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Can the Laffer curve become a policy tool for reducing tax evasion? Stratification of property tax collection by land use

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Research Article

Can the Laffer curve become a policy tool for reducing tax evasion? Stratification of property tax collection by land use☆

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ABSTRACT

We construct Laffer curves to evaluate the efficiency of local property tax collection based on a micro-level panel dataset referring to 2013–2016 and obtained from the Jerusalem municipality. Unlike previous literature, we apply a tractable ad hoc methodology, which, compared with the conventional approach, might prove to be more useful to practitioners and policy makers. Results indicate the efficiency of a tax policy designed to increase tax rates for on-sample taxpayers. According to one estimate, to preserve the same collected sum of payments as before, for the entire sample, the minimal anticipated required raise is 4.17% per annum.

1. Introduction

The Laffer curve is a hump-shaped curve describing the relationship between accumulated tax revenues and tax rates. While the idea that people respond to increasing tax rates by tax avoidance (e.g., diminishing consumption) or tax evasion (e.g., encouraging smuggling) is quite familiar to economists,[1] the more controversial claim of Laffer is that the current tax rate is greater than the optimal tax rate, which maximizes revenues (Fullerton, The New Palgrave Dictionary of Economics, 2008).[2]

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[1] A nice example of tax avoidance is given in Fischel, 1992. Given that in the rural town of Orford, New Hampshire, constructing a barn increases property tax charge, the local farmers used Scottish Highland cattle breed, which do not have to be kept in a barn during winter. The author states that: "The deadweight loss of the property tax is hairy cattle." (page 171). In addition, there is a vast empirical and experimental literature on tax evasion and tax auditing. For reviews of the literature see Andreoni, Erard and Feinstein, (1998); and Kirchler, 2007. Two subsequent examples are: Kastlunger et al., 2009; Rees-Jones, 2018.

[2] The origin of the term "Laffer curve" is Wanniski, 1978. As Laffer, 2004 notes: "As recounted by Wanniski (associate editor of The Wall Street Journal at the time), in December 1974, he had dinner with me (then professor at the University of Chicago), Donald Rumsfeld (Chief of Staff to President Gerald Ford), and Dick Cheney (Rumsfeld's deputy and my former classmate at Yale) at the Two Continents Restaurant at the Washington Hotel in Washington, D.C. While discussing President Ford's "WIN" (Whip Inflation Now) proposal for tax increases, I supposedly grabbed my napkin and a pen and sketched a curve on the napkin illustrating the trade-off between tax rates and tax revenues. Wanniski named the trade-off "The Laffer Curve."

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Table 1
Distribution and Anticipated and Actual Local Tax Collection 2013–2016 Stratified by Land Use.

VARIABLES	Frequency	%	Actual Payment ($)	%	Total Net Tax Charge ($)	%
OWNER_OCCUPIER (RESIDENCE)	54,064	61.41%	160,842,636.35	61.18%	215,427,626.60	60.45%
RENTERS (RESIDENCE)	29,963	34.03%	45,453,285.80	17.29%	72,575,524.50	20.36%
OFFICES_BELOW_150	2838	3.22%	20,813,306.12	7.92%	24,279,588.04	6.81%
OFFICES_ABOVE_150	410	0.47%	20,662,129.95	7.86%	24,154,888.80	6.78%
WORKSHOP_GARAGES	317	0.36%	3,292,817.00	1.25%	3,746,709.75	1.05%
INDUSTRY	123	0.14%	3,156,841.35	1.20%	3,811,334.55	1.07%
HOTELS	26	0.03%	3,036,127.36	1.15%	4,165,223.68	1.17%
INSTITUTIONS	202	0.23%	2,157,560.72	0.82%	3,642,860.16	1.02%
PARKING_LOTS	11	0.01%	1,645,250.03	0.63%	2,319,727.10	0.65%
BOWLING_GYMS	21	0.02%	575,923.68	0.22%	754,467.36	0.21%
GOVERNMENT	7	0.01%	485,923.69	0.18%	498,987.58	0.14%
CINEMA_THEATERS	9	0.01%	228,579.79	0.09%	289,798.49	0.08%
INSURANCE	8	0.01%	181,924.60	0.07%	191,455.20	0.05%
OCCUPIED_LAND	21	0.02%	129,974.88	0.05%	175,503.86	0.05%
BANQUETTE_HALLS	2	0.00%	117,694.92	0.04%	198,528.98	0.06%
BANKS	3	0.00%	78,492.70	0.03%	81,341.45	0.02%
DANCE_CLUBS	1	0.00%	19,858.58	0.01%	20,145.13	0.01%
ATAROT_WAREHOUSES	1	0.00%	10,500.00	0.00%	27,833.88	0.01%
ARTIST_STUDIOS	10	0.01%	8875.00	0.00%	14,936.73	0.00%
FREE_PARKING	1	0.00%	387.01	0.00%	390.92	0.00%
Observations	88,033	100.00%	262,898,089.53	100.00%	356,376,872.76	100%

Notes: The budget is originally collected in NIS (the local Israeli currency). All the figures are converted to US Dollars, where 1 NIS roughly equals $0.25. The sum in US Dollars for each land use is calculated as the product between the number of observations and the sample mean. Land uses are sorted in descending order based on the respective share of revenues from each of them.

Empirical researchers have attempted to estimate this optimal income tax rate by developing two prominent empirical methodologies. The earlier methodology was based on simple models of leisure and home production (Stuart, 1981) and estimates or assumptions made concerning labor supply and demand elasticities (e.g., Fullerton, 1982). The latter approach used tax reforms as natural experiments by observing the response of individuals to these tax reforms. A common measure employed in these studies, e, is defined as the elasticity of taxable income with respect to a change in the marginal net of tax share ($(1-t)$, where t is the marginal tax rate). If the economy had only a single tax rate, the revenue maximizing tax rate is simply $t^* = \frac{1}{1+e}$ (Fullerton, The New Palgrave Dictionary of Economics, 2008).

Feldstein, 1995 examines the fall of the highest marginal tax bracket (from 50 percent to 28 percent), and high and middle marginal tax brackets following the 1986 Tax reform Act in United States based on panel data of 3792 individuals (see Table 1, page 561). He calculated e for each marginal tax bracket, and found that $e = 1.04 - 1.45$, if we offset partnership tax losses (see Table 2, page 565). This implies $t^* = 40.82\% - 49.0\%$. Gruber and Saez (2002) used a 1979–1990 panel of tax returns to analyze *all* state and Federal tax reforms during the 80 s, and found that $e = 0.4$, which implies $t^* = 71.43\%$. This estimate is similar to those obtained by the earlier methodology, and seems to be consistent with Fullerton's view for an over-simplified world (Fullerton, 2008).[3]

Another strand of the literature is the attempt to estimate the VAT Laffer curve. Oliviera, Francisca and Costa (2015) examine a panel data of 27 European states in 1995 and 2000–2011. By using regression analysis, and a time variable (equals 1 in 1995, and 6–12 for 2000–2011), the authors distinguished between periods of economic recession and expansion, and demonstrated that the optimal VAT decreased from 25.0% in expansion periods (1995) to 22.0% in expansion periods (2011). The equivalent figures in recession periods are 23.50% (1995) and 21.50% (2011).

Very few studies examined the efficiency of tax collection at the municipal level. Based on a time series of aggregated data, Haughwout, Inman, Craig, Steven and Luce (2004) constructed Laffer curves for four U.S. cities (Houston, Minneapolis, New York and Philadelphia). Yet, unlike micro-level panel data, the use of aggregated data is associated with information-loss and might be subject to aggregation bias.[4] Moreover, this approach might prove to be less useful to practitioners and policy makers in the municipal level who, rather than tax charge, are more interested in actual tax collection.

We propose and apply a different methodology to estimate the Laffer curve. The two key variables in our analysis are the actual tax collection, which is the main interest of local municipalities, compared with the actual tax charge. We thus construct Laffer Curves directly by estimating the elasticity of annual payment with respect to the annual local property tax charge for different land uses and across time. The parabolic shape of the curve permits this elasticity to vary with the level of tax charge.

We employ a unique panel dataset referring to 2013–2016 obtained from Jerusalem municipality. The dataset contains micro-level information of the land use, the annual local property tax charge and payment of each individual taxpayer, and the area of each asset measured in square meters. To avoid extraordinary cases of coverage of debt in arrears, we restrict the sample only to taxpayers,

[3] For a survey of a more recent literature, see, for example, Saez, Slemrod and Giertz (2012).
[4] For a discussion on the different estimates obtained in aggregated and micro level housing demand data see, for example, Mayo, 1981.

Table 2
Average Collection Rates for Different Land Uses 2013–2016.

VARIABLES	Frequency	%	$AVG\left[\frac{PAYMENT}{ARNONA}\right]$
OWNER_OCCUPIER(RESIDENCE)	54,064	61.41%	94.13%
RENTERS(RESIDENCE)	29,963	34.03%	85.25%
OFFICES_BELOW_150	2838	3.22%	86.52%
OFFICES_ABOVE_150	410	0.47%	86.94%
WORKSHOP_GARAGES	317	0.36%	90.61%
INDUSTRY	123	0.14%	82.80%
HOTELS	26	0.03%	76.80%
INSTITUTIONS	202	0.23%	85.02%
PARKING_LOTS	11	0.01%	72.32%
BOWLING_GYMS	21	0.02%	80.31%
GOVERNMENT	7	0.01%	96.14%
CINEMA_THEATERS	9	0.01%	85.83%
INSURANCE	8	0.01%	86.35%
OCCUPIED_LAND	21	0.02%	76.21%
BANQUETTE_HALLS	2	0.00%	60.08%
BANKS	3	0.00%	95.29%
DANCE_CLUBS	1	0.00%	98.58%
ATAROT_WAREHOUSES	1	0.00%	37.72%
ARTIST_STUDIOS	10	0.01%	75.23%
FREE_PARKING	1	0.00%	99.00%
Observations	88,033	100.00%	91.22%

Notes: The $\left[\frac{PAYMENT}{ARNONA}\right]$ is the collection rate namely payment-property-tax-charge ratio, which is calculated to each observation separately. The $AVG\left[\frac{PAYMENT}{ARNONA}\right]$ is the average across all observations with the same land use.

who paid between 0% to 100% of the annual property tax charge. The local property tax can be examined in three dimensions: temporally, cross sectional based on different land uses, and geographically (West vs. East Jerusalem). During 2013–2016, the Jerusalem municipality steadily increased the property tax rate by 0.46%-1.42% per annum. Our study thus permits the examination of the response of taxpayers to those increases, and provides efficiency evaluation of this policy.

