***	0.060***
Change in GDP	0.512***	0.501***	0.381***	0.068
Bank of Israel interest rate, estimated	0.590***	0.446***	0.366***	0.208***
Bank of Israel interest rate, residual	0.935***	0.695***	0.547***	0.339***
Inflation expectations for the coming year	-0.648***	-0.330***	-0.165***	0.055**
VIX index for the US	0.012***	0.014***	0.014***	0.016***
Intercept	0.810***	1.122***	1.368***	1.972***
Number of observations	198	198	198	198
R-squared	0.990	0.985	0.985	0.977
RMSE	0.217	0.245	0.225	0.233
ADF test for residuals	-6.71***	-5.89***	-6.40***	-5.22***
Breusch-Pagan test	T=468.687, Pr= 0.000			

[a] The results of a linear regression using SUR. The control variables are identical to the control variables in the standard estimation equation presented in the paper itself. However, yields on government bonds in the US were not included in the estimation.

EXCHANGE RATE PASS-THROUGH TO PRICES

Summary

• The exchange rate pass-through to prices increased since mid-2017, after being at a near-zero level from the beginning of the decade and having declined for a prolonged period beforehand. A possible explanation for the increase is the enhanced competition in recent years.

• The average estimated short term pass-through (6 months) from the NIS/$ exchange rate to inflation has been about 25 percent in recent years.

• In contrast to the past, in late 2017 the estimated pass-through to prices from appreciation—24 percent—is greater than the estimated pass-through from depreciation—14 percent.

Introduction

The exchange rate pass-through to prices (hereinafter, "ERPT" or "pass-through") is defined as the change in prices due to change in the exchange rate. ERPT is comprised of both level and speed; the ERPT level is the degree to which a change in the exchange rate affects prices; while the speed refers to the duration it takes for such a change to affect prices. Complete pass-through is defined as a change in the exchange rate that leads to a change in prices by the same rate. We typically refer to pass through in a period of several months as short-term ERPT, and in a period of one year or more as long-term ERPT.

Identifying the pass-through mechanism, level, and speed, is an important measure for making informed monetary decisions, as it makes it possible to identify inflationary pressures arising from changes in the exchange rate. When the exchange rate affects import prices, which impact manufacturing prices and consumer prices, policy makers may have to respond to changes in the exchange rate in order to achieve the designated target inflation rate (Rincon & Rodriguez, 2016).

The exchange rate is one of the mechanisms through which monetary policy affects prices. An accommodative policy should result in depreciation pressures and accelerated inflation through the pass-through mechanism, while tighter monetary policy should bring about appreciation and a slower inflation rate.

This study looks at the short-term pass-through from the NIS/$ exchange rate[1] in Israel and changes in it over time. These changes are reviewed using rolling OLS regression over a 4-year window, with monthly data from January 1996 to June 2018. The study shows that the pass-through level in Israel declined over time, in line with the global trend, that it is not fixed and is lower than in the past (Gagnon & Ihring, 2004), despite the upward trend in recent years. Short-term pass-through[2] (6 months) for the 4 years ended at the end

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1 Since import prices included in pass-through calculation are denominated in USD, we refer to the NIS/$ exchange rate. While import prices are denominated in USD, they include a weighting of goods whose prices are denominated in other currencies. Therefore, USD-denominated import prices also include the effect of cross-exchange rates.

2 For seasonally adjusted Consumer Price Index. Data source: Central Bureau of Statistics.

of the second quarter of 2018 is 18 percent and statistically significant.[3] The study distinguishes between pass-through resulting from depreciation and pass-through resulting from appreciation, and findings show that over the reviewed period, pass-through from appreciation has been more dominant. Pass-through from appreciation and from depreciation differ from one another, at 24 percent and 14 percent, respectively, and are significantly different from zero.

Literature review – The pass-through mechanism

Given the importance of identifying the pass-through level and mechanism, there are many articles which explore the channels through which change in exchange rates translates into change in prices and the elements that determine the pass-through level.[4] Many researchers show that, similar to the situation in Israel, pass-through to consumer prices is incomplete (Rincon & Rodriguez, 2016). Edwards (2006) reinforces the findings with regard to decrease over time in the pass-through level, adding that pass-through to prices of tradable and non-tradable goods differ from one another. Most of the empirical findings show that pass-through levels have been declining in most industrialized countries from 1980 to the early 2000s, primarily after a change in the inflationary regime in many countries in the 1990s (Bailliu & Fujii, 2004; Gagnon & Ihring, 2004).

Many studies find a strong relation between the monetary regime and the pass through level (Rahimov & Jafarova, 2017; Ihring & Ganon, 2001; Edwards, 2006; Choudhri and Hakura, 2012). A regime consisting of a floating exchange rate and an inflation target anchor inflationary expectations within the target range, hence reducing pass-through, since companies would maintain fixed prices in order to remain competitive (Caselli & Roitman, 2016). A study of 20 industrialized countries by Gagnon & Ihring (2004) found that between 1971 and 2003, after implementing an inflation targeting regime, the long-term pass-through level declined on average from 16 percent in the sample prior to application of the target inflation rate, to 5 percent thereafter. The authors believe that the reason for this is that when companies expect the monetary authority to maintain price stability (low inflation), they hesitate in changing their prices due to changes to the exchange rate, which are perceived as temporary. Bailliu & Fujii (2004) show similar results in a study of 11 industrialized countries: short-term pass-through to consumer prices declined from 11 percent to 5.4 percent after applying an inflation targeting regime in the 1990s. Burlon, et al. (2018) find, using a DSGE model, that the monetary policy response—be it standard (interest rate change, according to the Taylor rule) or non-standard (Forward Guidance)—is relevant for determination of the pass-through level, in response to structural shocks. A less aggressive response (Forward Guidance) to a positive demand shock results in moderate change in the "policy coefficient", which the model estimates by comparison to interest rates in other countries, hence resulting in exchange rate depreciation and higher import prices and consumer prices, as well as higher pass-through, compared to a standard policy.

A common explanation of the pass-through level is that it is determined by the percentage of companies which price their products in foreign currency terms. Deveraux, Engel & Stogaard (2004) propose a model where the pass-through level is determined by the percentage of exporters to the domestic economy who price their products in their own currency (PCP, or Producer Currency Pricing) compared to the percentage

[3] At 5 percent significance level, unless otherwise indicated.

[4] The study (Bache, 2006) provides an exhaustive overview of the literature on pass-through to prices and how it may be estimated.

of exporters who price their products in the local currency (LCP, or Local Currency Pricing). According to this theory, short-term changes in exchange rates are fully passed through to product prices using PCP, and are not at all passed through to product prices using LCP. Choudhri & Hakura (2012) suggest a similar model, where selection of the pricing method, PCP or LCP, is dynamic, hence the pass-through level changes over time.

Ozyurt (2016) explains that competition in markets may affect the pass-through level. Competition motivates exporters to adjust prices in order to retain their market share, hence they would not fully translate the change in exchange rate to prices. She claims that growing use of local currency pricing (LCP) may explain some of the decrease in pass-through. Furthermore, a strong presence of importers and exporters may result in low pass-through levels (such as in Germany), whereas a less competitive economy (such as in Italy) shows a high, fixed pass-through level compared to all of Europe. One possible explanation of this phenomenon is that smaller local companies have lesser bargaining power compared with overseas manufacturers or with larger companies, and therefore are less capable of pricing that is not adjusted for changes in the exchange rate. Burlon, et al. (2018) expand on this matter, noting that distribution services in export target countries impact the pricing method used by exporters, which results in variance in demand elasticity between countries. Therefore, large (monopolistic) exporters price differently in the local and foreign markets, and do not fully translate changes in the exchange rate to prices.

Sofer (2006) studied pass-through in Israel, measured using 31 CPI components, and found it to be at 33.2 percent in a sample for 1991–98, later decreasing to 23.5 percent in a sample for 1999–2004. Orfaig (2015) proposes a different method for estimating pass-through to prices – calculating the tradable portion of the Consumer Price Index, which should be impacted by changes to the exchange rate and therefore serves as an estimate for the overall pass-through, according to her method. She found the pass-through to be 36 percent.

The above review shows that the theory offers multiple explanations as to how pass-through works: pricing methods used by companies, country-specific attributes, hedging options for individuals in the economy, competition in the economy, its concentration level, monetary regime and so forth. This study looks at pass-through in Israel and changes thereto, offering explanations for some of its attributes, in line with the mechanisms as described in the literature.

Methodology – calculation of short-term pass-through

Overall pass-through from changes to the exchange rate to prices is estimated using OLS regression[5], based on monthly data from January 1996 to June 2018, over a rolling four-year window (48 months), which allows us to see changes in pass-through over time. The regression includes common explanatory factors used in literature on pass-through: Monthly inflation of consumer goods import price index[6] (three-month moving average), rate of change in USD exchange rate (three-month moving average) and rate of change in oil prices (three-month moving average).[7] The explanatory variables are also included in the

5 Regression 1, see Appendix 6.

6 Import price index in USD, calculated using the Paasche method. Source: Central Bureau of Statistics.

7 Data for exchange rates and oil prices are calculated for each month, by a simple average of daily data, and then the changes to log of prices is calculated.

regression, with a 3-month lag. As for partial series of the Consumer Price Index (prices of tradable and non-tradable goods), which are not seasonally adjusted, dummy variables were added for each month, to basically control seasonality.

To ensure that no other explanatory variables have been omitted, which may affect inflation, variables commonly used in the literature on pass-through were added, such as labor cost per unit of output, GDP growth rate, GDP gap, unemployment, other variables for the labor market and oil price, and their impact on pass-through was estimated. We found oil to be the most dominant variable of all these additional control variables, hence it was included in the regression.[8]

In order to test the pass-through from depreciation and from appreciation, the OLS regression is calculated using a specification[9] where, for the same data and time frame, the variable DEP (for Depreciation) is used, with a value of Δe_t if the change is greater than 0 (devaluation), or 0 otherwise; and the variable AP (for Appreciation), with a value of Δe_t if the change is less than 0 (appreciation), or 0 otherwise. These variables are also included in the regression, with a 3-month lag. The pass-through, its standard deviation and confidence interval are calculated similarly for both regressions, with the depreciation and appreciation variables assigned, respectively. Regression 2 allows us to identify the difference in the level of short-term pass-through from the exchange rate to prices, in case of devaluation and appreciation. We conducted testing, using the same specification, for tradable price indices, tradable goods price indices excluding clothing and footwear, prices of non-tradable goods and inflation excluding housing.

Results

The results of Regression 1 show that pass-through from change in exchange rate to inflation for the past six months[10], for a 4-year time window ending in June 2018, is 18 percent[11], and is statistically significant.[12] The average pass-through to inflation for the trailing 12 periods is 25 percent. This means that a 1 percent depreciation in the exchange rate is reflected, within six months, by a 0.25 percent increase in prices. Pass-through to non-tradable product prices is also statistically significant, and is at 25 percent for the most recent sample, and 15 percent on average for the 12 trailing periods, of which it is only significant in 3 periods. Testing the pass-through to tradable product prices excluding clothing and footwear (an item that is highly volatile) found the pass-through to be at 33 percent and significant. Pass-through to prices of tradable goods is statistically significant or most of the recent periods (8 of 12 samples), at a 47 percent level on average for the 12 most recent samples.

Similar to the global trend, pass-through to prices in Israel has decreased in recent decades, then increased in recent years (4-year sub-periods ending in the last two years). Pass-through to overall inflation (Figure 1.1) and to prices of non-tradable goods (Figure 1.4) is lower than in the past, whereas pass-through to inflation excluding housing (Figure 1.2) and to prices of tradable goods (Figure 1.3) in recent periods is

8 For more information about further tests, see "Robustness testing" below.

9 Regression 2, see Appendix 6.

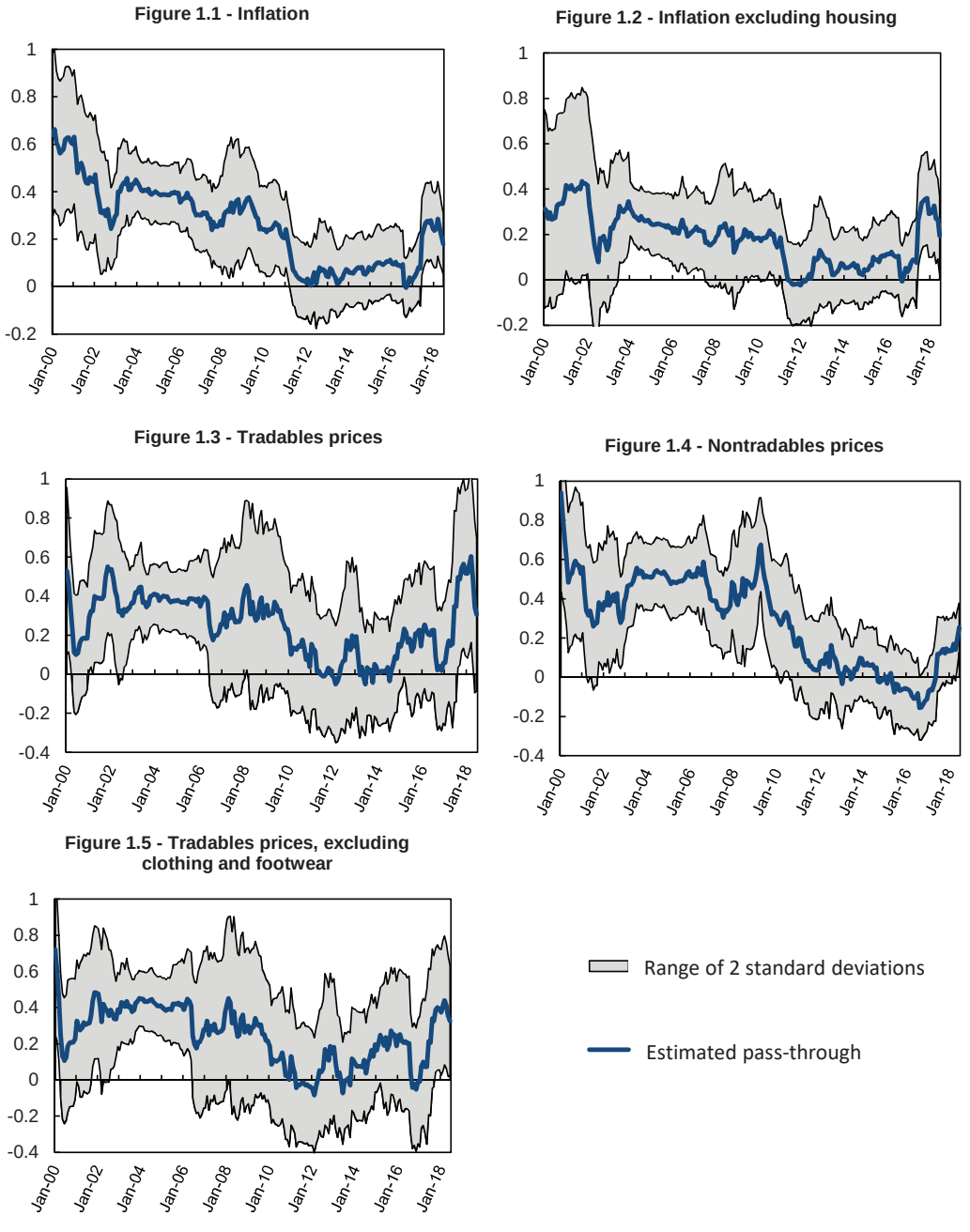
10 Pass-through to seasonally adjusted inflation.

11 See Appendix 5 "Summary Table".

12 At a 5 percent level, unless stated otherwise.

similar to that in periods ending in the early 2000s. In the sample ending in 2012, pass-through is near zero and then increasing in recent years.

Figure 1
Exchange Rate Pass-Through
(End date of the 48-month rolling window, January 2000–June 2018)



In the past, the housing market was strongly correlated with the USD, as noted in Bank of Israel reviews.[13] Through 2007, some 90 percent of leases were denominated in USD, but since then this percentage has declined to negligible levels. Therefore, through 2007, pass-through to inflation excluding housing is lower than pass-through to overall inflation, while in recent years they are of similar levels. The trend has changed starting with the sample ending in August 2016: Pass-through increased rapidly from near zero to 27 percent for the period ending in August 2017, and stabilized at that level through the sample ending in March 2018.[14] On average for the 12 most recent periods, where pass-through was statistically significant, it was at 30 percent.

The change in trend is also observed in pass-through to prices of both tradable and non-tradable goods. Prices of tradable goods consist of imported or importable goods, and are affected by the exchange rate through its effect on import prices.[15,16] Therefore, it is likely that the effect of change in the exchange rate on such prices would be stronger than its effect on prices of non-tradable goods, consisting of goods and services whose only supply source is local. The effect of the exchange rate on prices of non-tradable goods comes from those goods manufactured using imported inputs.

Estimates show that pass-through to prices of tradable goods increases from near zero for the period ending September 2016, to 50 percent for the period ending August 2017, then continues to increase to a level of 60.6 percent (statistically significant at the 5 percent level) for the period ending in March 2018, the highest pass-through level to prices of tradable goods across all sample periods (Figure 1.3). After this period, pass-through to prices of tradable goods is no longer statistically significant, but the average pass-through to prices of tradable goods is 47 percent for the 12 most recent sample periods, and is statistically significant for most of these. Pass-through to prices of tradable goods, excluding clothing and footwear, moves in similar fashion but is less volatile than pass-through to prices of all tradable goods, across all sample periods, and is at a level of 33 percent for the period ending June 2018 (Figure 1.5). A similar trend is seen for prices of non-tradable goods (Figure 1.4): For the period ending March 2018, the pass-through to such prices is not statistically significant, but for the most recent sample period, ending in June 2018, it is statistically significant and increases to 25 percent. Pass-through to prices of tradable goods, excluding clothing and footwear, is 35 percent on average and is significant for 8 of the 12 periods.

13 Bank of Israel press release on the economy and economic activity "Pass-through from USD rate to housing component of the Consumer Price Index", October 4, 2009.

14 As from this period, the pass-through to inflation excluding housing decreased, but even in the most recent sample, ending in June 2018, it is statistically significant, and at a level of 19 percent.

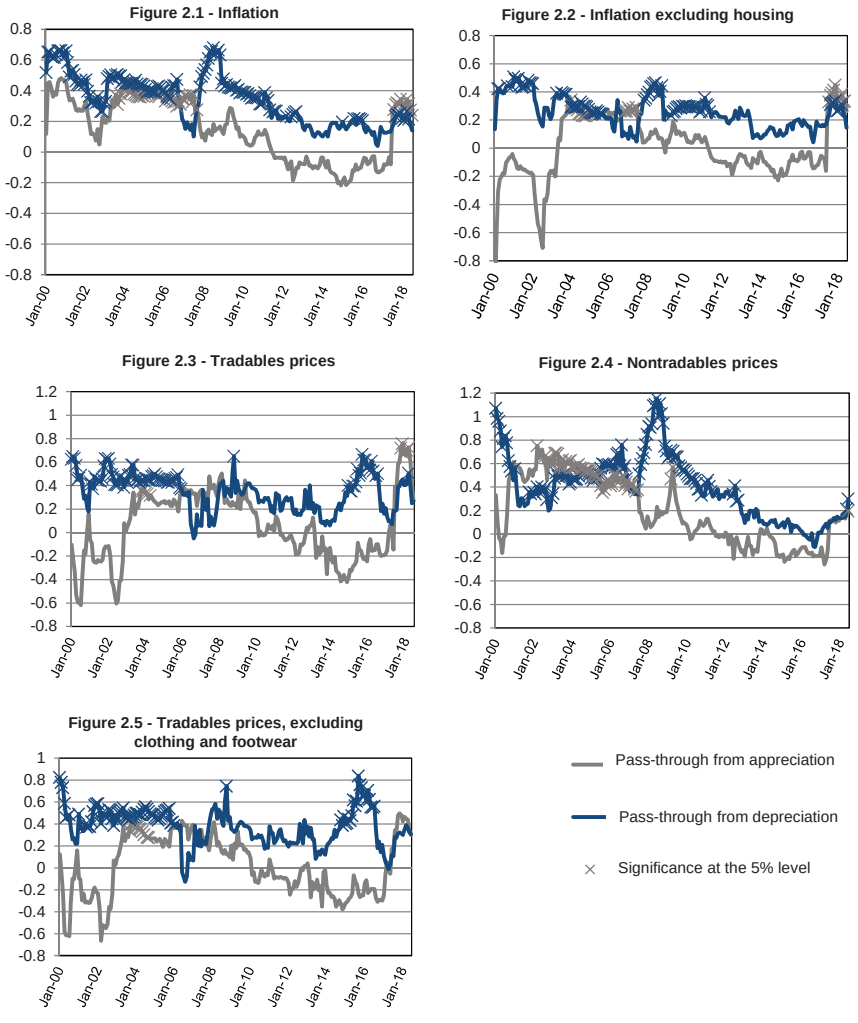
15 Bank of Israel Annual Report, 2017.