The main contribution of the current study lies in the application of a tractable and direct methodology that may become a useful tool for municipal policy makers. This methodology enables planning for the future tax policy, as well as improving the efficiency of local property tax collection based on actual collection tax data. The proposed methodology requires only a limited number of variables, including annual tax charge, annual tax collection, area and land use of the asset. Unlike empirical studies at the macro level, the proposed model is not limited to a single tax rate, and can provide different predictions to each land use and asset based on empirical data.

Results indicate that on the one hand, for most taxpayers in land uses such as residence, office, hotel and parking lot, tax collection is expected to *rise* significantly following a 10% *increase* in local property tax. On the other hand, within the on-sample range, the elasticity of payment with respect to local property tax charge is quite low. For the entire sample, a 10% increase in after-discount (before-discount) tax charge is expected to yield only 3.625–5.768% (1.538- 3.064%.) increase in tax collection.[5] Nevertheless, these figures imply that raising the tax rate is efficient. For a $90 payment of a current after-discount net tax charge of $100, a 10% rise to $110 is associated with a minimum and maximum anticipated rise to $93.26 and $95.19, respectively.[6] Despite the drop in anticipated collection rates from 90% to 84.78–86.54%, the collected sum is nevertheless expected to rise.[7]

Moreover, additional outcomes obtained from direct estimation of payment-property tax charge elasticities show that on the one hand, if local property tax charge remains unchanged, collection rates are anticipated to drop by 3.37% per annum. On the other hand, if the municipality prefers to preserve the same collected sum of payments as before, for the entire sample, the minimal anticipated required raise is 4.17% per annum. Finally, within the on-sample range (between -5% and 10% variation in the net local property tax), the elasticity of payment-property tax charge is around 0.8. This implies that the projected increase in payment following a 10% increase in after-discount net local property tax charge is approximately 8%.

Referring to the geographical dimension of West vs. East Jerusalem, following a 10% increase of the net after-discount annual

[5] Discounts are given on the basis of economic and socio-demographic criteria. Given that Jerusalem is one of the poorest cities in Israel, many taxpayers, particularly in the residential sector, receive these discounts. From the taxpayer's perspective, the relevant tax charge is the net charge after discounts.

[6] As demonstrated in Table 2, the initial tax collection rate for all sectors is 91.22%

[7] The minimum rise is: $\$90 \cdot \left[1+\frac{3.625}{100}\right] = \$93.2624$ and the maximum rise is $\$90 \cdot \left[1+\frac{5.768}{100}\right] = \$95.1913$. The minimum and maximum collection rates are: $\frac{93.2624}{110} = 84.78\%$ and $\frac{95.1913}{110} = 86.54\%$, respectively. All the calculations are based on the assumption that the area of the asset remained unchanged during the sample period.

local property tax tariffs of $10, $15, $20 and $25 per square meter, payments of taxpayers in West (East) Jerusalem are expected to rise by 3.554%, 4.498%, 5.18% and 5.695% (5.761%, 6.48%, 6.847%, 7.027%). Consequently, compared with West Jerusalem, for a given tax tariff, raising the tax charge in East Jerusalem produces higher revenues.

Referring specifically to the residential land use, according to our calculations, this land use is expected to yield the highest revenues for the municipality (61.18% of the total anticipated collection for owner-occupiers and 17.29% of the total anticipated collection for renters). Results support those obtained in Arbel, Fialkoff and Kerner (2017), according to which compared with renters, the level of tax compliance is higher among owner-occupiers. Following a 10% increase of the after-discount net annual local property tax tariffs per square meter of $18, $20, $22 and $24, payments of owner-occupiers are expected to rise by 7.078%, 7.064%, 7.023% and 6.961%, and payments of renters are expected to increase by 6.504%, 6.491%, 6.446% and 6.375%.

Referring specifically to land use of offices below and above 150 m^2, according to our calculations, these land uses are expected to yield the second highest revenues after residential use for the municipality (7.92% and 7.86% of the total anticipated collection for offices below and above 150 m^2, respectively). Also, compared with residential land use, the after-discount net property tax tariffs of office land uses are much higher ($81-$84 compared with only $18-$24 per square meter). Results indicate that the efficiency associated with a rise in local property tax tariffs in the office sector is much higher among big offices. Following a 10% increase of the after-discount net annual local property tax tariffs of $83, $84, $85 and $86 per square meter, payments of big offices with area above 150 m^2 are expected to rise by 14.756%, 14.848%, 14.938% and 15.026%,[8] and payments of small offices with area below 150 m^2 are expected to increase by only 1.960%, 1.963%, 1.965% and 1.966%.[9]

The rest of this paper is organized as follows. Section 2 provides background for the municipal tax system in Jerusalem, Israel. Section 3 discusses the Laffer Curve in an aggregated level of all land uses. Section 4 stratifies the micro-level dataset based on different land uses, and constructs Laffer curves for selected land uses. Section 5 provides robustness tests by estimating directly the payment-local tax charge elasticity, while considering the actual increases and reductions in tax rate tariffs in 2013–2016. Finally, Section 6 concludes and summarizes.

2. Background: local property tax in Jerusalem

Jerusalem is Israel's capital and the country's largest city with a population of almost 865,000 persons at the end of 2015.[10] According to the Israeli Central Bureau of Statistics (CBS), stratification of population based on religion shows that the two major populations are Jews (61.4%) and Arab-Muslims (35.6%). These populations are economically segregated and also live in predominantly separate geographical locations, namely West and East Jerusalem (Alperovich & Deutsch, 1996). Until the Six Day War in 1967, East Jerusalem was part of Jordanian Kingdom. Since its annexation, the inhabitants of East Jerusalem were granted full municipal rights. Still, and as shown below, East Jerusalem suffers from relatively low municipal investment and relatively higher poverty rates.

Jerusalem is also one of the poorest cities in Israel. According to the Israeli CBS, on a scale of 0–10 with 10 being the highest rating, the socio-economic cluster of Jerusalem is only 3. The Israeli CBS performs a socio-economic-ranking of the 255 cities and towns in Israel based on factor analysis using a large number of variables. Among other objectives, one of the purposes for generating such an index is the provision of a criterion for the allocation of resources to these authorities. Yitzhaki et al. (2013) compare between the current ranking and that which would be obtained if the ranking based solely on the income variable. Given the availability of this variable and the anticipated high correlation with other socio-demographic variables, the comparison is important. The main finding of their study is that there is little difference in the ranking of municipal authorities between that based solely on mean per-capita income and that based on additional variables.

The two ranking criteria are the socio-economic cluster of the population (on a scale from 1 – the lowest, to 10 – the highest); and the relative socio-demographic location of each city (from 1 – the poorest to 255 – the wealthiest). The map in Appendix B describes the clusters of all geographical units in Israel.[11] Jerusalem is ranked in cluster 3 (a drop of one place from previous years); and the socio-demographic location is 61, which is below 194 of the 255 ranked cities, namely, the lowest quartile in terms of wealth.[12]

The high poverty rate in Jerusalem is reflected in the high percentage of households who received partial discounts or total waivers of their local residential property tax obligation for residential use. Appendix C presents the 2015 percentage of discount on local property tax in Jerusalem stratified by income levels. Discounts are determined based on the number of persons living in the dwelling unit, and the average monthly income during the last quarter of 2014. Descriptive statistics available upon request show

[8] Based on the collection rates from the office sector, for a $85 payment of a current after-discount net tax charge of $100, a 10% rise to $110 is associated with a minimum and maximum anticipated rise to $85•$\left[1+\frac{14.756}{100}\right]$=$97.5426 and $85•$\left[1+\frac{15.026}{100}\right]$=$97.7721, respectively. These figures imply an increase in collection rates from 85% to $\frac{97.5426}{110}$ = 88.675% – $\frac{97.7721}{110}$ = 88.8837%

[9] Based on the collection rates from the office sector, for a $85 payment of a current after-discount net tax charge of $100, a 10% rise to $110 is associated with a minimum and maximum anticipated rise to $85•$\left[1+\frac{1.960}{100}\right]$=$86.666 and $85•$\left[1+\frac{1.966}{100}\right]$=$86.6711, respectively. These figures imply a drop in collection rates from 85% to $\frac{86.666}{110}$ = 78.787% – $\frac{86.6711}{110}$ = 78.792%

[10] The map in Appendix A shows that Jerusalem is located in region 1.

[11] The map is available at: http://www.cbs.gov.il/hodaot2013n/24_13_087map.pdf

[12] We calculated the quartile as: $\frac{194}{255}$ = 76.08%

that of the total 83,751 residential taxpayers in the sample, 43,627 households (a majority of 52.09%) received a discount, which is equal to or above 4% (the minimum discount rate for the non-residential sector). The median and average discount rate for this group of 43,627 households is 46.56% and 50.11%, respectively.

Appendix D presents the annual local property residential tax tariffs per square meter in NIS in 2013 and 2017.[13] The three criteria to determine these tariffs are the building types, the geographic zone (A, B, C or D), and the unit's area in square meters. The appendix implies a 7.25%-7.31% increase in local tax charge per square meter during a period of five-years. This implies a $[(1 + 0.0725)^{0.2}-1]=1.41\%$ a $[(1 + 0.0731)^{0.2}-1]=1.42\%$ increase per annum.

Finally, Appendix E displays the annual local non-residential property tax tariffs per square. meter in NIS in 2013 and 2017. With the exception of offices, with a relatively high charge per square meter, the table indicates a 7.25%-7.31% increase, which is quite similar to the increase obtained in the residential sector. Unlike the residential sector, however, of the 3984 panels belonging to other sectors, the vast majority of 3885 panels (consisting of 97.52%) receive no discounts at all, and only 99 panels (consisting of 2.48%) receive discounts. The average discount given to these few panels is 57.89% and the minimum and maximum discounts are 4.11% and 67% respectively.