16 It is likely that prices of tradable and non-tradable goods are also impacted by import alternatives, which result in pricing pressure. Thus, for example, the price of tourism services would be impacted by the price and quality of overseas tourism services available to consumers.

Pass-through from depreciation and appreciation to prices

Over most of the sample periods, the pass-through from depreciation was higher than the pass-through from appreciation, but according to results of Regression 2, this trend is reversed in samples ending in 2017.[17] For the period ended June 2018, pass-through to consumer prices (Figure 2.1) from appreciation is 24 percent[18], whereas pass-through from depreciation is only 14 percent. The trend in pass-through from depreciation and appreciation to prices of tradable goods is similar to that to overall inflation (change in the overall, seasonally adjusted CPI), but in recent periods, the trends are not statistically significant (Figure 2.3). Pass-through to prices of tradable goods, excluding clothing and footwear, is similar to pass-through to prices of all tradable goods, but as from periods ending in late 2016, it is not statistically significant (Figure 2.5).

Figure 2
Pass-through from Appreciation and Depreciation
(End date of the 48-month rolling window, January 2000–June 2018)



17 The samples ending in the past two years show a continued trend of appreciation (Appendix 2). For periods ending in 2017–18, there are on average 18 observations for depreciation and 30 observations for appreciation.

18 See Appendix 5 “Summary Table”.

The picture for pass-through to prices of non-tradable goods is slightly different: No change in trend is apparent in recent periods. Pass-through from depreciation to prices of non-tradable goods is positive and higher than pass-through from appreciation, across most of the sample periods (Figure 2.4). For the period ending June 2018, pass-through from depreciation and appreciation to prices of non-tradable goods is at 30 percent and 19 percent, respectively.

Robustness testing

Pass-through is affected by a variety of shocks, such as shocks to the risk premium or to overseas demand for exports, which affect the exchange rate and inflation in each period, but this study does not attempt to identify such shocks[19], but merely describes the empirical relation between exchange rates and inflation (pass-through). To ensure that the results are not sensitive to the particular analysis chosen, we tested different ways to calculate pass-through, such as calculation as a sum of exchange rate coefficients over time t=-5 to t=0 (sum over 6 periods) and testing pass-through as the coefficient of the moving average change in exchange rate over 6 months. The resulting pass-through levels obtained by these calculations are very similar. In a further test, the rolling window was shortened to 3 years (36 months); we found that the estimator for pass-through for such a window is similar to the estimator calculated using a 4-year window, but the 3-year estimator is more volatile over the entire period.[20] Testing using a 6-year window shows similar results to estimation using the original model, except for samples ending in the recent periods, where most of these resulted in statistically insignificant pass-through. An 8-year rolling window shows pass-through that is stable and significant over the most recent periods (average pass-through of 15 percent for the 12 most recent periods), but testing of the period which differentiates between the 6-year pass-through estimator (which is not significant for the most recent periods) to the 8-year one, shows that the difference is due to a high pass-through environment in the past, which is included in the sampled 8 years but excluded in the 6-year period.

Adding macro variables[21] to the regressions, as explanatory variables and as interaction variables with the exchange rate, using various specifications, did not significantly change the pass-through direction. Estimating pass-through using 39 different specifications[22] of the model, combined with relevant macro variables, shows that on average, the pass-through estimators are very close across the entire sample, and the estimator range grows narrower across the sample, especially in recent periods. Due to the strong resemblance between the various estimation results (Figure 3) and the original estimation, we chose not to introduce these explanatory macro variables into the model.

Estimating pass-through while controlling for the Bank of Israel interest rate and the US Federal Reserve interest rate (the federal funds rate) allows us to identify pass-through net of exchange rate volatility due

19 For more information about shocks which affect inflation and the exchange rate, see Argov, Barnea, Binyamini, Borenstein, Elkayam and Rozenshtrom, "MOISE: A DSGE model for the Israeli economy" (2012).

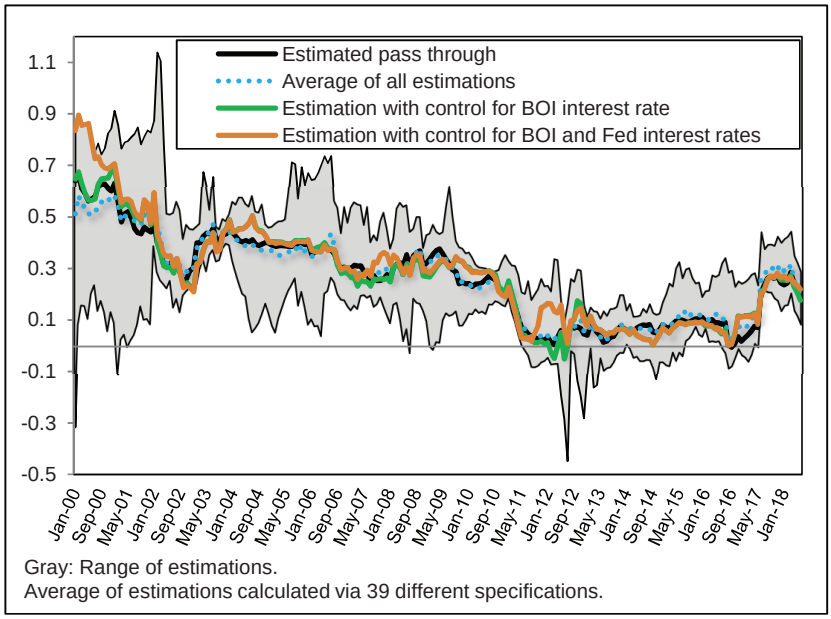
20 In recent periods, pass-through for the 3-year window also increased rapidly, at an even faster pace, and in the most recent period, the pass-through values are very close to each other.

21 Macro variables tested under various specifications: unemployment, labor market tightness, GDP gap, labor cost per unit of output, GDP rate of change, 3-month moving average of the GDP rate of change, 3-month moving average of oil price change rate, Bank of Israel interest rate and seasonally adjusted inflation in the US.

22 Some interactions with macro variables, such as GDP growth rate and core inflation in the US, with a 3 month lag, were found to have significant effect on pass-through level in recent years. However, this study does not look at pass-through causes and does not elaborate on this matter.

to monetary policy in Israel and in the US, and allows us to look at pass-through for a given monetary policy. Such estimates further support the chosen model: the estimators over time are close to each other and move in similar fashion, except for a few short periods in the sample. The model cannot distinguish between changes in the ERPT due to change in the pass-through mechanism, or changes due to the import composition or due to the structure of price indices. For example: Pass-through for a product in a given year is 10 percent, its weight in the CPI is 30 percent, and its contribution to the over-all pass-through is

Figure 3
The Model's Robustness, 2000–18



Gray: Range of estimations.
Average of estimations calculated via 39 different specifications.

3 percent; in the following year, its weighting in the CPI is up to 35 percent and pass-through remains unchanged, but now its contribution to the pass-through is 3.5 percent. In such case, the pass-through would change—even though only the consumption mix has changed. However, looking at the structure of indices and import composition over the sample periods shows no significant changes in this mix.

Summary

The pass-through level is an important measure for monetary-policy decision making. This matter has been covered by many studies around the world, which found that pass-through to consumer prices in advanced economies is not full, and has been declining in recent decades. This study finds that after a prolonged decline, pass-through has increased in recent years. This rapid increase is of interest, because similar to findings in the literature reviewed, pass-through has constantly declined over the past decade, along with inflation. This concurrent decline is evident as from October 2008, when the annual inflation rate started to decline from 5 percent to reach a negative level in September 2014. Concurrently, pass-through declined from 35 percent for periods ending in 2008, to near-zero for periods ending in 2014.

The recent increase in the ERPT may indicate that change in monetary policy would have a more intense impact on inflation through the exchange rate than in the past, but due to the asymmetry between pass-

through from depreciation to pass-through from appreciation, the extent of the change would also be affected by the direction of the monetary policy – expansionary or contractionary.

The increase in pass-through may be a result of growing competition. Bank of Israel Annual Reports for 2016 and 2017 indicate change in consumer behavior, partly due to technology improvements, which allow for price comparison and for online purchase of local or foreign goods. The report for 2016 further notes that some public companies show a trend of lower operating and gross margins, which is in line with increased competition: in a competitive market, in case of depreciation, it is likely that firms would hesitate to raise prices, so as not to lose their market share, hence they would absorb part of the increase in the exchange rate.[23] In recent years, the exchange rate has seen a trend of appreciation. One could imagine a state of ever increasing competition in the market, with firms taking advantage of the opportunity to reduce prices due to appreciation, with minimal impact to earnings, since appreciation reduces the cost of imported goods, and the lower prices may increase their attractiveness to consumers. In other words: Reducing prices, concurrently with appreciation, may explain the recent increase in exchange rate pass-through.

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[23] That is to say, they would not fully translate the depreciation in the exchange rate to the consumer price.

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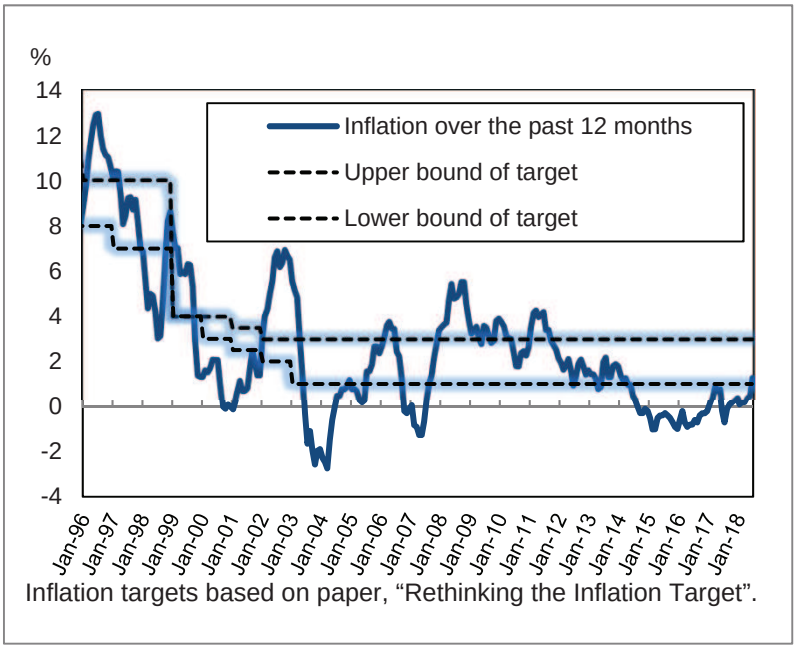
Appendix

Figure A.1
The Inflation Environment, January 1996–June 2018



Inflation targets based on paper, "Rethinking the Inflation Target".

Figure A.2
The NIS/$ Exchange Rate, Monthly Average,
January 1996–June 2018

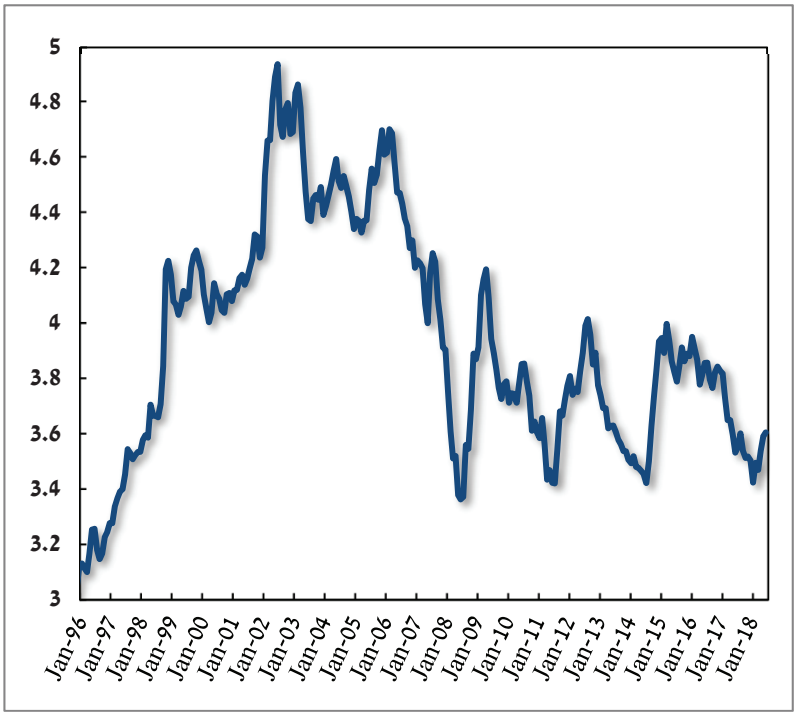


Table A.3
Regression 1 results—the pass-through to prices
(June 2014–June 2018)

	(1) Δp	(2) Δp_nh	(3) Δp_tr	(4) Δp_ntr	(5) Δp_tr_ncf
Δe_t	0.100***	0.0947**	0.0548	0.162***	0.117
	(0.032)	(0.043)	(0.092)	(0.029)	(0.071)
Δe_{t-3}	0.0795*	0.0995	0.251*	0.0918**	0.210*
	(0.047)	(0.064)	(0.139)	(0.044)	(0.108)
Δpim_t	0.273*	0.27	0.654	0.802***	0.566
	(0.155)	(0.209)	(0.568)	(0.181)	(0.440)
Δpim_{t-3}	-0.142	-0.125	-0.349	-0.584***	-0.177
	(0.104)	(0.140)	(0.383)	(0.122)	(0.297)
Δoil_t	0.0186***	0.0247***	0.0284**	0.0176***	0.0356***
	(0.006)	(0.008)	(0.013)	(0.004)	(0.010)
Δoil_{t-3}	0.00915	0.00788	0.0112	0.00572	0.00398
	(0.006)	(0.008)	(0.013)	(0.004)	(0.010)
α	0.000141	-0.000427	0.00316	-0.00147**	-0.00254
	(0.000)	(0.000)	(0.002)	(0.001)	(0.002)
Observations	48	48	48	48	48
R-squared	0.377	0.33	0.681	0.878	0.617

1. Two dummy variables for months, which were included in regressions 3–5, were deleted from this table.

2. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A.4
Regression 2 results—the pass-through from appreciation and depreciation to prices
(June 2014–June 2018)

	(1) Δp	(2) Δp_nh	(3) Δp_tr	(4) Δp_ntr	(5) Δp_tr_ncf
Δdep_t	0.0845*	0.0786	0.1080	0.182***	0.1550
	(0.045)	(0.061)	(0.133)	(0.042)	(0.103)
Δdep_{t-3}	0.0557	0.0668	0.1580	0.116*	0.1520
	(0.070)	(0.094)	(0.193)	(0.062)	(0.150)
Δap_t	0.127*	0.1210	-0.0361	0.131**	0.0541
	(0.072)	(0.097)	(0.176)	(0.056)	(0.137)
Δap_{t-3}	0.1130	0.1410	0.3100	0.0623	0.2450
	(0.068)	(0.092)	(0.186)	(0.059)	(0.145)
Δpim_t	0.2720	0.2630	0.5410	0.829***	0.4960
	(0.169)	(0.229)	(0.599)	(0.191)	(0.467)
Δpim_{t-3}	-0.1480	-0.1280	-0.2590	-0.603***	-0.1200
	(0.114)	(0.154)	(0.408)	(0.130)	(0.318)
Δoil_t	0.0172***	0.0231***	0.0288*	0.0193***	0.0360***
	(0.006)	(0.008)	(0.015)	(0.005)	(0.012)
Δoil_{t-3}	0.0088	0.0072	0.0048	0.0060	-0.0002
	(0.006)	(0.008)	(0.015)	(0.005)	(0.012)
α	0.0005	0.0000	0.0030	-0.00179**	-0.0027
	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)
Observations	48	48	48	48	48
R-squared	0.385	0.337	0.69	0.882	0.624

1. Two dummy variables for months, which were included in regressions 3–5, were deleted from this table.
2. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table A.5
Summary table

	Inflation	Inflation excluding housing	Tradables	Tradables excluding clothing and footwear	Nontradables
General	0.18	0.194	0.306	0.327	0.253
	(0.06)	(0.09)	(0.20)	(0.15)	(0.06)
Depreciation	0.14	0.145	0.266	0.306	0.298
	(0.09)	(0.12)	(0.26)	(0.20)	(0.08)
Appreciation	0.24	0.262	0.274	0.299	0.193
	(0.11)	(0.15)	(0.29)	(0.23)	(0.09)

Standard errors in parentheses.

Appendix 6

Regressions 1, 2, and the calculation of the pass-through estimate

(Regression 1)

$$\Delta p_t = \alpha + \beta_1 \Delta e_t + \beta_2 \Delta e_{t-3} + \gamma_1 \Delta pim_t + \gamma_2 \Delta pim_{t-3} + \delta_1 \Delta oil_t + \delta_2 \Delta oil_{t-3} + \sum_{i=1}^{11} \delta_i m_{i,t} + u_t$$

Where:

α–is a constant

Δp_t –the change in the log CPI

Δe_t – 3-month moving average of the change in the log NIS/$ exchange rate

Δpim_t –3-month moving average of the change in the log index of import prices in dollars

Δoil_t – 3-month moving average of the change in the log price of oil in dollars

$m_{i,t}$ – Dummy variable for month

u_t –Estimation error

(Regression 2)

$$\Delta p_t = \alpha + \beta_1 \Delta dep_t + \beta_2 \Delta dep_{t-3} + \beta_3 \Delta ap_t + \beta_4 \Delta ap_{t-3} + \gamma_1 \Delta pim_t + \gamma_2 \Delta pim_{t-3} + \delta_1 \Delta oil_t + \delta_2 \Delta oil_{t-3} + \sum_{i=1}^{11} \delta_i m_{i,t} + u_t$$

The regression variables are the same as those in regression 1 except:

Δdep_t 3-month moving average of the change in the log NIS/$ exchange rate in a case of depreciation, 0 if otherwise

Δap_t 3-month moving average of the change in the log NIS/$ exchange rate in a case of appreciation, 0 if otherwise

Definition of the pass-through:

The pass-through from the exchange rate $\beta_1 + \beta_2$

The standard deviation of the pass-through $\sqrt{var(\beta_1) + var(\beta_2) + 2 * cov(\beta_1, \beta_2)}$

The confidence interval $\beta_1 + \beta_2 \pm 2 * \sqrt{var(\beta_1) + var(\beta_2) + 2 * cov(\beta_1, \beta_2)}$

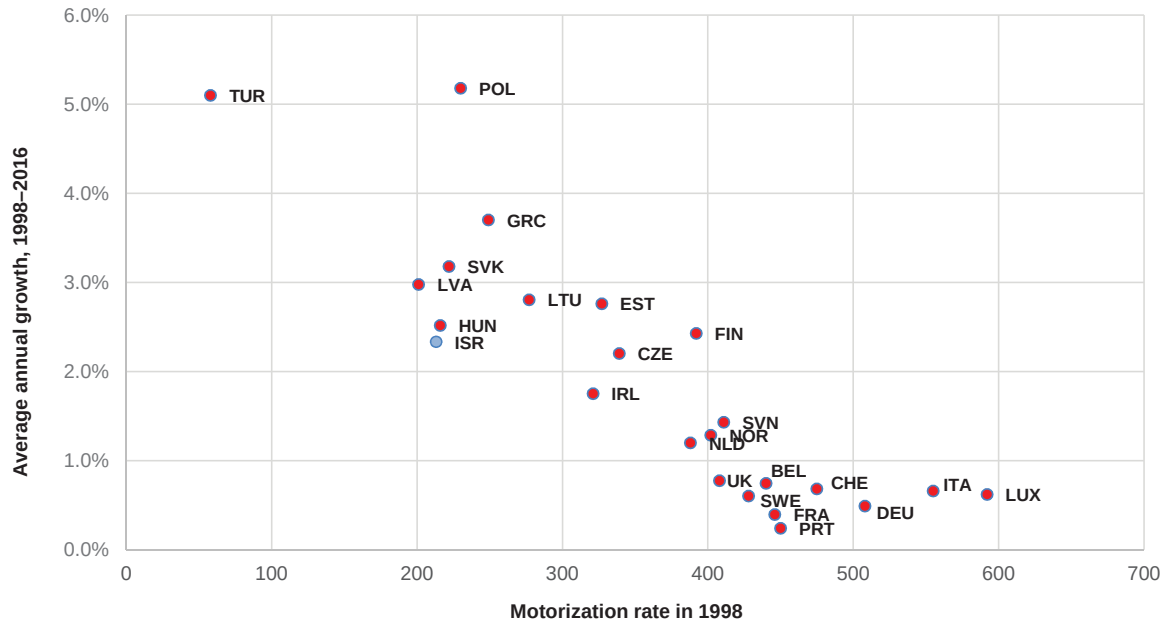
PRIVATE TRANSPORTATION IN ISRAEL: AN ANALYSIS OF DEVELOPMENTS IN THE PAST TWO DECADES

- Policy measures regarding private vehicle transportation in Israel—including the decision to reduce taxes on the purchase of new cars beginning in 2005 and the decision to increase the tax on variable expenses only slightly compared with the increase in household income—contributed directly to increased road congestion. These steps joined other economic processes that were leading toward rapid growth in private vehicle kilometers traveled (VKT) in Israel.
- In order to avoid a situation in which the increase in congestion has a serious negative impact on all road users due to its nonlinear effect on travel speed, existing policy must be adjusted. This can be done through policy that combines incentives to slow the pace of growth in VKT—such as increasing investment in improving public transportation and increasing taxes on kilometers traveled, particularly during peak times—and aligning investment in roads to the growth rate of demand.