3. An aggregated Laffer curve

To estimate the coefficients of the Laffer curve, we propose and apply the following fixed-effect model:

$$Y_{i,t} = A_1 X_{i,t}^2 + B_1 X_{i,t} + C_1 + \mu_{1,i,t} \tag{1}$$

$$\mu_{1,i,t} = \alpha_{1,i} + \epsilon_{1,i,t} \tag{2}$$

Where i is the index for each panel (individual or asset); t is the time index (t = 2013, 2014, 2015, 2016); $Y_{i,t} = (PAYMENT_{i,t})$, the annual payment; $X_{i,t} = \left[\frac{ARNONA_{i,t}}{AREA_{i,t}}\right]$, where $ARNONA_{i,t}$ is the net annual local property tax charge for asset i at year t converted to US dollars (exchange rate of 1 NIS = \$0.25), [14] and $AREA_{i,t}$ is the area of asset i at year t measured in square meters (1 m^2 = 10.7639 square feet), A_1, B_1, C_1 are parameters, $\alpha_{1,i}$ reflects a row vector of parameters (one parameter for each panel), and $\mu_{1,i,t}$ and $\epsilon_{1,i,t}$ are the random disturbance terms. The parabolic model defined by Eq. (1) enables us to calculate the maximal point ($-\frac{B_1}{2A_1}$), and the elasticity of $Y_{i,t}$ with respect to $X_{i,t}$ $\left(E_{i,t} = \frac{2A_1X_{i,t}^2 + B_1X_{i,t}}{A_1X_{i,t}^2 + B_1X_{i,t} + C_1}\right)$

Referring to Eq. (2), if the fixed-effect model holds, each individual or asset i has a different $\alpha_{1,i}$. If these differences across panels exist, but are ignored, then the estimation results may be biased and inconsistent (see, for example, Johnston and Dinardo, 1997: 395–396; Greene, 2012: 399–402).[15] Consequently, we ran two statistical tests to support the fixed-effect model: 1) F-test for the null hypothesis of equal coefficients across all panels. 2) The Wu-Hausman procedure, which tests the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (e.g., Johnston and Dinardo, 1997: 403–404. Greene, 2012: 419–421).

Fig. 1 displays the 2013–2016 aggregated Laffer curve of all land uses at the top of the figure, and the horizontal box-plot after omission of outliers at the bottom of the figure. The horizontal axis of the Laffer curve and the box-plot is the ARNONA (annual net local property tax charge) divided by the area, which is measured in square meters. The vertical axis of the Laffer curve is the projected 2013–2016 annual payment. For the sake of simplicity, we omitted the indices i and t from the variables.

Results indicate that the maximum projected payment of \$15,499.19 is expected to be collected for a property tax charge of \$722.06 per square meter.[16] However, as the figure demonstrates, the local property tax between \$340 and \$1380 per square meter is off-sample, and for 95% of the full population, the property tax charge is below or equals to \$26.39 per square meter.[17] The charges

[13] NIS is the local Israeli currency, where the conversion rate is 1 NIS roughly equals \$0.25. Referring to the units' area, the conversion rate for square meters is: 1 m^2 roughly equals 10.8 square feet.

[14] *ARNONA* is the Hebrew terminology for local property tax charge. To reflect the taxpayer's perspective, we took the tax charge after discounts. Note, however, that the municipality has tighter control on the before discount tax charge and a limited control on discount rates, which are based on economic and socio-demographic criteria. Consequently, we ran robustness tests based on the before-discount tax charge.

[15] Johnston and Dinardo, 1997 stress the importance of panel data estimation in econometrics. According to the authors: "Instead panel data estimation has grown in popularity because it has held out the promise of reducing a grave problem faced by most researchers: the lack of an adequate list of independent variables to explain the dependent variable" (page 395).

[16] As a robustness test, we estimated the model based on the before-discount local property tax charge per square meter. Results indicate that The maximum projected payment of \$7641.98 is obtained for the property tax charge of $\frac{18.43}{2 \cdot 0.0128} = \$720.92$ per square meter.

[17] The average data for these 83,511 panels are:

Panels	Years	Proj(PAYMENT)	PAYMENT	ARNONA/AREA
83,511	2013–2016	\$1264.77	\$1101.15	\$13.76

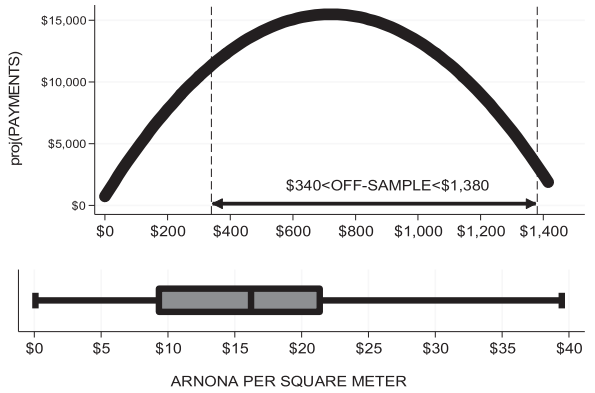


Fig. 1. 2013–2016 Laffer curve of the local property tax in Jerusalem for all land uses. Notes: The upper figure displays the 2013–2016 Laffer Curve of the local property tax in Jerusalem for all land uses (with the exception of municipal assets) and for individuals who paid between 0% to 100% of the annual local property tax charge. The horizontal axis is the ARNONA (net local property tax charge) divided by the area, which is measured in square meters (1 m^2 = 10.7639 square feet). The vertical axis is the projected 2013–2016 annual payment. The lower figure displays the horizontal box plot of Arnona per square meter after omission of outliers. All charges and payments are originally measured in NIS (the local Israeli currency) and translated to US dollars (exchange rate of 1 NIS = 4 US Dollars). The figure is based on the following fixed effect regression outcomes for 87,711 panels (numbers in parentheses are standard errors, and all the coefficients are statistically significant at the 1% significance level): $proj(PAYMENT) = -2.84 \cdot 10^{-2}\left[\frac{ARNONA}{AREA}\right]^2 + 40.97\left[\frac{ARNONA}{AREA}\right] + 707.73.$
$(0.10 \cdot 10^{-2})$ (1.10) (18.06).
The maximum projected payment of \$15,499.19 is obtained for the property tax charge of $\frac{40.97}{2 \cdot 0.0284} = \$722.06$ per square meter.The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(87710, 103752) = 23.93). This outcome supports the fixed-effect model. The Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(2) = 908.58). The elasticity of the equation $Y = A_1X^2 + B_1X + C_1$ where $Y = proj(PAYMENT)$ and $X = \left[\frac{ARNONA}{AREA}\right]$ is given by the formula: $E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$. The following table provides the elasticities for 95% of the full population of 196,915 observations (87,711 panels), who paid a local property tax below or equal to \$26.39 per square meter, and for the highest local property tax charge per square meter.

$X = \left[\frac{ARNONA}{AREA}\right]$	\$10.00	\$15.00	\$20.00	\$25.00	\$1,400
$E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$	0.3625	0.4573	0.5256	0.5768	-21.8890

.

of only one office exceeds \$1386 per square meter.[18] These outcomes imply that, on the one hand, for most of the population, the policy of raising the local property tax each year is efficient. On the other hand, there is a clear tendency to avoid local property tax payments. For households, businesses or institutions whose after-discount charge is \$10, \$15, \$20 and \$25 per square meter, a 10% increase in the local property tax charge per square meter is expected to raise the projected payments by only 3.625%, 4.573%, 5.256% and 5.768%.[19] Still, for a \$90 payment of a current tax charge of \$100, a 10% rise to \$110 is associated with a minimum and maximum anticipated rise to \$91.38 and \$92.76, respectively. In spite of the fact that anticipated collection rates dropped from 90% to 84.78–86.54%, the collected sum is nevertheless expected to rise.[20]

Referring to the highest end of the most expensive local property tax per square meter, for the highest charge of \$1400 per square meter, a 10% *increase* is associated with 218.89% *drop* in the projected payment. Note, however, that the projected payment for the

[18] The full data of this panel are:

Panels	Year	Proj(PAYMENT)	PAYMENT	ARNONA/AREA	AREA	ARNONA_NET
1	2015	\$1873.16	\$16,857.93	\$1415.09	12.0	\$16,981.08
1	2016	\$2961.67	\$17,024.80	\$1386.84	12.4	\$17,196.84

[19] As a robustness test, we estimated the model based on the before-discount local property tax charge per square meter. Results indicate that for households, businesses or institutions, whose after-discount charge is \$10, \$15, \$20 and \$25 per square meter, a 10% increase in the local property tax charge per square meter is expected to raise the projected payments by only 1.538%, 2.127%, 2.63% and 3.064%.

[20] The minimum rise is: $\$90 \cdot \left[1 + \frac{3.625}{100}\right] = \$93.2624$ and the maximum rise is $\$90 \cdot \left[1 + \frac{5.768}{100}\right] = \$95.1913$. The minimum and maximum collection rates are: $\frac{93.2624}{110} = 84.78\%$ and $\frac{95.1913}{110} = 86.54\%$, respectively. All the calculations are based on the assumption that the area of the asset remained unchanged during the sample period.

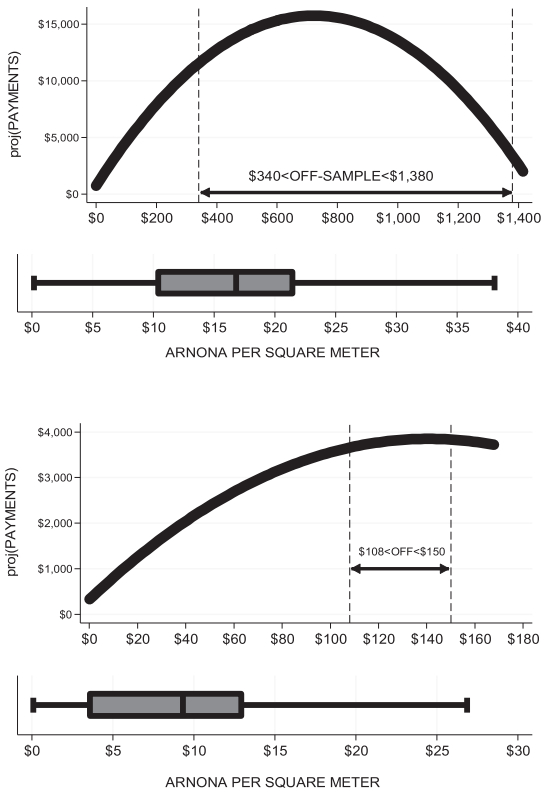


Fig. 2. Laffer curves of the local property tax for west vs. east Jerusalem. Notes: The upper (lower) figure refers to 76,713 (11,000) taxpayers in West (East) Jerusalem. The elasticities of payment with respect to local tax per square meter are given in the following table:

ARNONA	$10.00	$15.00	$20.00	$25.00	$180
Elasticity West	0.3554	0.4498	0.5180	0.5695	0.7707
Elasticity East	0.5761	0.6480	0.6847	0.7027	-0.6988

.

$1386.84–1415.09 charge for square meter equals $1873.16–2961.67, which is much lower than the actual payment of $16,857.93-$17,024.80. This projection obeys the law of regression toward the mean (e.g., Liberman and Tversky, 1996).[21] Yet, the projection provides a good approximation only for large number of panels. Consequently, a projection based on an outlier of one panel might not be reliable.[22]

Fig. 2 stratifies the Laffer curve geographically between West and East Jerusalem. As noted in Section 3, the two major populations are Jews (61.4%), and Arab-Muslims (35.6%). These populations are economically segregated and also live in predominantly separate geographical locations, namely West and East Jerusalem (Alperovich & Deutsch, 1996).

Indeed, the outcomes reported in Fig. 2 reflect these differences in tax charges. For 75% of the full population of 170,407 (21,058) households, businesses or institutions in West (East) Jerusalem, the property tax charge is below or equals to $21.65 ($15.11) per square meter. Compared with West Jerusalem, the average property tax charge per square meter is lower significantly by $6.08 at the 1% significance level. For the upper decile of property tax charge above $ 80 per square meter, compared with West Jerusalem, the average property tax charge per square meter is lower significantly by $3.41 at the 1% significance level. Finally, while the maximum property tax charge and annual payment in West Jerusalem in 2015–2016 is $1,386.84-$1,415.09 per square meter, the equivalent

[21] According to the law, the projection is expected to become higher (lower) than the actual payment for values of the independent variable, which are above (below) the sample mean.

[22] In this context, Liberman and Tversky (1996), and Kahneman (2002) pointed out that for a large number of observations sharing the same value of the independent variables, projected values (generated after removal of random components) provide better approximations of the dependent variable than the information they rely on. As Kahneman, 2002 notes: “As I understood clearly only when I taught statistics some years later, the idea that predictions should be less extreme than the information on which they are based is deeply counterintuitive.”(Kahneman, 2002 – Biographical: The Military Experience, the end of the second paragraph, at:
http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2002/kahneman-bio.html)

figures in East Jerusalem are only $107.28-$162.91.

Referring to the Laffer curve, while in West Jerusalem the local property tax tariff that yields the highest payment is $723.13, in East Jerusalem the equivalent figure is $140.89. The projected maximal payments are $15,746.03 in West Jerusalem and only $3,850.66 in East Jerusalem. For property tax charge of $10, $15, $20 and $25 the elasticity of average payment with respect to average after-discount net charge per square meter increases from 0.3554 to 0.5695 in West Jerusalem and from 0.5761 to 0.7027 in East Jerusalem. This implies an increasing tax collection rate with property tax charge per square meter in West (East) Jerusalem. Yet, for a 10% rise in local property tax charge per square meter, the maximum anticipated rise in payment is only 5.695% in West Jerusalem and 7.027% in East Jerusalem.

4. The Laffer curve: stratification based on land use

Table 2 displays the distribution of anticipated and actual tax collection, namely, the local property tax charge and the actual payment, stratified by land use and based on our panel dataset from 2013–2016. The budget is collected in NIS (the local Israeli currency). All the figures are converted to US dollars, where 1 NIS roughly equals $0.25. The sum in US dollars for each land use is calculated as the product between the number of observations and the sample mean. Land uses are sorted in descending order based on the respective share of revenues from each of them.

Referring to the different land uses, the municipality produces the highest total revenues from the residential land use. According to our calculation in Tables 2, 78.47% of the revenues are produced from this use. This share is stratified to $160,842,636.35 ($45,453,285.80) originating from owner-occupiers (renters), and consisting of 61.18% (17.29%) of the total actual payments. Note, that unlike the United States, under the Israeli law, the local property tax charge is based on occupancy rather than ownership (e.g., Arbel et al., 2017). Consequently, in the normal state of events, municipal property tax charge is registered and paid directly by the Israeli renters and owner-occupiers.[23]

Other land uses, which yield the highest revenues in descending order, include: office below and above 150 m^2 (7.92% and 7.86%); workshop and garage (1.25%); industry (1.20%); hotel (1.15%); public institution (0.82%); parking lot (0.63%); and government office (0.18%). The next step would thus be to construct estimated Laffer curves based on different land uses. Obviously, the projections obtained would become more reliable for large number of panels in sectors, such as, owner-occupiers (54,064 panels); renters (29,963 panels); office below and above 150 m^2 (2,838 and 410 panels, respectively); workshop and garage (317 panels); industry (123 panels); hotel (26 panels); and public institution (202 panels).

Table 2 displays the average collection rates for different land uses in 2013–2016. The $\left[\frac{PAYMENT}{ARNONA}\right]$ represents the current collection rate namely payment-property-tax-charge ratio, which is calculated for each observation separately. The $AVG\left[\frac{PAYMENT}{ARNONA}\right]$ is the average collection rate across all observations with the same land use. According to the table, collection rates are 37.72%-99.00%, where the lowest (highest) collection rate is obtained in.

Fig. 3 displays the estimated Laffer curve for owner-occupiers of dwelling units, who paid between 0% to 100% of the local property tax charge. Given our intent to avoid cases of arrears in debt payments, we excluded households who paid more than 100%. The upper figure is based on the fixed effect regression outcomes for 54,064 panels. Two tests support the fixed-effect model. The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(54,063, 73,355) = 33.84). Also, the results of the Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(2) = 3893.88).

Results indicate that the maximum projected payment of $3328.27 is obtained for the after-discount property tax charge of $\frac{76.14}{2 \cdot 0.48} = \$79.98$ per square meter, and the effective range of positive projections of payments is obtained for the after-discount local property tax charge of between $0 and $163.58 per square meter.[24] Based on the lower figure of the box-plot, excluding the small group of outliers, the on-sample panel is within this range of positive projections of payments, namely up to $33. Finally, note that the corresponding elasticities for $18.00, $20.00, $22.00 and $24.00 after-discount tax charge per square meter are: 0.7078, 0.7064, 0.7023 and 0.6961. Elasticities, which are lower than 1 imply that for 10% rise in the charge per square meter the payment is expected to rise by less than 10%, namely by 7.078%, 7.064%, 7.023% and 6.961%, respectively.[25]

Fig. 4 displays the estimated Laffer curve for renters of dwelling units, who paid between 0% to 100% of the local property tax charge. As noted, under Israeli law, local tax is paid on the basis of occupancy rather than ownership. Given our interest in filtering cases of arrears in debt payments, we excluded households who paid more than 100%. The upper figure is based on the fixed effect regression outcomes for 29,963 panels. Two tests support the fixed-effect model. The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(29,962, 25,625) = 6.99). Also, the Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(2) = 571.04).

[23] American renters, for example, never see a tax bill and simply assume that they don't pay local property taxes – a phenomenon called "renter illusion" (see, for example, Banzhaf & Wallace, 2013; Brunner, Ross, Stephen, Becky & Simonsen, 2015).

[24] The maximum projected payment of $3286.58 is obtained for the before-discount property tax charge of $\frac{102.87}{2 \cdot 0.72} = \$71.47$ per square meter.

[25] Note that the corresponding elasticities for $20.00 and $24.00 before-discount tax charge per square meter are: 1.0736 and 0.9849, respectively. These higher estimates are plausible given that 1% rise in the after-discount tax charge is higher than 1% increase in the before-discount tax charge.

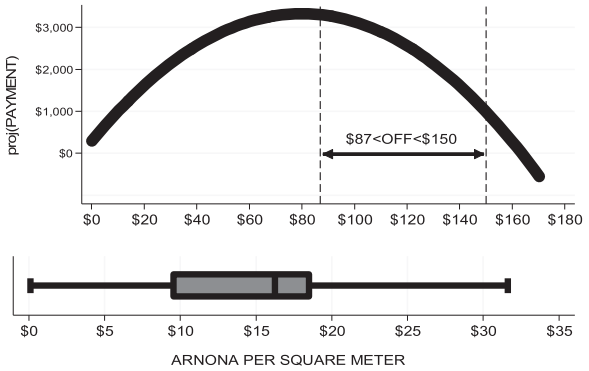


Fig. 3. Laffer curve of the local property tax in Jerusalem for owner-occupiers of dwelling units. Notes: The upper figure displays the 2013-2016 Laffer curve of the local property tax in Jerusalem for owner-occupiers who paid between 0% to 100% of the annual local property tax charge. The horizontal axis is the ARNONA (net local property tax charge) divided by the area, which is measured in square meters (1 square meter = 10.7639 square feet). The vertical axis is the projected 2013-2016 annual payment. The lower figure displays the horizontal box plot of Arnona per square meter after omission of outliers. All charges and payments are originally measured in NIS (the local Israeli currency) and translated to US dollars (exchange rate of 1 NIS = 4 US Dollars).

The figure is based on the following fixed effect regression outcomes for 54,064 panels (numbers in parentheses are standard errors, and all the coefficients are statistically significant at the 1% significance level): $proj(PAYMENT) = -0.48\left[\frac{ARNONA}{AREA}\right]^2 + 76.14\left[\frac{ARNONA}{AREA}\right] + 284.22.$
(0.01)(0.57)(6.45).