1. Introduction

Road congestion in Israel increased in the past two decades due to economic processes and due to the government's tax policy. The economic processes include an increased standard of living and expanded employment, in parallel with population dispersion. Figure 1 helps us clarify the argument regarding the standard of living. It relates to selected countries, and presents the annual growth in the motorization rate (the number of private vehicles per 1,000 inhabitants) in the past 20 years, as a function of the motorization rate at the beginning of the period.

Figure 1
Change in the Motorization Rate between 1998 and 2016 as a Function of the Motorization Rate in 1998



Written by Yoav Friedmann.

The figure shows that the motorization rate increases faster where it begins at a lower level. This link reflects the fact that as the standard of living increases, the motorization rate increases to saturation.[1] In 1998, Israel had a low motorization rate, so the number of vehicles per person expanded rapidly (beyond the increase in population, which is a high figure on its own). In the past two decades, the motorization rate in Israel increased by more than 50 percent, from approximately 210 vehicles per 1,000 inhabitants in 1998 to 320 vehicles per 1,000 inhabitants in 2017.

The process of expanding employment in parallel with the dispersion of the population greatly expanded commuting—leaving the residential locality in order to go to work. In 1995, 45 percent of workers in Israel commuted, compared with 55 percent currently. According to the Social Survey conducted by the Central Bureau of Statistics, these workers travel an average of 18 km to get to their places of work. Assuming that people who work in their residential locality travel only a few kilometers to work, the change in commuting patterns increased the average travel distance to work by 10–15 percent. Among other things, this is a result of the increase in the use of private vehicles, investment in road infrastructure[2], and land use planning in the National Outline Plan. All of these factors create feedback pressure for continued investment in private transport infrastructure.[3]

These economic processes are among the forces that increased the motorization rate by more than 50 percent in the past two decades. Annual per capita vehicle-kilometers traveled (VKT) increased during that period by a similar rate—about 45 percent.[4] Expanded per capita private VKT was accompanied by a much more moderate increase in paved road area per capita—about 6 percent during the period—which led to a tremendous increase in road congestion.

However, as noted at the beginning of this article, the taxation policy adopted by Israel in the past decade has also contributed to the increase in the motorization rate and in private VKT. The State reduced taxes on the fixed expenses involved in purchasing a new vehicle (mainly purchase tax), and instituted only a moderate increase in the taxes on variable expenses (mainly fuel excise). The overall change in taxation increased demand for private vehicles. This article focuses on an analysis of this policy, and also briefly discusses the policy regarding vehicle leasing, and the development of roads in relation to the increase in their use.

2. Policy regarding private transport travel pricing in the past two decades

the cost of traveling in a private vehicle includes (1) a fixed component—purchase and maintenance; and (2) a variable component—the cost per kilometer of travel. It may be assumed that already at the time of

1 It is not likely that the motorization rate will exceed the ratio between the number of adults in the population and the overall population. It is reasonable to assume that the closer the number of vehicles is to the number of adult inhabitants, the slower the growth rate of total vehicles and of VKT will be.

2 Frish and Tsur (2010) discuss how improvement in transport infrastructure affects commuting.

3 Had a residential construction policy been adopted to increase population density and create employment centers in the existing cities, it may have reduced the growth in VKT and the need to expand intercity transport infrastructure. However, this is outside the scope of our discussion. Ewing and Cervero (2010) conducted a meta-analysis of the findings of various studies regarding the elasticity of the connection between the volume of VKT and variables representing the urban structure. The link between urban structure, population density and VKT was also studied in later years (e.g., Ding et al., 2017, and Kim and Brownstone, 2013).

4 Annual per capita VKT is equal to total kilometers traveled in private vehicles in Israel divided by the population.

purchase, the buyer considers the trips expected in the vehicle, and the vehicle's VKT is determined by the two components (and not just the variable component as some might think).[5] Of course, marginally, a decline in the per-kilometer cost of travel will encourage traveling by vehicles that individuals already own, and a decline in purchase price will encourage vehicle ownership even for relatively low travel volumes. The first part of this section surveys the development of the fixed costs in the past two decades, and the second part discusses the variable costs. The third part sums up the development of the overall cost.

a. The fixed costs

Purchase tax

Israel imposes a high purchase tax on the purchase of private vehicles. At the beginning of the 2000s, statutory purchase tax was 95 percent, and effective tax was between 80 and 85 percent, since a credit was given for safety features. In 2005, the government decided to gradually lower purchase tax to 72 percent, with the aim of encouraging residents to purchase new vehicles, since they are safer and less polluting. The average age of private vehicles began declining in 2007.[6] Before the process ended, when purchase tax was 75 percent, it was decided to implement another measure—the green tax reform. Purchase tax was increased to 83 percent, while those purchasing vehicles were given tax benefits in accordance with pollutant emission levels.[7] The green tax reform was intended to either increase effective purchase tax slightly[8] or leave it unchanged, but since the public changed its behavior and transitioned to purchasing smaller and less polluting vehicles, the effective purchase tax continued to decline after the reform was implemented, reaching just 60 percent in 2013.[9] With the aim of moderating the decline, the green tax formulation was revised in August 2013, and it was later decided to update it every two years. Accordingly, it was updated in January 2015 and in January 2017. The update increased the weighted purchase tax on vehicles slightly, but it remained relatively low—around 60 percent.[10]

5 This argument holds regarding fixed or planned travel. Regarding one-off travel, the marginal cost per kilometer of travel can be viewed as the relevant cost for the decision regarding VKT. In most cases, this cost is lower than the alternative (with the exception of foregoing the trip altogether), so vehicle owners who would like to move from one place to another will apparently choose to use their vehicle. The literature shows that when individuals own a vehicle, they tend to use it to get to work or for one-off trips. See, for instance, Santos et al. (2013) and Kitamura (2009).

6 The average age of private vehicles fluctuated a number of times over the past 30 years. In 1989–90, during a recession, it climbed from 6.8 to 7.2 years. Right after that, it declined relatively rapidly, to 6.3 years in 1996–97, apparently due to the wave of immigrants that arrived in Israel during that time, and the tax benefits they received on purchasing a vehicle. In the following years, the average age of vehicles again increased. Beginning in 2007 it declined again, apparently due to the decline in the effective tax on new vehicles. But as we explain below, the decline was also due to the increase in household income, the decline in interest rates, and the real appreciation of the shekel.

7 For a brief time, the tax was raised to 90 percent, but it was then lowered to 83 percent and the tax credit on installing a stability control system was cancelled since such systems became mandatory in 2010.

8 Since the tax benefits are given at fixed amounts in accordance with the safety and emission levels, the purchase tax varies as a share of the vehicle's value, depending on the vehicle. The effective tax discussed here is equal to the total purchase tax revenue on private vehicles, divided by the total value of private vehicle imports.

9 In addition to purchase tax, customs is applied in accordance with the country of origin, and VAT is added (including VAT on the tax component). The average customs rate on a passenger vehicle has been about 3 percent of the vehicle's value in recent years, while VAT is 17 percent.

10 It is quite possible that the tax reduction led to some increase in the sale price of vehicles to the domestic importers, meaning that some of the decline in the tax component may not have been rolled over to the vehicle's final price. This is a likely outcome if we take into account that there is a sharp distinction between the Israeli and global vehicle markets, and that, except for extreme cases, the tax imposed on a good is divided between consumers and manufacturers.

The change in taxation, a central policy factor, contributed to a decline in the relative price of private vehicles.[11] In addition to it, other factors contributed (and continue to contribute) to the decline: the development of the real exchange rate in Israel, the decline in the real interest rate, and the fact that a vehicle is a tradable good the price of which tends to decline over time, while its quality tends to increase. While these factors are not under the direct control of policy makers, since they do have an effect on developments in the economy, there is room to take note of them when setting policy.

The real exchange rate

In the past decade, the shekel has appreciated significantly. While an analysis of the past 20 years finds that there was a decline in real terms prior to the beginning of the appreciation in 2008, that decline pales by comparison to the appreciation in the past decade. The real effective exchange rate index in 2018 had appreciated by 20 percent relative to its level in 2005 and by 5 percent relative to its level in 1999. The stronger shekel contributed to lower vehicle prices since vehicles are imported.

The real interest rate

The decline in the real interest rate reduces the cost of purchasing a vehicle by lowering the capital cost. The overall capital cost involved in owning a vehicle is equal to the capital loss derived from a decline in its value, plus the alternative cost of the capital. The real interest rate declined from an average of more than 3 percent between 2005 and 2007, to near-zero in the past four years. Assuming that a vehicle's value drops by 10 percent per year, the decline in the interest rate reduced the overall capital cost from about 15 percent per year a little more than a decade ago, to 12 percent per year currently.[12],[13]

A vehicle as an imported (tradable) good

Vehicles are tradable goods, for which the quality of later-year models is higher than earlier models, while its price remains stable. This contributes to lower prices relative to other consumer goods. While technological improvements should make production more expensive relative to the production price before the improvement, global competition means that prices have remained stable. Improved quality without a change in price means a decline in the quality-adjusted price, and in the vehicle industry this is reflected in the second-hand market. The improvement in the quality of new vehicles contributes to faster declines in the prices of used vehicles (relative to a situation where there is no improvement in quality), and expands the population that has the ability to purchase a private vehicle.