The maximum projected payment of $3328.27 is obtained for the property tax charge of $\frac{76.14}{2 \cdot 0.48} = \$79.98$ per square meter. The effective range of positive projections is (-3.65, 0) and (163.58, 0). The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(54,063, 73,355) = 33.84). This outcome supports the fixed-effect model. The Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(2) = 3893.88). The elasticity of the equation $Y = A_1X^2 + B_1X + C_1$ where $Y = proj(PAYMENT)$ and $X = \left[\frac{ARNONA}{AREA}\right]$ is given by the formula: $E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$. The following table provides the elasticities for 95% of the full population of 127,421 observations (54,064 panels), who paid a local property tax below $24 per square meter, and for the highest local property tax charge per square meter.

$X = \left[\frac{ARNONA}{AREA}\right]$	$18.00	$20.00	$22.00	$24.00	$140
$E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$	0.7078	0.7064	0.7023	0.6961	-4.963

.

Results indicate that the maximum projected payment of $1992.99 is obtained for the after-discount property tax charge of $\frac{49.73}{2 \cdot 0.35} = \$70.35$ per square meter, and the effective range of positive projections of payments is obtained for after-discount local property tax charge of between $0 and $145.44 per square meter.[26] Based on the lower figure of the box-plot, excluding the small group of outliers, the on-sample panel is within this range of positive projections of payments, namely below $33. Finally, the corresponding elasticities for $18.00, $20.00, $22.00 and $24.00 after-discount tax charge per square meter are: 0.6504, 0.6491, 0.6446 and 0.6375.[27] Note, that compared with owner-occupiers, a 10% increase in the same after-discount local property tax charge for renters is expected to yield an average lower rise in payments of 6.454% (compared with 7.0315% for owner-occupiers). These outcomes are also in-line with the lowest collection rates from renters of 85.25% compared with 94.13% from owner-occupiers (see, for example, Table 2, and Arbel et al., 2017).

Figs. 5 and 6 display the estimated Laffer curve for individuals in the office sector, who paid between 0% to 100% of the local property tax charge. Fig. 4 refers to the small office sector below 150 m^2 and Fig. 5 covers the big office sector above 150 m^2. As discussed above, we excluded offices who paid more than 100%. The upper figures are based on the fixed effect regression outcomes for 2838 panels (small offices) and 410 panels (big offices). Two tests support the fixed-effect model. The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(2837, 3039) = 18.22 for small offices and F(409, 492) = 34.38 for big offices). Also, the Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic only for small offices (chi2(2) = 5.17 for small offices and chi2(1) = 2.22 and p-value = 13.65% for big offices).

Results indicate that for the sector of small offices the maximum projected payment of $4068 is obtained for the after-discount property tax charge of $\frac{14.35}{2 \cdot 0.36} = \$201.25$ per square meter, and the effective range of positive projections of payments is obtained for after-discount local property tax charge of between $0 and $539.05 per square meter. As for the sector of big offices, the graph

[26] the maximum projected payment of $1658.57 is obtained for the before-discount property tax charge of $\frac{42.84}{2 \cdot 0.31} = \$70.06$ per square meter.

[27] Finally, the corresponding elasticities for $20.00 and $24.00 before-discount tax charge per square meter are: 0.6859 and 0.6691.

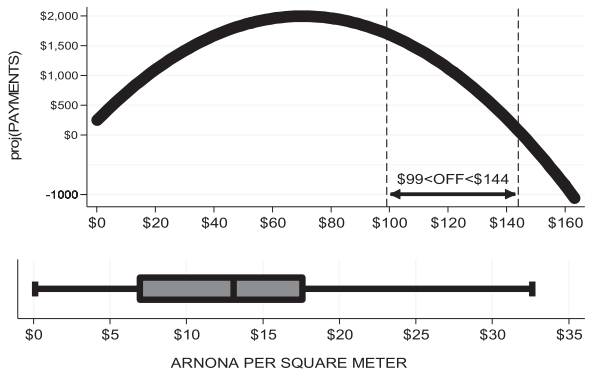


Fig. 4. Laffer Curve of the Local Property Tax in Jerusalem for Renters of Dwelling Units. Notes: The upper figure displays the 2013-2016 Laffer curve of the local property tax in Jerusalem for renters who paid between 0% to 100% of the annual local property tax charge. The horizontal axis is the ARNONA (net local property tax charge) divided by the area, which is measured in square meters (1 square meter = 10.7639 square feet). The vertical axis is the projected 2013-2016 annual payment. The lower figure displays the horizontal box plot of Arnona per square meter after omission of outliers. All charges and payments are originally measured in NIS (the local Israeli currency) and translated to US dollars (exchange rate of 1 NIS = 4 US Dollars).

The figure is based on the following fixed effect regression outcomes for 29,963 panels (numbers in parentheses are standard errors, and all the coefficients are statistically significant at the 1% significance level): $proj(PAYMENT) = -0.35\left[\frac{ARNONA}{AREA}\right]^2 + 49.73\left[\frac{ARNONA}{AREA}\right] + 243.55.$

(0.01)(1.07)(11.93).

The maximum projected payment of $1992.99 is obtained for the property tax charge of $\frac{49.73}{2 \cdot 0.35} = \$70.35$ per square meter. The effective range of positive projections is (-4.74, 0) and (145.44, 0). The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(29,962, 25,625) = 6.99). This outcome supports the fixed-effect model. The Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(2) = 571.04). The elasticity of the equation $Y = A_1X^2 + B_1X + C_1$ where $Y = proj(PAYMENT)$ and $X = \left[\frac{ARNONA}{AREA}\right]$ is given by the formula: $E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$. The following table provides the elasticities for 92% of the full population of 55,590 observations (29,963 panels), who paid a local property tax below or equal to $28 per square meter, and for the highest local property tax charge per square meter.

$X = \left[\frac{ARNONA}{AREA}\right]$	$18.00	$20.00	$22.00	$24.00	$140
$E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$	0.6504	0.6491	0.6446	0.6375	-24.7650

.

increases monotonically, and the maximum projected payment is obtained for the outlier of $180 after-discount net charge per square meter. Based on the lower figure of the box-plot, excluding the small group of outliers, the on-sample panel for both sectors is around after discount net tax tariffs of $80-$86 per square meter. Compared with the residential sector tariffs of $18-$24, these tariffs are very high. Finally, the corresponding elasticities for $83, $84, $85 and $86 after-discount tax charge per square meter are: 0.196, 0.1963, 0.1965 and 0.1966 for small office and .1.4756, 1.4848, 1.4938 and 1.5026 for big office land use categories.

The latter outcomes thus indicate that the efficiency associated with a rise in local property tax tariffs in the office sector is higher among big offices. Following a 10% increase of the after-discount net annual local property tax tariffs of $83, $84, $85 and $86 per square meter, payments of big offices with area above 150 m^2 are expected to rise by 14.756%, 14.848%, 14.938% and 15.026%,[28] and payments of small offices with area above 150 m^2 are expected to increase by only 1.960%, 1.963%, 1.965% and 1.966%.[29]

5. Robustness test: first difference

One of the drawbacks associated with the analysis so far is the fact that the estimation procedure does not account for increases or reductions in local property tax rates across time. To remedy this drawback, we propose and apply the following fixed-effect model, which permits direct estimation of the payment-charge elasticity:

[28] Based on the collection rates from the office sector, for a $85 payment of a current after-discount net tax charge of $100, a 10% rise to $110 is associated with a minimum and maximum anticipated rise to $85·$\left[1+\frac{14.756}{100}\right]$=$97.5426 and $85·$\left[1+\frac{15.026}{100}\right]$=$97.7721, respectively. These figures imply an increase in collection rates from 85% to $\frac{97.5426}{110} = 88.675\% - \frac{97.7721}{110} = 88.8837\%$

[29] Based on the collection rates from the office sector, for a $85 payment of a current after-discount net tax charge of $100, a 10% rise to $110 is associated with a minimum and maximum anticipated rise to $85•$\left[1+\frac{1.960}{100}\right]$=$86.666 and $85•$\left[1+\frac{1.966}{100}\right]$=$86.6711, respectively. These figures imply a drop in collection rates from 85% to $\frac{86.666}{110} = 78.787\% - \frac{86.6711}{110} = 78.792\%$

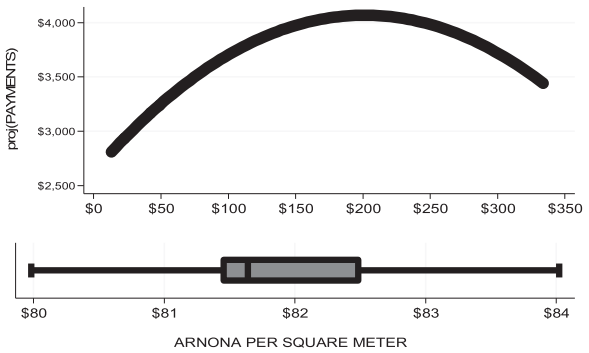


Fig. 5. Laffer curve of the local property tax in Jerusalem for small offices. Notes: The upper figure displays the 2013-2016 Laffer curve of the local property tax in Jerusalem for small offices below 150 square meters who paid between 0% to 100% of the annual local property tax charge and below $350 per square meter. The horizontal axis is the ARNONA (net local property tax charge) divided by the area, which is measured in square meters (1 square meter = 10.7639 square feet). The vertical axis is the projected 2013-2016 annual payment. The lower figure displays the horizontal box plot of Arnona per square meter after omission of outliers. All charges and payments are originally measured in NIS (the local Israeli currency) and translated to US dollars (exchange rate of 1 NIS = 4 US Dollars).

The figure is based on the following fixed-effect regression outcomes for 2,838 panels (numbers in parentheses are standard errors, and all the coefficients are statistically significant at the 5%-1% significance levels): $proj(PAYMENT) = -3.57 \cdot 10^{-2}\left[\frac{ARNONA}{AREA}\right]^2 + 14.35\left[\frac{ARNONA}{AREA}\right] + 2{,}624.77$. $(1.43 \cdot 10^{-2})(4.71)(294.54)$.

The maximum projected payment of $4068.98 is obtained for the property tax charge of $\frac{14.35}{2 \cdot 0.36} = \$201.25$ per square meter. The effective range of positive projections is (-136.55, 0) and (539.05, 0). The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(2837, 3039) = 18.22). This outcome supports the fixed-effect model. The Wu-Hausman test clearly rejects the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(2) = 5.17). The elasticity of the equation $Y = A_1X^2 + B_1X + C_1$ where $Y = proj(PAYMENT)$ and $X = \left[\frac{ARNONA}{AREA}\right]$ is given by the formula: $E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$. The following table provides the elasticities for 99.95% of the full population of 5879 observations (2838 panels), who paid a local property tax below or equal to $400 per square meter, and for the highest local property tax charge per square meter.

$X = \left[\frac{ARNONA}{AREA}\right]$	$83.00	$84.00	$85.00	$86.00	$390.00
$E = \frac{2A_1X^2 + B_1X}{A_1X^2 + B_1X + C_1}$	0.1960	0.1963	0.1965	0.1966	-1.8759

.

$$100 \cdot \Delta \ln(Y_{i,t}) = A_2[100 \cdot \Delta \ln(X_{i,t})]^2 + B_2[100 \cdot \Delta \ln(X_{i,t})] + C_2 + \mu_{2,i,t} \quad (3)$$

$$\mu_{2,i,t} = \alpha_{2,i} + \epsilon_{2,i,t} \quad (4)$$

Where i is the index for each panel (individual or asset); t is the time index (t = 2013, 2014, 2015, 2016); $Y_{i,t} = (PAYMENT_{i,t})$, the annual payment; $\Delta \ln(Y_{i,t})$ is payment differences between two subsequent years for each panel, which provides an approximation to the variation in percent across years; $X_{i,t} = \left[\frac{ARNONA_{i,t}}{AREA_{i,t}}\right]$, where $ARNONA_{i,t}$ is the net annual local property tax charge for asset i at year t converted to US dollars (exchange rate of 1 NIS = $0.25), [30] and $AREA_{i,t}$ is the area of asset i at year t measured in square meters (1 m^2 = 10.7639 square feet); $\Delta \ln(X_{i,t})$ is the net annual tax charge differences between two subsequent years for each panel, which provides an approximation to the variation in percent across years; A_2, B_2, C_2 are parameters, $\alpha_{2,i}$ reflects a row vector of parameters (one parameter for each panel), and $\mu_{2,i,t}$ and $\epsilon_{2,i,t}$ are the random disturbance terms. The parabolic model defined by Eq. (3) enables us to calculate the maximal point $(-\frac{B_2}{2A_2})$, and the elasticity of $Y_{i,t}$ with respect to $X_{i,t}$ $(\frac{\Delta \ln(Y_{i,t})}{\Delta \ln(X_{i,t})} = 2A_2\Delta \ln(X_{i,t}) + B_2)$

Fig. 7 displays the estimation outcomes of Eqs. (3) and (4) for all sectors. The upper figure is based on the projected values for $-5 < 100 \cdot \Delta ln\left[\frac{ARNONA}{AREA}\right] < 10$ obtained from the fixed-effect regression outcomes for 69,472 panels whose collection rates are between 0% to 100%. The null hypothesis that the coefficients of all panels are equal is clearly rejected (F(69,471, 47,561) = 1.03 and the p-value is 0.00%). This outcome supports the fixed-effect model.

An interesting outcome obtained from the estimation of Eqs. (3) and (4) is the intersection points with the vertical and horizontal axes. On the one hand, the point (0, -3.3723) implies that if the net after-discount tax charge remains unchanged over time, projected payments are expected to drop by 3.3723% per annum. On the other hand, the point (4.1775, 0) indicates that for a 4.1775% net after-discount tax charge increase, projected payments remained unchanged. Consequently, the empirical model predicts that in order to maintain the same level of payments, an average 4.1775% increase is required per annum. Note also that payment-charge elasticity is around 80%, which is higher than the estimates obtained in previous section.

[30] Recall that *ARNONA* is the Hebrew terminology for local property tax charge.

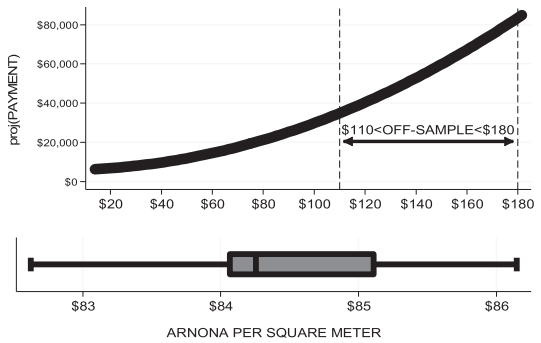


Fig. 6. Laffer Curve of the Local Property Tax in Jerusalem for Big Offices. Notes: The upper figure displays the 2013-2016 Laffer curve of the local property tax in Jerusalem for big offices above 150 square meters who paid between 0% to 100% of the annual local property tax charge. The horizontal axis is the ARNONA (net local property tax charge) divided by the area, which is measured in square meters (1 square meter = 10.7639 square feet). The vertical axis is the projected 2013-2016 annual payment. The lower figure displays the horizontal box plot of Arnona per square meter after omission of outliers. All charges and payments are originally measured in NIS (the local Israeli currency) and translated to US dollars (exchange rate of 1 NIS = 4 US Dollars).
The figure is based on the following fixed effect regression outcomes for 410 panels (numbers in parentheses are standard errors, and the coefficient of the explanatory variable is statistically significant at the 1% significance level): $proj(PAYMENT) = 2.40\left[\frac{ARNONA}{AREA}\right]^2 + 5{,}868.48$.
(0.68)(4,854.96).
The maximum projected payment of $83,525.42 is obtained for the property tax charge of $180 per square meter. The null hypothesis of equal coefficients for all panels is clearly rejected at the 1% significance level (F(409, 492) = 34.38). This outcome supports the fixed-effect model. The Wu-Hausman test supports the null hypothesis that the differences between the coefficients obtained via the fixed-effect and random-effect procedures are not systematic (chi2(1) = 2.22 and p-value = 13.65%). The elasticity of the equation $Y = A_1X^2 + C_1$ where $Y = proj(PAYMENT)$ and $X = \left[\frac{ARNONA}{AREA}\right]$ is given by the formula: $E = \frac{2A_1X^2}{A_1X^2 + C_1}$. The following table provides the elasticities for 99% of the full population of 903 observations (410 panels), who paid a local property tax below or equal to $86 per square meter, and for the highest local property tax charge per square meter.

$X = \left[\frac{ARNONA}{AREA}\right]$	$83.00	$84.00	$85.00	$86.00	$180
$E = \frac{2A_1X^2}{A_1X^2 + C_1}$	1.4756	1.4848	1.4938	1.5026	1.8595

.

The lower figure displays a box plot of the annual percentage of change in net local property tax charge per square meter during 2013–2016 and excluding outliers. The median increase is 1.26%, the increase in the third quartile is 3.30%, and the mean increase is 4.02%. The average increase is a bit lower than the projected increase of 4.1775% required to preserve the payments unchanged. Moreover, the distribution of the net local property tax charge is right-tailed, and the skewness is 2.26. This outcome may suggest that the municipality might encounter difficulties in preserving the current level of payments by raising each year the local property tax by 4.1775%.

Finally, note, that of the 76,698 panels in the sample, 10,546 panels (consisting of 13.75%) experience a decrease in local property tax after discounts, and only 2333 panels (consisting of 3.05%) experience a decrease in the local property tax before discounts. This suggests that for many households the source of this decrease in local property tax charges is additional discounts based on economics and socio-demographic criteria.

6. Summary and conclusion

The objective of the current study is to examine the efficiency of tax collection in the municipal level. This is done by constructing Laffer curves and estimating the elasticity of annual payment with respect to the after-discount net annual local property tax charge per square meter for different land uses and across time. No other paper we are aware of have employed this direct and tractable methodology. Given that practitioners are interested in tax collection rather than tax base, this methodology might prove to be useful. The relevant literature on Laffer curves have focused on income-tax brackets, labor and capital income tax, and the VAT in the US and European countries (e.g., Feldstein, 1995; Gruber and Saez, 2002; Trabandt and Uhlig, 2011; Oliviera, Francisca and Costa, 2015).

We employ a unique panel dataset referring to 2013–2016 obtained from Jerusalem municipality. The dataset contains micro-level information of land use, the annual local property tax charge and payment of each individual taxpayer, and the area of each asset measured in square meters. The local property tax can be examined in three dimensions: temporally, cross sectional based on different land uses, and geographically (West vs. East Jerusalem). During 2013–2016, the Jerusalem municipality steadily increased the local property tax rate by 0.46–1.42% per annum.[31] Our study thus permits to examine the response of taxpayers to those

[31] We also found a few cases of tax reductions.

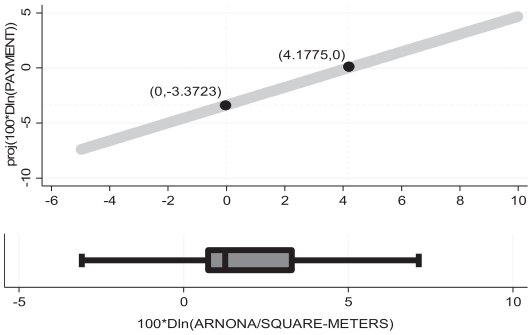


Fig. 7. Elasticity of payments - local property tax charge 2013–2016. Notes: The upper figure displays the 2013–2016 relationship between the projected annual percentage of change in payment (vertical axis) and the annual percentage of change in local property tax charge per square meter (horizontal axis). The upper figure is based on the projected values for $-5 < 100 \cdot \Delta ln\left[\frac{ARNONA}{AREA}\right] < 10$ obtained from the following fixed-effect regression outcomes for 69,472 panels whose collection rates are between 0% to 100% (numbers in parentheses are standard errors and all the coefficients are statistically significant at the 1% significance level):.

$proj\left[100\Delta ln(PAYMENT)\right] = -3.787 \cdot 10^{-4}\left[100\Delta ln\left[\frac{ARNONA}{AREA}\right]\right]^2 + 80.88 \cdot 10^{-2} \cdot 100\Delta ln\left[\frac{ARNONA}{AREA}\right] - 337.23 \cdot 10^{-2}$.