***

11 The reduction in the purchase tax constituted slightly more than 10 percent of the price of a new vehicle. Moreover, the green tax reform encouraged the public to purchase smaller and less expensive vehicles.

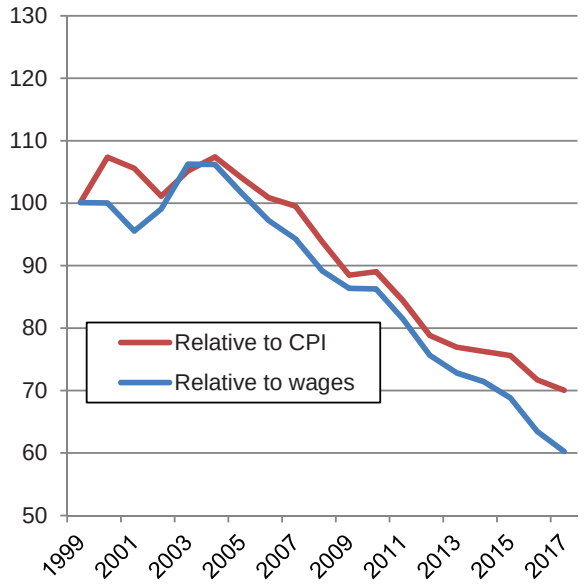
12 In addition to decline in the price of the vehicle itself, a price that forms the basis for calculating the capital cost.

13 The depreciation figure is mainly intended to illustrate the order of size. The average real yield on two-year government bonds was 3.0 percent in 2005–07, the yield on five-year bonds was 3.3 percent, and the yield on ten-year bonds was 3.6 percent. Between 2014 and 2017, the average real yield on a five-year government bond was zero. The decline in the interest rate may have increased depreciation in the first years of the vehicle's lifespan, but since a change in the interest rate has almost no effect on the lifespan of vehicles, we assume that the average depreciation did not change over the course of the lifespan.

Figures 2 and 3 provide a summary of the development of the fixed component in the cost of traveling by private vehicle. Figure 2 displays how vehicle prices have developed since 1999, and shows that between 1999 and 2004, there was no significant change in real prices, but that a prolonged downward trend in price began in 2005. From 2005 to 2017, real prices of vehicles dropped by about 30 percent, and relative to employee wages, they declined by even more.

Figure 3 shows how the fixed cost of owning a typical private vehicle developed as calculated for reimbursement purposes. This cost is comprised of the alternative capital cost (it is derived from the price of the vehicle and the price of capital), annual depreciation, and other fixed costs such as insurance and licensing fees.[14] The figure shows that this component declined significantly since 2005—more than 40 percent in fixed prices, and by about 50 percent relative to employee wages.

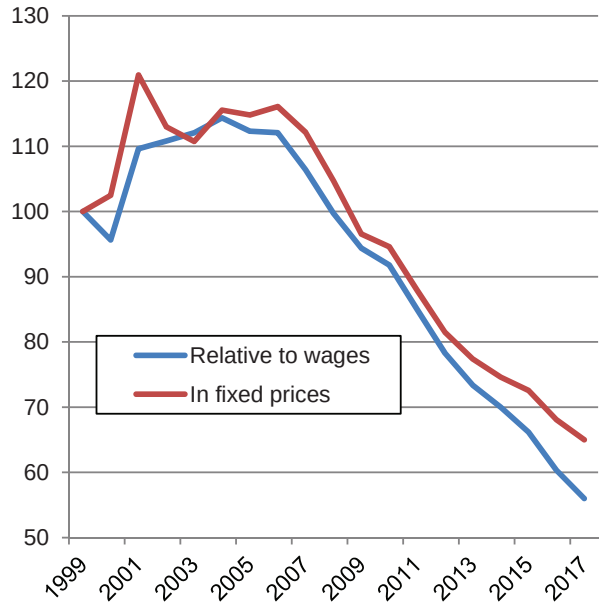
Figure 2
Development of the Private Vehicles Component[a] of the CPI Relative to the Overall CPI and to Employee Wages, 1999–2017



[a] This price reflects new and used vehicles together. Since used vehicles account for a sizeable portion of the market, the development of new car prices affects the CPI mainly through its effect on used car prices.

SOURCE: Bank of Israel calculatons based on Central Bureau of Statistics data.

Figure 3
Development of The Fixed Cost of Owning a Typical Private Vehicle[a], 1999–2017



[a] The costs of a typical private vehicle (average of Groups 2 and 3) according to the calculation used for reimbursement per kilometer traveled.

SOURCE: Bank of Israel calculatons based on data from the "Kol Natun" software from "Hashavim" and the Central Bureau of Statistics..

[14] Insurance prices (in fixed prices) have been in a downward trend over the course of the past two decades, and are currently more than 30 percent lower than they were at the end of the 1990s. Some of the decline is due to the fact that vehicle safety and quality of infrastructure improved over the years, and another part is due to the decline in the price of the vehicle itself. Fees and levies remained relatively stable. It is worth noting that insurance expenses constitute about one-third of the fixed expenses on owning a vehicle (based on the weight of insurance expenses in the consumption basket used to calculate the Consumer Price Index), and expenses on fees constitute less than 10 percent.

b. The variable costs per kilometer of travel

The variable cost per kilometer of travel is comprised mainly of the cost of fuel, which includes the cost of raw materials (petroleum) and taxes.

Taxes

Taxes, including VAT, account for more than 60 percent of the price of gasoline. Excise currently accounts for about 50 percent of the price of gasoline, and is indexed to the Consumer Price Index. In the past 25 years, fuel excise increased in two stages, the first in 1996–97, and the second in 2009.[15] Between 1997 and 2009, it remained fixed (except for changes due to indexation)[16], and in 2009 it was raised by NIS 0.30 per liter—13 percent. Fuel excise is currently 12 percent higher in fixed prices than it was in 1999, and relative to employee wages it is 3 percent lower than it was in 1999 (Figure 4).

The question may be asked, which way is more correct to examine the development of excise and fuel prices in general—relative to the development of the Consumer Price Index, or relative to the development of wages (or household income). Indexing excise to the CPI means that over time, the tax will take up a smaller share of income, and will therefore contribute less to lowering private VKT. Since the supply side (road infrastructure) is not tradable and increases in price as the standard of living increases—due to the increase in the price of land, the increase in capital necessary to expand roads with the increase in population density, and the increase in the cost of paving—and since on the demand side the price of time taken up by traffic jams also increases, it seems that there is room to increase fuel excise over time in accordance with the increase in wages (or another measure of income), or to increase the price of private vehicles' use of roads through the use of innovative technology.[17] In other words, the cost of using roads should be linked to the standard of living and to the cost of labor. The fact that excise has remained fixed relative to wages shows that this tax, in and of itself, did not contribute to the increase in VKT consumption, but was also not used to offset the effect of the decrease in purchase tax on demand for private vehicles or on VKT.

The State has tried to increase fuel excise beyond the increase in wages. In the budget for 2011–12, the government decided to increase it by NIS 0.40 in two stages. However, following the first stage, in January 2011, a social protest broke out and excise was lowered back to its pre-increase level, where it has remained ever since. The first stage of the increase was made at an inauspicious time from a political/public standpoint, as global oil prices continued to increase, and fuel prices increased by more than 10 percent within a month.[18] The public viewed the first stage of the increase as cruel abuse on the part of the government during a time when the public was suffering from a sharp increase in home prices and a standstill in real wages—which had not yet returned to their levels from before the Global Financial Crisis—and the increase inflamed the social protest that developed during the year. Having already been burned, the government left the excise unchanged even after global oil prices dropped in 2014 and in 2015

15 Excise on diesel fuel was raised gradually from September 2005 in order to equalize it with excise on gasoline. However, since diesel fueled only 2.6 percent of private vehicles at the time, this increase is not being discussed here.

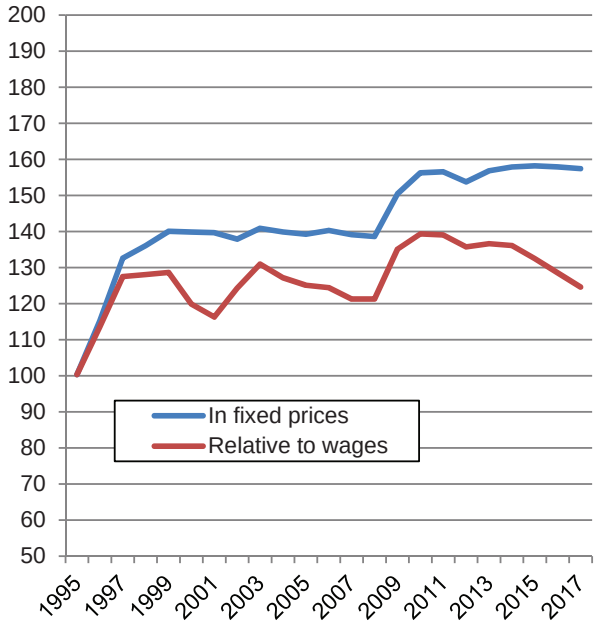
16 Excise as a defined tax on gasoline was imposed in 1993, and by 1997 it had been increased by more than 30 percent.

17 The OECD recommended strengthening the connection between the use of roads and the prices of using them in its 2018 survey of the Israeli economy (OECD Economic Surveys, Israel, March 2018).

18 Excise is indexed to the CPI, but the indexation is only periodic. This increase included the periodic indexation, as a partial factor in the increase in fuel excise.

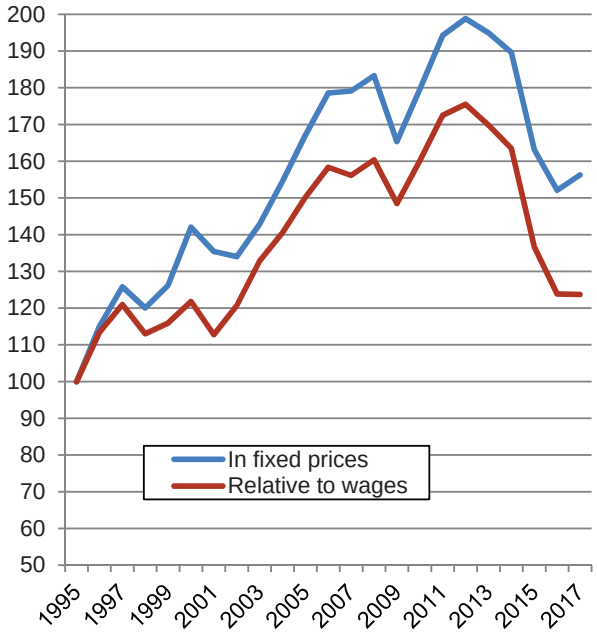
and fuel prices in Israel fell back from the record high levels of close NIS 8 per liter[19] to around NIS 6 per liter.