$(0.88 \cdot 10^{-4})$ $(1.32 \cdot 10^{-2})$ $(1.32 \cdot 10^{-2})$.

These outcomes imply that the intersection point with the horizontal axis is (4.1775, 0) based on the formula for the solution of the quadratic equation $\frac{-B-\sqrt{B^2-4AC}}{2A}$ where $= -3.787 \cdot 10^{-4}$; $B = 80.88 \cdot 10^{-2}$ and $C = -337.23 \cdot 10^{-2}$, and the intersection point with the vertical axis is (0, -3.3723). The null hypothesis that the coefficients of all the panels are equal is clearly rejected ($F(69{,}471, 47{,}561) = 1.03$ and the p-value is 0.00%). This outcome supports the fixed-effect model.

The lower figure displays a box plot of the annual percentage of change in local property tax charge per square meter during 2013-2016 and excluding outliers. The median increase is 1.26%, the increase in the third quartile is 3.30% and the mean increase is 4.02%. Of the 76,698 panels in the sample, 10,546 panels (consisting of 13.75%) experience a decrease in local property tax after discounts, and only 2333 panels (consisting of 3.05%) experience a decrease in the local property tax before discounts.

Referring to Eq. (3), the payment-charge per square meters elasticity is given by the formula $\frac{\Delta \ln(Y)}{\Delta \ln(X)} = 2A_2 \Delta \ln(X) + B_2$ where $Y = proj(PAYMENT)$ and $X = \left[\frac{ARNONA}{AREA}\right]$. The following table provides the on sample elasticities:

$100 \cdot \Delta \ln(X)$	-4	-2	0	2	4	6	8
$\frac{\Delta \ln(Y)}{\Delta \ln(X)} = 2A_2 \Delta \ln(X) + B_2$	0.8119	0.8103	0.8088	0.8073	0.8058	0.8043	0.8028

.

increases, and provides efficiency evaluation of this policy.

The outcomes imply that within the on-sample boundaries, raising the tax rate is efficient. For a $90 payment of a current after-discount net tax charge of $100, a 10% rise to $110 is associated with a minimum and maximum anticipated rise to $93.26 and $95.19, respectively.[32] In spite of the fact that anticipated collection rates dropped from 90% to 84.78%-86.54%, the overall collected sum is nevertheless expected to rise.[33]

Moreover, additional outcomes obtained from direct estimation of payment-property tax charge elasticities show that on the one hand, if local property tax charge remains unchanged, collection rates are anticipated to drop by 3.37% per annum. On the other hand, if the municipality would like to preserve the same collected sum of payments as before, for the entire sample, the minimal anticipated required raise is 4.17% per annum. Finally, within the on-sample range (between -5% and 10% variation in the net local property tax), the elasticity of payment-property tax charge is around 0.8. This implies that the projected increase in payment following a 10% increase in after-discount net local property tax charge is around 8%.

Additional findings, which refer separately to the two sectors yielding 94% of the total revenues, namely, the residential and office sectors, suggest that increasing local property tax tariffs are more efficient for owner-occupiers rather than for renters, and for big offices rather than small ones. Research findings may thus be of assistance to municipal policy planners.

[32] As demonstrated in Table 2, the initial tax collection rate for all sectors is 91.22%

[33] The minimum rise is: $\$90 \cdot \left[1+\frac{3.625}{100}\right] = \$93.2624$ and the maximum rise is $\$90 \cdot \left[1+\frac{5.768}{100}\right] = \$95.1913$. The minimum and maximum collection rates are: $\frac{93.2624}{110} = 84.78\%$ and $\frac{95.1913}{110} = 86.54\%$, respectively. All the calculations are based on the assumption that the area of the asset remained unchanged during the sample period.

Appendix A. Israel: Regional division to statistical areas

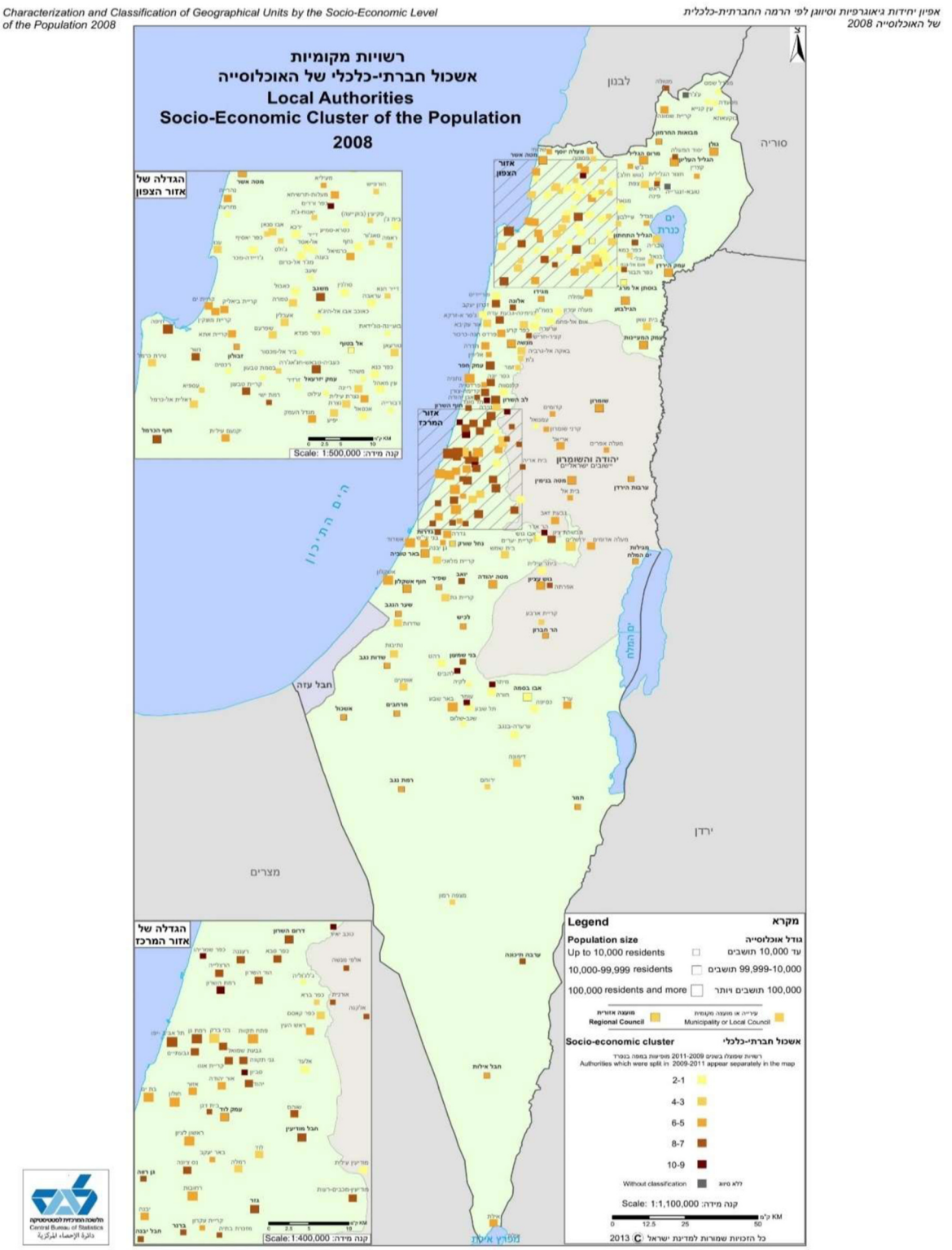
See Appendix Fig. A1.



Fig. A1. Source: Beenstock, Felsenstein and Zeev (2011); Fig. 1, page 604.

Appendix B. Local authorities: Socio economic clusters of population

See Appendix Fig. B1.


Characterization and Classification of Geographical Units by the Socio-Economic Level of the Population 2008
אפיון יחידות גיאוגרפיות וסיווגן לפי הרמה החברתית-כלכלית של האוכלוסייה 2008
רשויות מקומיות
אשכול חברתי-כלכלי של האוכלוסייה
Local Authorities
Socio-Economic Cluster of the Population
2008
הגדלה של אזור הצפון
הגדלה של אזור המרכז
Scale: 1:500,000
Scale: 1:400,000
Legend
מקרא
Population size
גודל אוכלוסייה
Up to 10,000 residents
עד 10,000 תושבים
10,000-99,999 residents
99,999-10,000 תושבים
100,000 residents and more
100,000 תושבים ויותר
Regional Council
מועצה אזורית
Municipality or Local Council
עירייה או מועצה מקומית
Socio-economic cluster
אשכול חברתי-כלכלי
Authorities which were split in 2009-2011 appear separately in the map
רשויות שפוצלו בשנים 2009-2011 מופיעות במפה בנפרד
2-1
4-3
6-5
8-7
10-9
Without classification
ללא סיווג
Scale: 1:1,100,000
קנה מידה: 1:1,100,000
KM
0 12.5 25 50
כל הזכויות שמורות למדינת ישראל © 2013
לבנון
סוריה
ירדן
מצרים
הים התיכון
ים כנרת
ים המלח
חבל עזה
נתיבות
אופקים
שדרות
אשכול
רמת נגב
מצפה רמון
אילת
מפרץ אילת
באר שבע
ערד
דימונה
ירוחם
מצפה רמון
תמר
אבו בסמה
להבים
מרחבים
שער הנגב
לכיש
שפיר
חוף אשקלון
בני שמעון
גוש עציון
הר חברון
שומרון
יהודה והשומרון
יישובים ישראליים
מחוז בנימין
בית אל
ערבות הירדן
מגילות ים המלח
עמק המעיינות
בקעת הירדן
נוף הגליל
מבואות הרמון
הגליל העליון
מרום הגליל
אזור הצפון
אזור המרכז
מנשה
עמק חפר
עמק יזרעאל
חוף השרון
חוף הכרמל
זבולון
משגב
אל בטוף
מטה אשר
מעלה יוסף
מבוא חמה
אלונה
מגידו
הגלבוע
עמק הירדן
בסמת טבעון
עמק לוד
חבל מודיעין
חבל איילות
שרונה חיכונה
דרום השרון
מתת תקוה
גבעת שמואל
אלעד
בן עזרה
מודיעין עילית
מודיעין-מכבים-רעות
גזר
חבל יבנה
בדיקת עקרון
רחובות
נס ציונה
רמלה
לוד
באר יעקב
גן רווה
אור יהודה
קריית עקרון
ברכיר
מזכרת בתיה
כפר ברא
אלקנה
כפר קאסם
ראש העין
כפר סבא
רעננה
הרצליה
נתניה
קריית אונו
אור יהודה
סביון
יהוד
עמק לוד
בית דגן
שוהם
חבל מודיעין
ראשון לציון
באר יעקב
רמלה
לוד
נס ציונה
מודיעין עילית
מודיעין-מכבים-רעות
גזר
חבל יבנה
קריית עקרון
ברכיר
מזכרת בתיה
רחובות
בן עזרה
גן רווה
אור יהודה
קריית אונו

Appendix C. Percentage of discount on the local property tax residential tariffs: low income households

Number of Residents	80% discount for income	60% discount for income		40% discount for income	
	Up to	From	Up to	From	Up to
1	2,703 NIS	2,704 NIS	3,108 NIS	3,109 NIS	3,513 NIS
2	4,054 NIS	4,055 NIS	4,662 NIS	4,663 NIS	5,270 NIS
3	4,703 NIS	4,704 NIS	5,408 NIS	5,409 NIS	6,113 NIS
4	5,351 NIS	5,352 NIS	6,154 NIS	6,155 NIS	6,957 NIS
5	6,535 NIS	6,536 NIS	7,515 NIS	7,516 NIS	8,496 NIS
6	7,719 NIS	7,720 NIS	8,877 NIS	8,878 NIS	10,035 NIS
Number of Residents	80% discount for income	80% discount for income		80% discount for income	
	Up to	From	Up to	From	Up to
7	8,903 NIS	8,904 NIS	10,238 NIS	10,239 NIS	11,574 NIS
8	10,087 NIS	10,088 NIS	11,600 NIS	11,601 NIS	13,113 NIS
9	11,271 NIS	11,272 NIS	12,961 NIS	12,962 NIS	14,652 NIS
10 and up	1,252 NIS per person	1,440 NIS per person		1,628 NIS per person	

Notes: Source of Information: Jerusalem Municipality website at:
https://www.jerusalem.muni.il/en/Municipality/Services/Arnona/Discounts/Income/Pages/default.aspx
The table displays municipal tax discounts for income reasons for the fiscal year 2015. Discounts are determined based on the number of persons living in the dwelling unit, and the average monthly income during the fourth quarter in 2014. NIS is the local Israeli currency, where 1 NIS roughly equals $0.25.

Appendix D. Local property tax residential tariffs in Jerusalem per square meter (NIS)

D1. 2017 Tariffs

Building type	Criteria	Zone A	Zone B	Zone C	Zone D
1	Apartment of more than 120 m^2	107.69 NIS	97.86 NIS	75.50 NIS	61.71 NIS
2	Apartment of up to 120 m^2	89.23 NIS	71.57 NIS	53.26 NIS	38.44 NIS
3	Apartment with external/joints lavatories	62.76 NIS	46.67 NIS	38.44 NIS	38.44 NIS
4	Apartment in building made of wood or tin	38.44 NIS	38.44 NIS	38.44 NIS	38.44 NIS

D2. 2013 Tariffs

Building type	Criteria	Zone A	Zone B	Zone C	Zone D
1	Apartment of more than 120 m^2	100.36 NIS	91.20 NIS	70.36 NIS	57.51 NIS
2	Apartment of up to 120 m^2	83.15 NIS	66.70 NIS	49.64 NIS	35.84 NIS
3	Apartment with external/joints lavatories	58.49 NIS	43.50 NIS	35.84 NIS	35.84 NIS
4	Apartment in building made of wood or tin	35.84 NIS	35.84 NIS	35.84 NIS	35.84 NIS

Notes: Source of this information: Jerusalem Municipality website:
https://www.jerusalem.muni.il/en/municipality/services/arnona/rates/pages/tariffs%20for%20residential%20assets.aspx
and
https://www.jerusalem.muni.il/Residents/MunicipalityServices/PropertyTax/taxorder/Documents/tax2013.pdf
NIS is the local Israeli Currency, where 1 NIS roughly equals US $ 0.25. 1 sq meter roughly equals 10.7639 square feet. The table implies a 7.25%-7.31% increase in local tax charge per square meter during a period of five-years. This implies a $[(1 + 0.0725)^{0.2} - 1] = 1.41\%$ a $[(1 + 0.0731)^{0.2} - 1] = 1.42\%$ increase per annum

Appendix E. Tax rate tarrifs for non-residential assets in Jerusalem per 1 sqm

Type of use	Zone	2013 Tariff Per 1 sqm	2017	% change
Services and commercial offices (above 150 sqm)	All city	326.07 NIS	333.72 NIS	2.34%
Services and commercial offices (up to 150 sqm)	All city	315.95 NIS	323.35 NIS	2.34%
Call Centers (not banks)	All city		135.51 NIS	
Workshops and garages	Area A	143.94 NIS	154.46 NIS	7.30%
	Area B	106.92 NIS	114.74 NIS	7.30%
	Area C	86.76 NIS	93.09 NIS	7.30%
Industrial plants	Area A	126.28 NIS	135.51 NIS	7.31%
	Area B	93.70 NIS	100.54 NIS	7.30%
	Area C	76.06 NIS	81.61 NIS	7.30%
Schools, kindergartens, yeshivas and universities	All city	97.58 NIS	104.72 NIS	7.32%
Banks	All city	1264.21 NIS	1356.79 NIS	7.32%
Main/regional bank management	All city	886.59 NIS	951.51 NIS	7.32%
Bank services call center	All city	422.16 NIS	453.07 NIS	7.32%
Central banking services branches	All city		707.40 NIS	
Stock exchange	All city	1233.87 NIS	1324.23 NIS	7.32%
Occupied land	Area A	37.93 NIS	40.69 NIS	7.28%
	Area B	33.08 NIS	35.48 NIS	7.26%
	Area C	21.74 NIS	23.32 NIS	7.27%
Clinics, health funds and public hospitals	All city	97.58 NIS	104.72 NIS	7.32%
Places of worship	All city	58.54 NIS	62.82 NIS	7.31%
Insurance companies	All city	443.51 NIS	475.98 NIS	7.32%
Consulates, embassies and UN institutions	All city	97.58 NIS	104.72 NIS	7.32%
Hotels and boarding houses with an area of more than 2000 sqm	Area A	132.80 NIS	142.51 NIS	7.31%
	Area B	123.67 NIS	132.70 NIS	7.30%
	Area C	99.70 NIS	106.99 NIS	7.31%
Hotels and boarding houses with an area of up to 2000 sqm	Area A	107.81 NIS	115.69 NIS	7.31%
	Area B	87.33 NIS	93.70 NIS	7.29%
	Area C	63.49 NIS	68.13 NIS	7.31%
Old age homes	Area A	100.36 NIS	107.69 NIS	7.30%
	Area B	91.20 NIS	97.86 NIS	7.30%
	Area C	70.36 NIS	75.50 NIS	7.30%
	Area D	57.51 NIS	61.71 NIS	7.30%
Museums	All city	97.58 NIS	104.72 NIS	7.32%
Bowling, gyms and sports halls	All city	166.85 NIS	179.05 NIS	7.31%
Sports center with an area over 10,000 m^2, Tariff for 1000 first square meters	All city	166.85 NIS	179.05 NIS	7.31%
Sports center with an area over 10,000 m^2, from 1001 sqm to 2000 sqm	All city		89.52 NIS	
Sports center with an area over 10,000 m^2, from 2001 sqm and up	All city		66.62 NIS	
Large Laundromats services with an area of more than 400 sqm in the Atarot Industrial area (parcel 510 and 710)	All city	108.62 NIS	116.56 NIS	7.30%
Marketing warehouses located at the Atarot Industrial area	All city	108.62 NIS	116.56 NIS	7.30%
Cinemas and theaters up to 300 sqm	All city	110.45 NIS	118.53 NIS	7.32%
Cinemas and theaters from 301 sqm to 1000 sqm	All city	73.63 NIS	79.01 NIS	7.31%
Cinemas and theaters with more than 1001 sqm	All city	36.81 NIS	39.48 NIS	7.25%
Electricity facility	All city	162.51 NIS	174.41 NIS	7.32%
Structure serving as a closed water reservoir used by the Gihon Spring	All city	62.61 NIS	67.18 NIS	7.30%
Paid Parking Lots	Area A	59.41 NIS	63.74 NIS	7.29%
	Area B	39.74 NIS	42.64 NIS	7.30%
	Area C	30.90 NIS	33.14 NIS	7.25%
Free Parking space open to the public	Area A	25.57 NIS	27.43 NIS	7.27%
	Area B	20.46 NIS	21.88 NIS	6.94%
	Area C	15.35 NIS	16.46 NIS	7.23%
Indoor Parking space which is not open to the public	Area A	25.57 NIS	27.43 NIS	7.28%
	Area B	20.46 NIS	21.88 NIS	6.94%
	Area C	15.35 NIS	16.46 NIS	7.23%
Studio artists and sculptors to 100 sqm	All city	54.67 NIS	58.67 NIS	7.32%

Studio Painters and Sculptors began sqm 101onwards	All city	163.96 NIS	175.97 NIS	7.32%
Farmland	All city	0.59 NIS	0.63 NIS	6.78%
Agricultural Structure	All city	38.87 NIS	41.70 NIS	7.28%
Banquet halls	All city		179.05 NIS	
Other assets	All city	326.07 NIS	339.62 NIS	4.16%

Source: Tarrifs for non-Residential Assets, Jerusalem Municipality Website at:
https://www.jerusalem.muni.il/en/municipality/services/arnona/rates/pages/non-residentialassets.aspx
https://www.jerusalem.muni.il/Residents/MunicipalityServices/PropertyTax/taxorder/Documents/tax2013.pdf
Notes: NIS is the local Israeli Currency, where 1 NIS roughly equals US $ 0.25. 1 sq meter roughly equals 10.7639 square feet

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