Figure 4
Development of Fuel Excise Tax, in Fixed Prices and Relative to Employee Wages, 1995–2017



SOURCE: Bank of Israel calculatons based on data from the Ministry of Energy's Fuel and Natural Gas Administration, State Revenue Administration, and Central Bureau of Statistics.

Figure 5
Development of Fuel Prices at Fuel Stations, in Fixed Prices and Relative to Employee Wages, 1995–2017



SOURCE: Bank of Israel calculatons based on data from the Ministry of Energy Fuel and Natural Gas Administration, State Revenue Administration, and Central Bureau of Statistics.

The price of oil

Global oil prices increased between 2000 and 2008, and stabilized at high levels between 2011 and 2014. As such, there was a marked prolonged increase in fuel prices in Israel over that period, despite the appreciation of the shekel in real terms. Figure 5 shows the development of gasoline prices at fuel stations, in fixed prices and relative to employee wages, between 1995 and 2017. The figure shows that gasoline prices showed a continued increase until 2012, when the price reached its peak. The sharp decline in oil prices that began in 2014 returned the price of gasoline at fuel stations (in wage terms) to a level similar to what it was at the end of the 1990s and beginning of the 2000s.

The increase in the price of oil and in the importance of protecting the environment reinforced the global demand for new vehicles with greater efficiency of fuel consumption. Until recently, this phenomenon was barely reflected in average fuel consumption of private vehicles in Israel, both because efficiency

19 For a few months, the price actually exceeded NIS 8 per liter.

improved only modestly, and because of the time that elapses until new and more efficient vehicles build up a critical mass in the number of cars on the road to influence average fuel consumption. However, the tax incentives currently offered as part of the green taxation reform encouraged people to change the type of private vehicles they purchase. Accordingly, vehicles with smaller engines and lower fuel consumption have increased as a share of all private vehicles in recent years. An attempt to estimate the improvement in passenger vehicles' fuel consumption in recent years, and the resulting decline in the cost of travel by private vehicle, shows that the average number of kilometers per liter of fuel increased by 0.5–1 percent between 2012 and 2016. This is only a slight improvement, but it seems that in the coming years, there will be a much more significant improvement in fuel consumption thanks to the expanded use of hybrid and electric vehicles.

In particular, hybrid vehicles consume much less fuel than similar vehicles with a gasoline engine. According to the American Environmental Protection Agency, the difference can reach more than 30 percent, and according to field tests (uncontrolled), it is between 20 and 35 percent.[20] The large tax break offered on hybrid vehicles is contributing to a sharp increase in their number, and they already constitute more than 15 percent of new vehicle deliveries. While hybrid vehicles still account for a very small portion of total private vehicles—about 2.5 percent in 2017—their share is increasing rapidly. The increased share of hybrid (and electric) vehicles is expected to lead over time to a marked improvement in average fuel consumption of all private vehicles and to a lower average cost per kilometer of private vehicle travel.[21,22]

c. Total price per kilometer

The reduction in the purchase tax on new vehicles since 2005, together with the difficulty in increasing the fuel excise, led to a continued decline in overall taxation on travel by private vehicle—total taxes charged on a private vehicle relative to total amount traveled. While the increase in the excise in 2009 was expected to compensate for a significant portion of the decline in the purchase tax, the green taxation reform that began in the same year reduced the effective purchase tax to a greater extent than foreseen, as described above, while VKT continued to increase.

If we total the fixed and variable expenses inherent in owning a private vehicle, we find that only one significant component became more expensive than it was at the end of the 1990s—the price of fuel—and that also declined in the past decade. The capital cost, a dominant factor in the price, declined significantly, as did the insurance component.[23,24]

20 Data from www.fueleconomy.gov and from *Yediot Aharonot*, "The Pump Test", July 26, 2018.

21 In terms of cost per kilometer of travel, there is no difference between a change in the cost of gasoline and a change in the efficiency of fuel consumption, but there is a dispute in the economic literature regarding the question of whether the two factors affect VKT to the same extent—Frondel and Vance (2013) and Small and van Dender (2007) argue that the two factors have the same effect (or at the very least they cannot reject this hypothesis), while Gillingham, et al. (2016) and De Borger, et al. (2016) report that the vehicle's efficiency has a lesser effect.

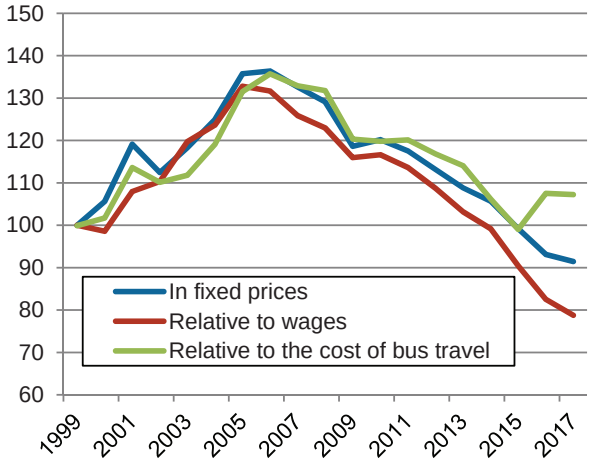
22 The next stage, a significant transition to electric vehicles, is still in its infancy. However, as it advances, the variable cost per kilometer of travel will decline further, and a comprehensive reform in the taxation of VKT will become necessary.

23 The real price of vehicle insurance declined by about 30 percent since the end of the 1990s. In 2017 and 2018, a discount was given on compulsory insurance, and in 2019, the discount was discontinued, but this doesn't change the overall picture.

24 Each component's share in the cost of maintenance depends on the price of the vehicle and how much it is used. In the Consumer Price Index, the current weights are currently used: 36 percent for the price of the vehicle; 28 percent for fuel and oil expenses; 21 percent for insurance; 8 percent for repairs and replacement parts; and 6 percent for vehicle and driver's licenses. The capital price is not included in maintenance expenses in the Consumer Price Index.

Figure 6 shows the cost per kilometer as calculated for purposes of reimbursement. This calculation essentially sums all expenses for owning a private vehicle—in accordance to the expense items listed above—after translating them into terms of expense per kilometer traveled. It can be seen that the overall cost per kilometer (fixed and variable expenses) has been in a downward trend for more than a decade. Compared to 1999–2000, the decline in costs relative to employee wages is about 20 percent. A similar trend is apparent in the private vehicles and maintenance component of the Consumer Price Index (Figure 7). The reform in bus travel prices enacted in 2016 offset some of the decline in the indices that show the cost of travel by private vehicle relative to the cost of travel by bus.

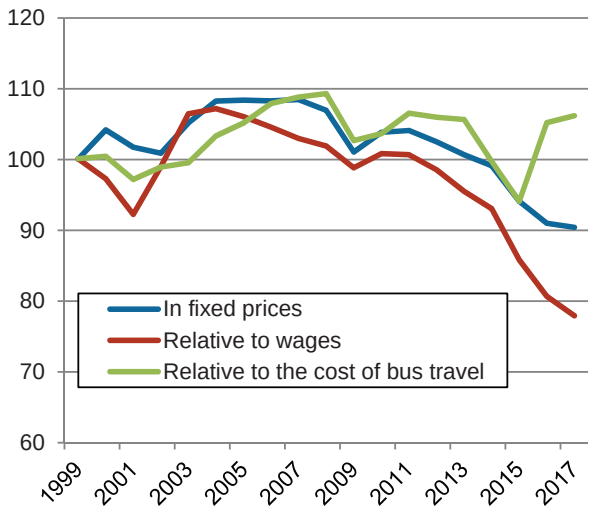
Figure 6
Development of The Fixed and Variable Costs per Kilometer Traveled of a Typical Private Vehicle[a], 1999–2017



[a] The costs of a typical private vehicle (average of Groups 2 and 3) according to the calculation used for reimbursement per kilometer traveled.

SOURCE: Bank of Israel calculatons based on data from the "Kol Natun" software from "Hashavim" and the Central Bureau of Statistics..

Figure 7
Development of The Costs of Purchasing and Maintaining a Private Vehicle, According to the CPI, 1999–2017



SOURCE: Bank of Israel calculatons based on Central Bureau of Statistics data.

It may be unrealistic to attempt to estimate how the decline in total maintenance cost, particularly fixed costs, has affected private VKT. This is because there are contemporaneous links between all of the variables that determine equilibrium, and because correlations between the changes in price per kilometer for a private vehicle (including fixed expenses) and changes in vehicle ownership and use develop over the longer term. However, it is clear that a decline in the fixed and variable costs contributes to an increase in the number of vehicles purchased and traveling on the roads.

Despite the difficulties, many studies try to identify the effect of fuel prices (the variable cost) on VKT volume[25], but only a few deal with the effect of the fixed costs on VKT or on vehicle ownership.[26] Since the policy in Israel is reflected mainly in a reduction of the fixed costs, there is only a small research basis for attempting to estimate the extent to which it affects VKT. However, a hint to the significant effect that policy can have on VKT—whether through an effect on price ratios, commuting volume, and/or trip duration on public transit—can be found in the annual growth rates of per capita VKT and the motorization rate, which developed differently in each of the past two decades. The VKT growth rate between 2005 and 2017 was more than twice as high as it was between 1995 and 2005[27], and almost twice as high as the rate between 1995 and 2000 (prior to the outbreak of the Second Intifada). The increase in the motorization rate between 2005 and 2017 was also much higher than in the two sub-periods between 1995 and 2005.

3. Leased vehicles[28]

The use of leased private vehicles—those owned by leasing companies—for personal use began to grow in the early 2000s. Employers provided employees with vehicles for personal use, and financed all expenses related to the vehicle, including fuel expenses, in return for the employee giving up a fixed amount of income. This arrangement grew due to the tax benefit it included. Israel Tax Authority data show that the market share of new vehicles purchased for vehicle fleets increased from 33 percent in 2001 to 60 percent in 2006.

The fact that employers financed the cost of owning the vehicle—including the cost of fuel—encouraged the use of cars, which gained in significance at the macro level as the share of leased cars in total private vehicles increased. In 2008, leased vehicles accounted for more than 9 percent of all vehicles on the road, and their VKT accounted for 16 percent of total VKT, since the average VKT of leased vehicles was twice as high as the general average.[29]

25 Brons, et al. (2008) conducted a meta-analysis and found that the average elasticity of demand for VKT relative to the price of fuel is -0.2 in the short term and -0.5 in the long term. These elasticities are similar to the elasticities found earlier by Espey (1998). Brons, et al. emphasize that the studies vary in terms of the estimated elasticities, and they believe that some of the variance is a result of the nature of the studies. Dimitropoulos, et al. (2018) also conducted a meta-analysis, and found that the average elasticity of demand for VKT relative to the cost per kilometer (or the price of fuel) is -0.1 in the short term and -0.3 in the long term. This is a relatively low average, and it may be the result of the fact that roughly two-thirds of the findings that it considers were published in studies during the last decade, a period in which the standard of living is higher and price changes are greater. Dimitropoulos, et al. argue that per capita income affects the elasticity gaps between countries. When per capita income increases by 10 percent, the elasticity (in absolute terms) declines by 16 percent.

26 Dargay and Hanly (2007) and Dargay and Vythoulkas (1999) show that the number of vehicles owned by households (in England and the Netherlands) is negatively impacted by the purchase cost and by variable expenses, and Dargay and Hanly (2007), Kitamura (2009), and Kim and Ulfarsson (2008) show that owning a vehicle encourages travel.
The literature finds a connection between fixed costs and vehicle ownership (for instance, Dargay and Hanly (2007) and Dargay and Vythoulkas (1999)), but the connection between them and travel is more "distant", and it is difficult to say much more about it than the fact that it exists and is negative.

27 The selection of years for comparison does not change the general conclusion: Between the last decade and the previous one, there is a significant gap (around double) in the growth rates of VKT.

28 This section is based mainly on: Israel Tax Authority (various years), T*axation and Selected Data on the Israeli Vehicle Industry* (in Hebrew).

29 Assessment for 2008 according to leased cars' share of the total in 2008 and average VKT in 2011.

Between 2008 and 2011, a reform was introduced that increased the tax paid on the use of company cars[30], and the number of new vehicles purchased for vehicle fleets declined to the level that was prevalent in the market in 1996.[31] The reform narrowed the expansion of the problem derived from the fact that the individual did not cover the costs of travel for personal needs, and the fact that individuals had less of an incentive to live close to their place of work. However, the problem still exists, since about 7 percent of vehicles on the road are company cars (owned by leasing companies).[32]

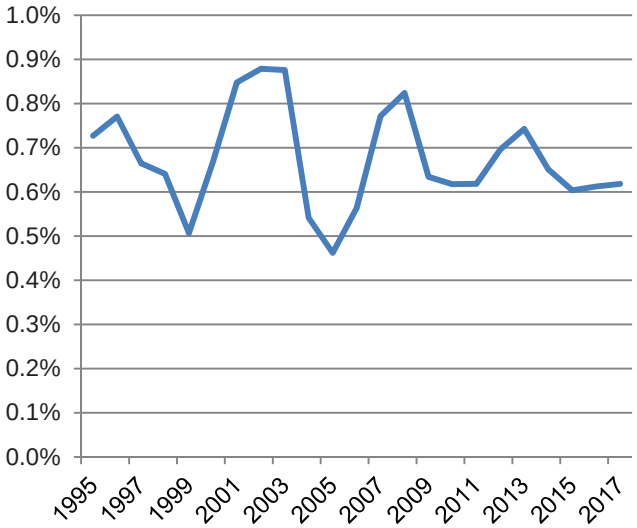
4. The increase in VKT and development of infrastructure

the relatively low motorization rate that was (and apparently still is) typical of Israel, the development of the relative price of travel by private vehicle, the rapid growth rate of the population and of employment, and the fact that many residents have chosen to live farther from places of employment, have all led to rapid growth in the use of road infrastructure for private vehicle travel in recent years. In the past two decades, the number of vehicles on the road has increased by 4.2 percent per year, and VKT has increased by 4 percent. The growth rates in the past decade were higher than in the preceding decade. These growth rates are higher than in advanced economies, and necessitate massive investment in infrastructure—whether in public transit infrastructure that is intended to slow the growth rate of private VKT, or whether in road infrastructure—so that the ratio between the infrastructure level and the volume of its use doesn't decline to the point of very low road travel efficiency.

Average annual investment in roads was about 0.7 percent of GDP throughout the reviewed period, and despite some fluctuations, it remained relatively stable over the years (Figure 8). Figure 9 shows private VKT relative to road stock (economic value), and Figure 10 shows private VKT relative to paved road area in Israel. The figures show that investment at this volume is not sufficient to maintain a stable ratio between VKT and road stock or paved road area.

Until 2004, there was a decline in the ratio between VKT and road stock, and the ratio between VKT and paved road area remained stable. However, beginning in 2005, there has been a marked upward trend in both ratios, and the increase in the road stock and in paved road area is not keeping up with the growth in private VKT. The difference in the development of the two indices

Figure 8
Investment in Roads, 1995–2017
(percent of GDP)



SOURCE: Bank of Israel calculatons based on Central Bureau of Statistics data.

30 The tax benefit depends on the volume of travel for personal needs, and we can therefore not determine the extent to which it was completely cancelled or even whether it became a burden for those with company-provided cars used for work purposes.

31 Not including new vehicles purchased for private leasing purposes.

32 In long-term equilibrium, an increase in VKT of those receiving the leasing arrangement will increase the price they must pay for it. However, the volume of VKT will be higher than the volume at equilibrium at which individuals pay for their expenses.

shows that over time, the capital required to expand the road network in Israel increases. One explanation for this is that as population density increases, land becomes more expensive and it becomes more necessary to build relatively expensive infrastructure, including interchanges, tunnels and bridges. A second explanation is that beginning in 2002, the cost of inputs for paving roads increased sharply—close to 60 percent in CPI terms, and more than 35 percent in wage terms—mainly because raw materials became more expensive.

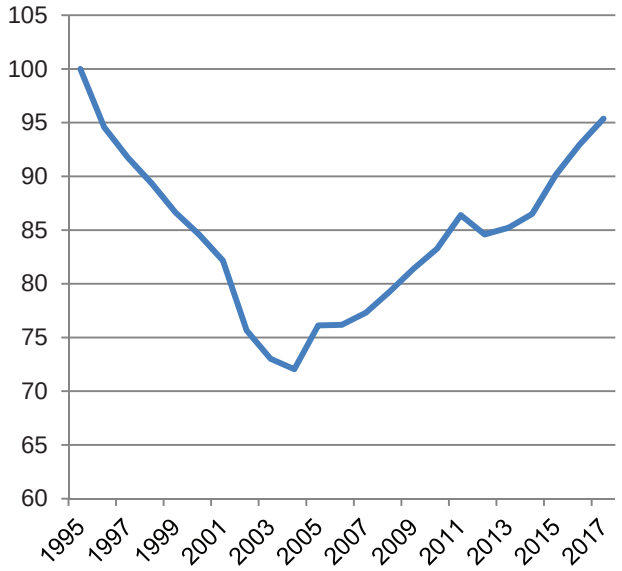
5. Conclusion

Since economic forces are acting to increase demand for private vehicle travel, and since increasing the supply of roads accordingly involves significant cost, a policy must be adopted to lower the increase in demand. However, Israel has not adopted an active policy in this direction, and the taxation measures that it has implemented in the past decade have actually contributed to an increase in demand for private vehicles and for private vehicle travel. Such measures have included a tax reduction for new vehicles—the effective purchase tax declined from 80–85 percent in the first half of the previous decade to about 60 percent currently—and relative stability in the taxation of fuel following the protest over the increase in fuel excise in 2011.

Despite the increase in demand and government policy's contribution to it, investment in road infrastructure as a share of GDP remained stable, and is not sufficient to guarantee that road congestion will not increase beyond the level where travel efficiency declines significantly.

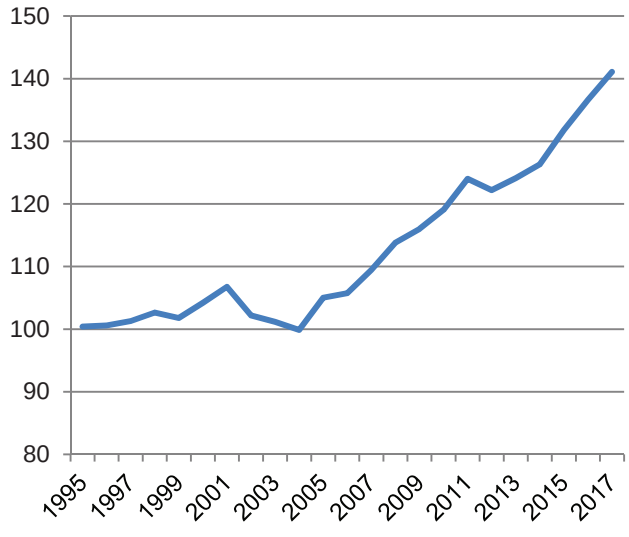
Empirical experience shows that there is a nonlinear decline in road efficiency—in terms of travel speed or in terms of the number of vehicles passing a specific point during a given unit of time—when congestion passes a certain

Figure 9
The Ratio of Private Vehicle Kilometers Traveled to Stock of Road Capital, 1995–2017
(index: 1995=100)



SOURCE: Bank of Israel calculatons based on Central Bureau of Statistics data.

Figure 10
Development of the Ratio of Private Vehicle Kilometers Traveled and Paved Road Area, 1995–2017



SOURCE: Bank of Israel calculatons based on Central Bureau of Statistics data.

level. The decline in efficiency leads to a worsening impact on all road users, and in order to prevent an inefficient equilibrium as much as possible, policy must be changed. The new policy must include a combination of incentives to slow the growth rate of private vehicle travel—making such travel more expensive and lowering the cost (primarily in terms of time) of traveling by public transit—and matching the growth rate of supply with the growth rate of demand. The more significant the policy is to reduce the demand for private vehicle travel, the less necessary it will be to increase the budget for investment in road infrastructure.

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